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Effect of Different Types of Rest-Break Interventions on Neck and Shoulder Muscle Activity, Perceived Discomfort and Productivity in Symptomatic VDU Operators: A Randomized Controlled Trial

Nuttika Nakphet
Montakarn Chaikumarn
Prawit Janwantanakul

Faculty of Allied Health Sciences, Chulalongkorn University, Bangkok, Thailand

Objective. *This study evaluated the effect of different types of activities during rest-break interventions on neck and shoulder muscle activity, muscle discomfort and productivity among symptomatic video display unit (VDU) operators performing prolonged computer terminal work.* ***Study design and setting.*** *Randomized controlled trial was used. Thirty symptomatic VDU operators were randomly assigned to 2 active break groups (stretching and dynamic movement) and a reference group. The subjects performed the same typing task for 60 min and received 3-min breaks after each 20 min of work. Root mean square and median frequency were calculated for neck and shoulder muscle activity. Muscle discomfort was measured with Borg's CR-10 scale. Productivity was measured by counting words.* ***Results.*** *There were no significant differences between the types of activities during breaks on neck and shoulder muscle activity, muscle discomfort or productivity. However, there was a significant difference in the level of muscle discomfort over time.* ***Conclusions.*** *Three types of activity during breaks showed a favourable effect on neck and shoulder muscle activity and productivity, and a positive effect on muscle discomfort in symptomatic VDU operators.*

electromyography   symptomatic VDU operators   rest breaks   neck and shoulders

1. INTRODUCTION

Work-related musculoskeletal disorders (MSDs) are common among office workers, due to the introduction of computer-based tasks at the workplace [1]. Work-related MSDs among office workers are a significant problem in the head and neck, and shoulder areas [2, 3, 4]; they predominantly affect the trapezius muscle [5] and result in pain and limited functional activity in daily life [6]. A report on prevalence found that 53% of female video display unit (VDU) operators had experienced neck pain of mild intensity [7]. These disorders have an important economic impact in terms of sickness absence and chronic disability [8, 9]. According to a recent report, MSDs of Thai office workers cost ~1339 USD per person per year [10].

The reasons why VDU operators develop such MSDs are multifactorial. Computer work tasks are often characterized by prolonged viewing of a monitor while maintaining static postures with repetitive movements of the arms [11]. VDU work is also monotonous and requires a prolonged static posture with low static muscle contractions [12, 13]. VDU work requires static loading of the muscles in the back, neck, shoulders and upper arms. Therefore, it is considered as a

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Correspondence should be sent to Montakarn Chaikumarn, Department of Physical Therapy, Faculty of Allied Health Sciences, Chulalongkorn University, Bangkok, Thailand, 10330. E-mail: cmontaka@chula.ac.th.

job with high physical exposure with regard to precision and repetitive demands [14]; it can produce several risk factors for developing MSDs [15].

VDU tasks involve exposure to high precision and repetitive motions, with long-lasting low-level loads. In addition, based on the Cinderella hypothesis, duration of exposure may be a major effect on musculoskeletal symptoms among VDU operators [16]. Thus, considering the logic of exposure which causes neck and shoulder MSDs among VDU operators, physical load and mental stress may decrease if rest breaks are added. Further, if the level of exposure at work cannot be reduced to a safe limit, rest-break interventions have been recommended to decrease musculoskeletal symptoms [2]. In the same way, a proper recovery of muscles is believed to be crucial in avoiding MSDs. In this context, the general purpose of exposure variation is to give the motor units that would otherwise be overloaded an opportunity to relax [17].

Adding rest breaks enhances recovery time periods and also disrupts periods of static posture, exposure duration and repetitiveness in VDU work [18]. Metabolic and circulatory variables within muscles improve [18] and local muscle loads decrease [18, 19, 20, 21, 22, 23, 24]. Furthermore, rest breaks taken at VDU operators' discretion are a practical recommendation since they are not costly [25]. However, there is limited scientific evidence on the effectiveness of rest-break interventions among VDU operators with work-related MSDs.

Rest breaks, rest or breaks in this consideration are defined as a cessation of computer work tasks. Individual operators can perform some physical activity, exercise or change their posture during the breaks [26]. Some authors use the word "pause" instead of rest break or break [27, 28]. Pauses during computer work tasks can be passive or active. Passive pauses in these appraisals mean that operators leave their computer tasks, and sit and relax during this period, while during active pauses operators are required to perform specific movements, e.g., shoulder elevation [27, 28].

Some studies investigated the effect of passive and active pauses. A few studies compared the beneficial effects of passive and active pauses, with focus on oxygenation in muscles [20, 28]. However, there is still limited clinical trial research that addresses the effects of different types of activities during rest-break interventions among VDU operators in terms of changes in local muscle loads, discomfort and productivity.

This study tried to identify which kind of rest-break intervention would be most effective for musculoskeletal health. Therefore, the aim of this study was to investigate the effects of different types of activities during rest-break interventions on neck and shoulder muscle activity, muscle discomfort and productivity of symptomatic VDU operators performing prolonged work at a computer terminal.

2. METHODS

2.1. Design

The study was carried out in a laboratory, which was set up to resemble a computer workstation and an office working environment. The experiment took place in the morning. Fifty females working with a VDU for over 4 h a day, and with experience of discomfort in the neck, shoulders or both were recruited through written advertisements sent to seven offices in Bangkok, Thailand. They were asked to complete questionnaires on muscle discomfort, general health and work profile (work in current position, computer use per day) and they received a physical examination.

Thirty qualified subjects were randomly divided into three intervention groups. They performed a typing test in Thai for 5 min, which was then used as a baseline. The computer workstation and the environment were suitably controlled during the experiment in accordance with the recommendations of the Occupational Safety and Health Administration (OSHA) [29]. The workstation consisted of a standard computer desk with an adjustable slide-out tray for the keyboard, an adjustable-height swivel chair with arm rests, a 20" liquid crystal display (LCD) screen, a standard mouse and a keyboard. The subjects were instructed to adjust the keyboard tray and the chair to assume a good posture for computer use. Seat height was adjusted depending on individual popliteal height so that the subjects' feet rested flat on the floor or on a footstool. The back was fully supported with a backrest when sitting vertically. The keyboard and screen were centred in front of the subjects. The top of the LCD screen was adjusted at approximately the horizontal eye height of the subjects with the eye–screen distance of individual arm length, so that the head and neck region was in a reasonable erect posture. The contrast and brightness of the computer screen were constant for all subjects. The subjects' forearms were supported on arm rests with elbows flexed at 90°. The height and position of the computer workstation were adjusted so that the subjects' body parts were well supported and their overall postures were similar to eliminate unnecessary movements contributing to variations in musculoskeletal load during VDU work.

Lighting in the laboratory was maintained at 300 lx with minimal reflectance or direct glare. Room temperature was kept at ~25 °C.

The subjects performed a typing task at their normal pace for 60 min. The task consisted of typing a document in Thai. The document was placed on a document holder on the right side. They received 3-min rest breaks every 20 min of work. Muscle discomfort and EMG activity of the neck and shoulders during work were measured. Work productivity was assessed as word count after 60 min of work divided by the overall time of typing.

2.2. Subjects

The subjects in this study were female VDU operators. They were university office workers and civil service officers. Fifty female VDU operators replied to participate. After a report on their general health, work profile and a physical examination of musculoskeletal symptoms, 15 subjects were excluded because they did not meet the inclusion criteria for the interventions; 35 subjects were selected on the basis of the following criteria:

- age between 18 and 40 years;
- work at a VDU for over 4 h a day;
- symptoms of muscle discomfort in the area of the neck, shoulders or both of at least 3 on Borg's CR-10 scale (0 = *nothing at all*, 10 = *extremely strong*), muscle discomfort for over 3 months, present in the past 7 days and on the day of testing (3 subjects were excluded because there had fewer than three present symptoms);
- experience of muscle discomfort related to computer use (7 subjects were excluded because they reported that their symptoms were related to other activities such as playing sport, a prior accident, traumatic injuries or housework);
- right-handedness;
- work in the current position for a minimum of 2 years;
- ability to give an informed consent.

Out of those criteria, the subjects were excluded if they were pregnant or on maternity leave, their body mass index (BMI) was over 25 or they had an uncorrected visual defect. Five subjects were excluded because their BMI was over 25.

The subjects were qualified on the basis of the inclusion criteria ($N = 35$) and randomly allocated into three groups: rest-break intervention with stretching ($n = 12$), rest-break intervention with dynamic contractions ($n = 12$) and reference ($n = 11$). After randomization, 5 subjects were excluded because they reported no symptoms on the day of the experiment. Thus, 30 subjects participated in the experiment. Figure 1 is a flow chart of the subjects through the intervention. The characteristics of the subjects in the three groups were matched with regard to age, BMI, height, weight, work profile and symptoms in the neck and shoulders. Table 1 shows the general characteristics of the three groups.

Informed consent was obtained from each subject; the study was approved by the Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University.

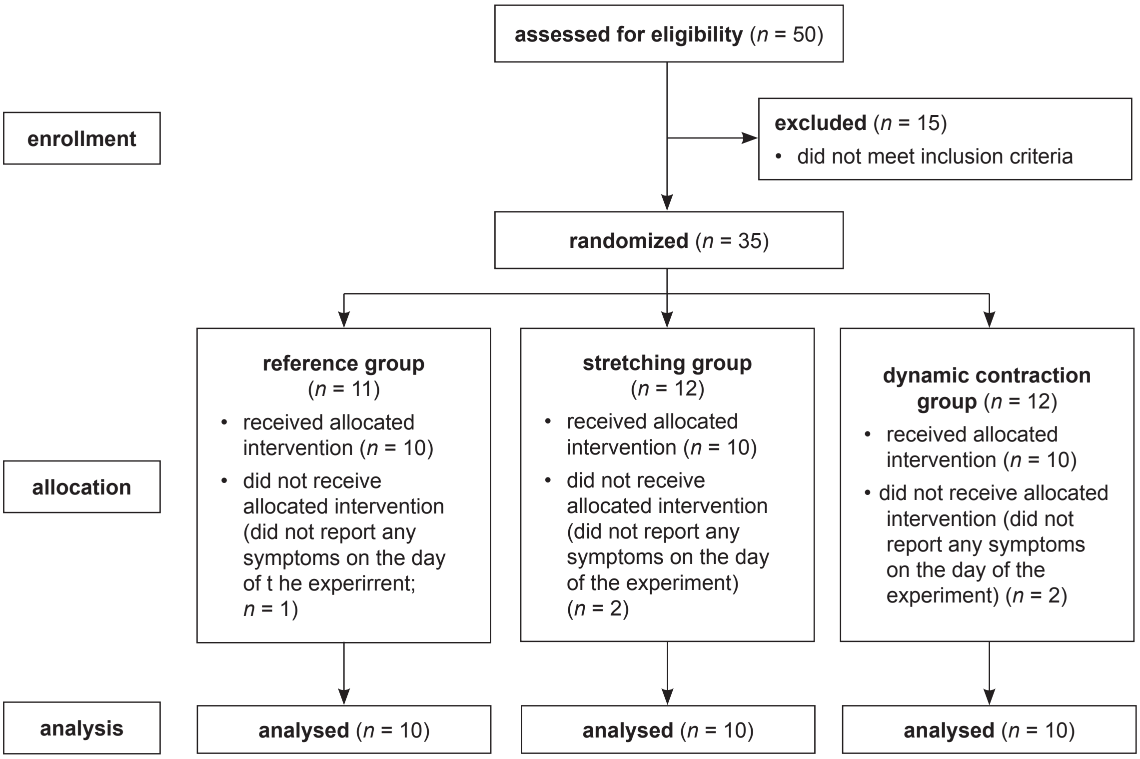

Figure 1. Flowchart of subjects.

TABLE 1. Characteristics of Study Subjects, *M* (*SD*)

	Group		
Characteristic	**Reference (*n* = 10)**	**Stretching (*n* = 10)**	**Dynamic contractions (*n* = 10)**
Age (years)	27.6 (3.0)	31.4 (5.9)	29.6 (5.9)
Body mass index	20.4 (1.5)	20.6 (2.2)	20.0 (1.84)
Height (cm)	156.6 (5.4)	158.0 (4.8)	159.7 (4.8)
Weight (kg)	50.2 (5.3)	51.5 (6.0)	51.0 (4.4)
Work in current position (years)	3.3 (1.3)	4.6 (4.1)	5.2 (4.3)
Computer use per day (h)	7.2 (1.3)	6.5 (0.5)	6.6 (1.5)
Perceived neck discomfort[a]	3.3 (1.8)	3.4 (1.1)	5.3 (2.7)
Perceived right shoulder discomfort[a]	3.4 (1.6)	2.7 (1.5)	4.7 (3.1)
Perceived left shoulder discomfort[a]	2.1 (1.9)	3.1 (2.0)	4.5 (3.5)

Notes. a = rating on Borg's CR-10 scale: 0 = *nothing at all*, 10 = *extremely strong*.

2.3. Interventions

A physical therapist instructed the subjects in all three intervention groups and supervised the intervention activities. To make sure that the subjects could perform correctly activities during the rest breaks, they received guidance and an opportunity to practise before the actual experiment.

2.3.1. Rest-break intervention with stretching

The subjects were instructed to stretch bilateral upper trapezius (UT), lower trapezius (LT), anterior deltoid (AD) and cervical erector spinae (CES) muscles in their 3-min rest breaks. The subjects left their chairs and computer workstations, and performed each stretch of the neck and shoulder muscles for 15 s at a sufficient intensity to elicit a feeling of stretching, not pain. The subjects consecutively stretched both UT, both LT, both AD and CES, and then repeated those stretches. Therefore, the subjects stretched each muscle twice during any 3-min rest break. When stretching, the subjects followed a video.

2.3.2. Rest-break intervention with dynamic contractions

The subjects were instructed to perform simple exercises of the neck and shoulders during each 3-min break, i.e., shoulder elevation, shoulder flexion and neck extension. Each subject performed three sets of different dynamic contractions. Each set involved 1-min sequential phases in the 20-min of work/3-min of rest schedule. The dynamic contractions gradually increased and decreased the length and tension of the muscles, which is known as isotonic contractions.

The activities during the dynamic contractions consisted of sets of five shoulder elevations, five shoulder flexions and five neck extensions. Three sets were performed in a 3-min break. The subjects received advice from a physical therapist before the experiment. During the experiment, they followed a video to perform in the manner and rhythm set by a metronome at 30 beats per minute. The order of the movements was the same as in the video.

2.3.3. Reference intervention

The subjects in the reference group were instructed to take their hands off the computer and relax sitting back on their chairs during the breaks.

2.4. Outcomes

2.4.1. Muscle electrical activity

Surface myoelectric activity (SEMG) signals were collected from right UT, right LT, right AD and CES. These muscles were selected because they are the major muscles involved in neck and shoulder stabilization during VDU work [30].

Four pairs of bipolar silver/silver chloride surface electrodes with a contact diameter of 6 mm (3 × 2 mm) and a centre-to-centre distance of 2 cm were placed over the neck and shoulder muscles at anatomical landmarks [31]. A neutral reference electrode was positioned at the acromion process. Each electrode cable was firmly fixed with a regular tape to avoid cable movement artifacts. The skin at the site of attachment was cleansed with an alcohol pad (2% alcohol) and shaved if necessary. Table 2 presents electrode placement.

The Noraxon Telemyo System (Noraxon USA, USA) was used to capture EMG signals. Raw EMG signals were transmitted through low- and high-pass filters at 20–200 Hz. The signals were carried via a differential amplifier located in active leads with a common mode rejection ratio of over 100 dB, input impedance of over 100 MΩ and base gain at 500 times to obtain a high quality signal. Baseline noise was filtered below 1 μV root mean square (RMS).

Raw EMG signals were recorded during the experiment. The recorded raw data were processed with electrocardiography (ECG) reduction, full-wave rectification. They were then averaged within 200 ms to determine RMS. The electrical activity of right UT, right LT, right AD and CES was recorded during the computer typing task. The muscle activity variable, i.e., RMS, was analysed in terms of normalized EMG and expressed as a percentage of maximum voluntary electrical activity (MVE). In spectrum frequency analysis, the fast Fourier transform was used to estimate the median frequency (MF).

2.4.2. EMG normalization

The SEMG normalization procedures were carried out prior to the 60-min typing task. Each subject performed three 5-s trials of isometric maximal voluntary contractions (MVCs) for each muscle. Before commencing the MVC measurement, the subjects warmed up with active stretching of the neck and shoulder muscles. Table 2 describes the testing position and exerted movement in EMG normalization of each muscle. During all normalization contractions, data were sample for 5 s, RMS amplitudes were computed across each contraction using a moving window of 200 ms. The window with the highest value of RMS across all contractions and all repetitions was used to represent the maximal voluntary activation amplitude (MVE) for each muscle [32].

TABLE 2. Electrode Placement and Muscle Action Tested in Normalization of Neck and Shoulder Muscles

Muscle	Position of Electrode	Starting Position and Application of Resistance	Muscle Action
UT [31]	2 cm lateral to midpoint between spinous process of C7 and acromion process	sitting in upright position and shoulder abduction of 90° in frontal plane with palms facing downwards [33] vertically adjustable strap fixed to stationary resistance was placed over right arm above elbow horizontal strap was fixed to subject's trunk and chair to prevent unwanted movement	shoulder abduction against fixed vertical resistance
LT [34]	distal: 2.5–3.0 cm lateral to T6 proximal: at 45° parallel to muscle fibers and 20 mm above distal	sitting and grasping bar fixed to stationary resistance with shoulder flexion of 90° and elbow flexion of 90° [35]	shoulder depression against fixed resistance
AD [34]	midpoint between electrodes at 2 cm anterior to midpoint between acromion and deltoid tuberosity	sitting, shoulders in 30° forward flexion, elbows in 75° flexion resistance was provided with strap placed proximally to elbow joint [34].	forward flexion of shoulders
CES [34]	distal: 1 cm lateral to C5 spinous process proximal: 20 mm above distal	prone lying resistance was provided with strap placed behind head [32]	neck extension against resistance

Notes. UT = upper trapezius, LT = lower trapezius, AD = anterior deltoid, CES = cervical erector spinae.

2.4.3. Muscle discomfort

Definitions of discomfort involving the assessment of work-related MSDs often describe uncomfortable sensations (e.g., pain, fatigue, muscle cramping) resulting from experimental tasks [36]. The subjects verbally rated the feeling of muscle discomfort in seven areas (the neck, both shoulders, both elbows, and both wrists and hands) on Borg's CR-10 scale before commencing computer work, at the end of each 20-min session and immediately after each break. Therefore, the subjects rated muscle discomfort six times: at the 0th, 20th, 23rd, 43rd, 46th, and 66th minute.

2.4.4. Productivity

Productivity was calculated to compare typing productivity between interventions. The productivity of typing was calculated by dividing the total number of correct words that the subject typed by the overall time of typing.

2.5. Statistical Analyses

SPSS version 17.0 was used to perform statistical analyses; significance was set at $p < .05$. The subjects were matched in terms of work profile, anthropometry and age. Repeated-measures analysis of variance (ANOVA) was used to test for a main effect of rest-break interventions for the dependent variables, i.e., EMG parameters (RMS and MF) and the rating of perceived exertion (RPE) of the neck and upper limbs. Time was introduced as a factor of repeated measures. To analyse the effects of rest-break interventions on EMG variability of the neck and shoulder muscles during a 60-min computer typing task, a two-way repeated ANOVA with rest-break intervention groups (between-subject factor, three groups) and time (within-subject factor, three levels) was performed. To examine the effects of rest-break intervention on RPE, time was introduced as a factor in a repeated-measure ANOVA at six levels: at the beginning, at the end of each 20-min session and immediately after each break. The sphericity test was used for any repeated-measure factors. If the assumption indicated lack of sphericity, the Greenhouse–Geisser correction was used. If there were significant effects, post-hoc comparisons using the Bonferroni correction were used to locate the differences.

Descriptive data were expressed as means and standard deviations for all variables. If distribution was normal, a paired *t* test was used to compare two means between baseline and 60-min work performance. If the variables did not present normal distribution, a Wilcoxon matched-pairs signed-ranks test was used instead.

3. RESULTS

3.1. Subjects

There were no significant differences between groups of subjects in terms of age, BMI, work profile or perceived muscle discomfort in the neck and shoulders (Table 1). It can be noted that the subjects in the dynamic group had higher muscle discomfort than the others.

Table 3 summarizes repeated-measure ANOVA on RMS, MF of each muscle during the typing task with the time factor (0th–20th, 23th–43th, 46th–66th minute) and rest-break intervention group (reference, stretching, dynamic contractions).

3.2. Normalized RMS of Each Muscle

There were no significant group effects of rest-break interventions on normalized RMS during 60 min of work.

UT	$F(2, 27) = 0.38$,	$p = .685$
LT	$F(2, 27) = 1.13$,	$p = .339$
AD	$F(2, 27) = 1.05$,	$p = .363$
CES	$F(2, 27) = 1.83$,	$p = .180$

There were no statistical differences in normalized RMS between three sessions of a 20-min computer typing task.

UT	$F(2, 54) = 5.06$,	$p = .010$
LT	$F(2, 54) = 0.74$,	$p = .483$
AD	$F(2, 54) = 0.69$,	$p = .507$
CES	$F(1.63, 43.90) = 0.35$,	$p = .662$

However, post-hoc analysis did not present significant differences in normalized RMS of UT between the task sessions.

There was no significant interaction between rest-break intervention and time during normalized RMS of 60 min of work.

UT	$F(4, 54) = 1.28$,	$p = .289$
LT	$F(4, 54) = 0.60$,	$p = .665$
AD	$F(4, 54) = 0.75$,	$p = .560$
CES	$F(3.25, 43.90) = 0.50$,	$p = .702$

3.3. MF of Each Muscle

There were no significant group effects of rest-break interventions on MF during 60 min of work.

TABLE 3. Summary of Repeated-Measure Analysis of Variance (ANOVA) on Root Mean Square (RMS) and Median Frequency (MF) During Typing Task With Time Factors (0th–20th, 23th–43th, 46th–66th min) and Rest-Break Intervention Group (Reference, Stretching, Dynamic Contractions)

	Factor		
Parameter	**Group**	**Time**	**Group × Time**
UT			
RMS	$F(2, 27) = 0.38$	$F(2, 54) = 5.06$*	$F(4, 54) = 1.28$
MF	$F(2, 27) = 0.14$	$F(1.59, 42.81) = 5.35$*	$F(3.17, 42.81) = 1.13$
LT			
RMS	$F(2, 27) = 1.13$	$F(2, 54) = 0.74$	$F(4, 54) = 0.60$
MF	$F(2, 27) = 0.45$	$F(1.28, 34.43) = 1.30$	$F(2.55, 34.43) = 0.64$
AD			
RMS	$F(2, 27) = 1.05$	$F(2, 54) = 0.69$	$F(4, 54) = 0.75$
MF	$F(2, 27) = 0.08$	$F(2, 54) = 2.45$	$F(4, 54) = 0.30$
CES			
RMS	$F(2, 27) = 1.83$	$F(1.63, 43.90) = 0.35$	$F(3.25, 43.90) = 0.50$

Notes. * $p < .05$; UT = upper trapezius, LT = lower trapezius, AD = anterior deltoid, CES = cervical erector spinae.

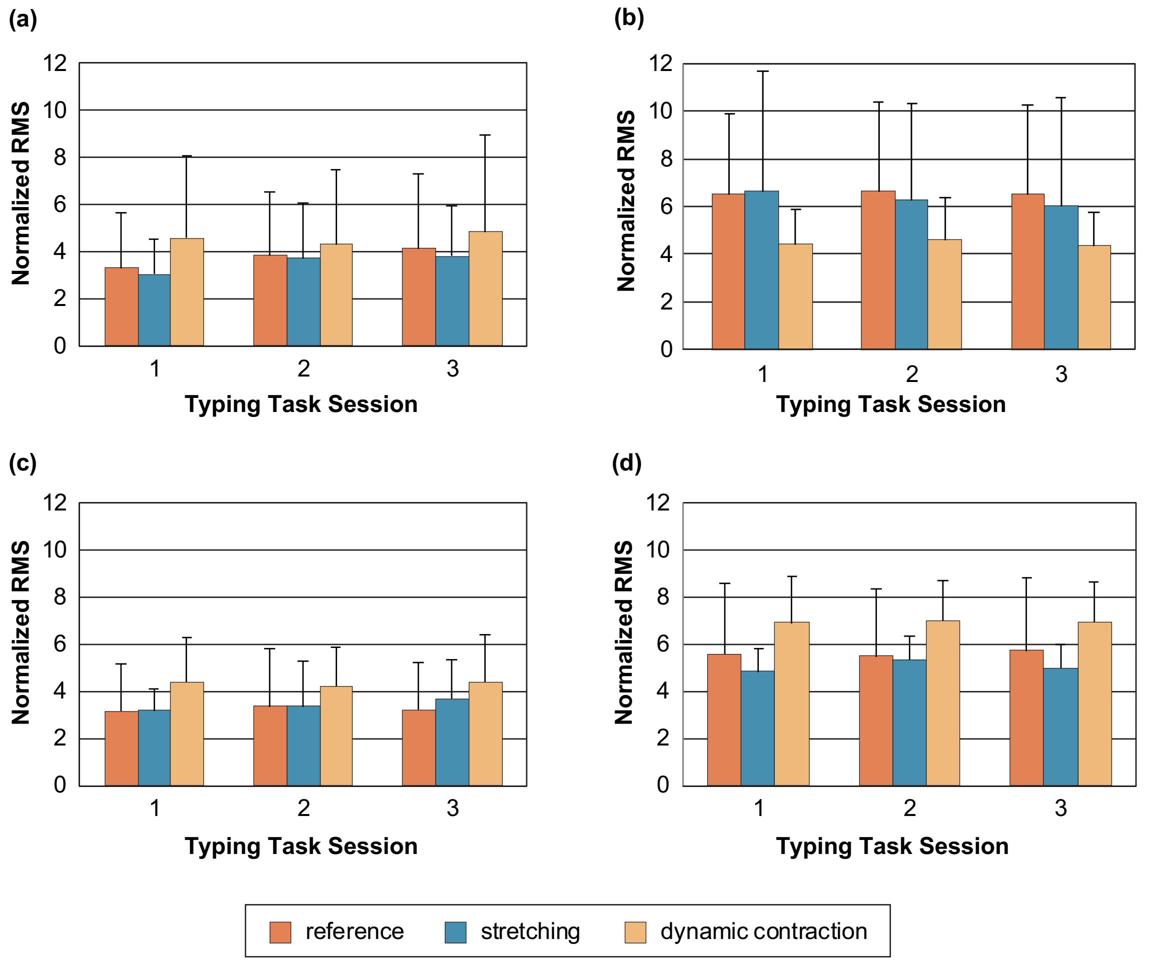

Figure 2. Normalized root mean square (RMS) of (a) upper trapezius, (b) lower trapezius, (c) anterior deltoid and (d) cervical erector spinae. *Notes.* Error bars denote *SD*.

UT	$F(2, 27) = 0.14$,	$p = .873$
LT	$F(2, 27) = 0.45$,	$p = .641$
AD	$F(2, 27) = 0.08$,	$p = .925$
CES	$F(2, 27) = 1.19$,	$p = .320$.

There was a significant time effect on MF between three sessions of a 20-min computer typing task of UT: $F(1.59, 42.81) = 5.35$, $p = .013$. Post-hoc analysis of session 1 (0th–20th min) and session 2 (23th–43th min): $F(1, 27) = 4.26$, $p = .049$. There was no significant interaction between rest-break intervention groups and time on MF.

UT	$F(3.17, 42.81) = 1.13$,	$p = .351$
LT	$F(2.55, 34.43) = 0.64$,	$p = .568$
AD	$F(4, 54) = 0.30$,	$p = .878$
CES	$F(2.62, 35.37) = 0.85$,	$p = .463$.

3.4. Muscle Discomfort

Table 4 is a summary of repeated-measure ANOVA on muscle discomfort with the time factor time at six levels, i.e., at the beginning, at the end of each 20-min session and immediately after each break, and rest-break intervention group (reference, stretching, dynamic). There was no significant difference on muscle discomfort between the intervention groups. The muscle discomfort score was significantly different across time in the neck, right shoulder, left shoulder, right elbow, left elbow, right wrist and hand, and left wrist and hand.

The subjects in all groups had lower scores of muscle discomfort immediately after each break than at the end of each 20-min working session in all body parts (Figure 4).

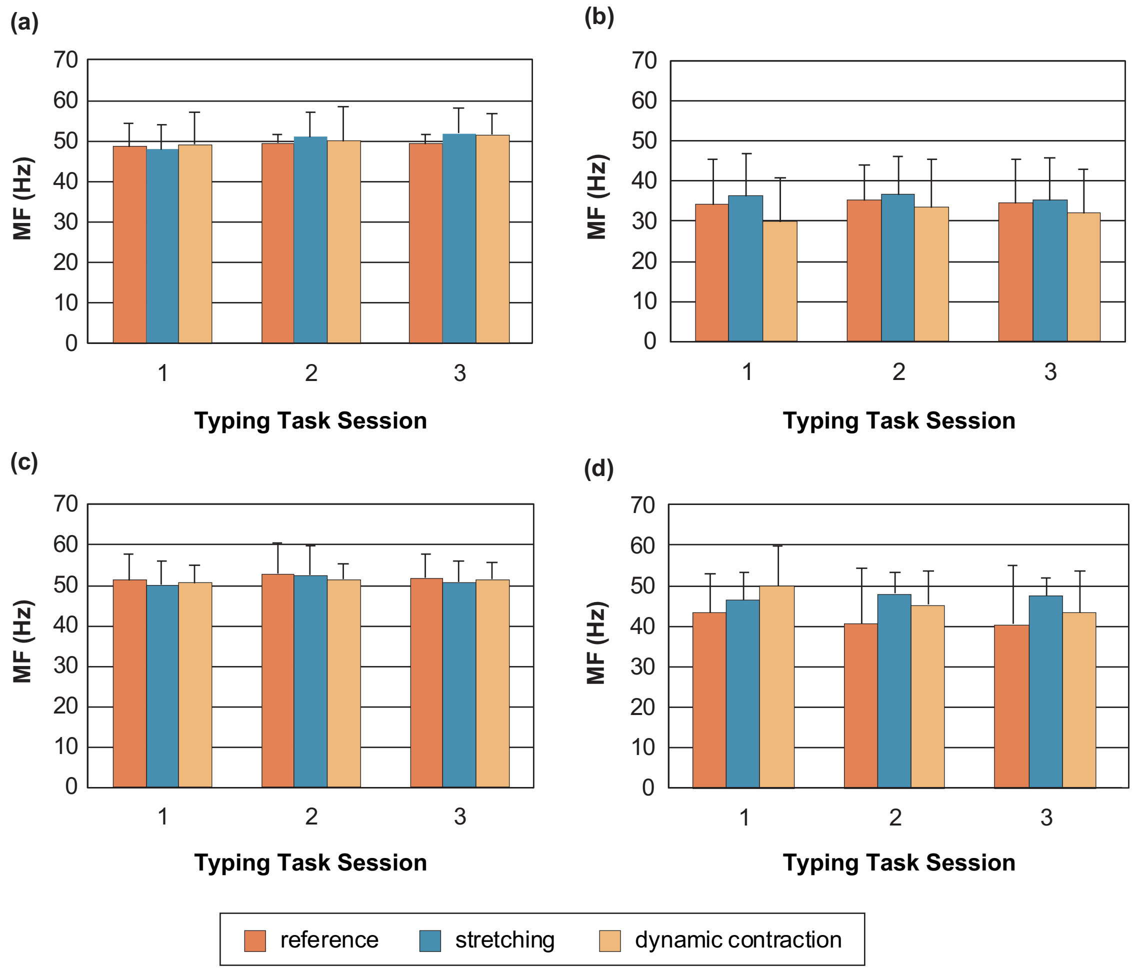

Figure 3. Median frequency (MF) of (a) upper trapezius, (b) lower trapezius, (c) anterior deltoid and (d) cervical erector spinae. *Notes.* Error bars denote *SD*.

TABLE 4. Summary of Repeated-Measure Analysis of Variance (ANOVA) on Perceived Discomfort With Time Factor at 6 Levels (Before Commencing the Typing Task, at the End of Each 20-min Working Session, and Immediately After Each Break) and Rest-Break Intervention Group (Reference, Stretching, Dynamic Contractions)

	Factor		
Parameter	Group	Time	Group × Time
Neck	$F(2, 27) = 1.27$	$F(3.08, 83.16) = 10.35$*	$F(6.16, 83.16) = 1.41$
Right shoulder	$F(2, 27) = 1.94$	$F(2.49, 67.11) = 16.15$*	$F(4.97, 67.11) = 1.30$
Left shoulder	$F(2, 27) = 0.66$	$F(3.28, 88.54) = 5.37$*	$F(6.56, 88.54) = 1.15$
Right elbow	$F(2, 27) = 0.79$	$F(3.40, 91.76) = 10.38$*	$F(6.78, 91.76) = 0.91$
Left elbow	$F(2, 27) = 0.30$	$F(2.64, 71.36) = 5.35$*	$F(5.29, 71.36) = 0.73$
Right wrist and hand	$F(2, 27) = 0.77$	$F(2.72, 73.55) = 8.99$*	$F(5.45, 73.55) = 1.14$
Left wrist and hand	$F(2, 27) = 0.93$	$F(2.43, 65.59) = 9.97$*	$F(4.86, 65.59) = 1.39$

Notes. * $p < .05$.

However, there was no significant group × time interaction; neck: $F(6.16, 83.16) = 1.41$, $p = .221$; right shoulder: $F(4.97, 67.11) = 1.30$, $p = .273$; left shoulder: $F(6.56, 88.54) = 1.15$, $p = .342$; right elbow: $F(6.78, 91.76) = 0.91$, $p = .500$; left elbow: $F(5.29, 71.36) = 0.73$, $p = .613$; right wrist and hand: $F(5.45, 73.55) = 1.14$, $p = .347$; and left wrist and hand: $F(4.86, 65.59) = 1.39$, $p = .242$.

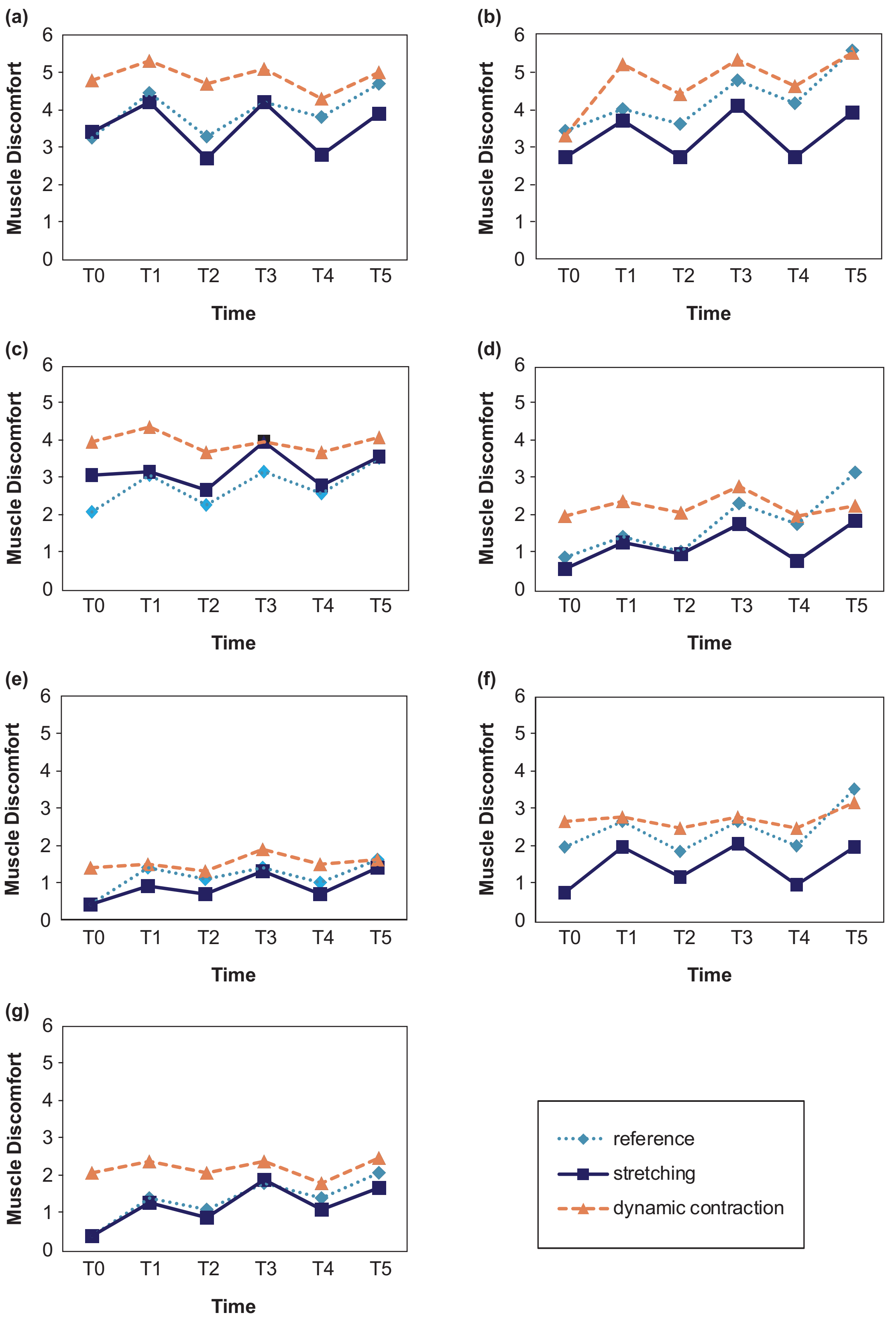

Figure 4. Muscle discomfort in (a) neck, (b) right shoulder, (c) left shoulder, (d) right elbow, (e) left elbow, (f) right wrist and hand and (g) left wrist and hand before working sessions (T0), at the end of each 20-min session (T1, T3 and T5) and immediately after each break (T2 and T4).

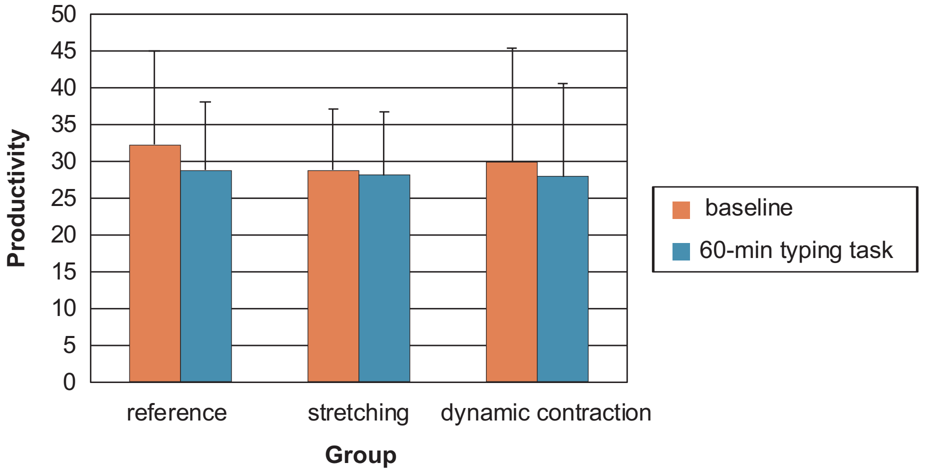

Figure 5. Productivity (words per minute) of subjects. *Notes.* Error bars denote *SD*.

3.5. Productivity

Figure 5 shows the mean words per minute scores at baseline and after 60 min of task for each group. There was no statistical difference in productivity after rest-break interventions in all groups.

4. DISCUSSION

4.1. Muscle Electrical Activity

4.1.1. Normalized RMS

The results showed that the dynamic contraction group had the highest amplitude in UT, AD and CES, but the lowest muscle activity in LT. The reference group had the highest muscle activity in LT. The stretching group had the lowest activity in UT and CES (Figure 2). However, the results did not reveal any difference in normalized RMS of the neck and shoulder muscles between groups of rest-break interventions or in three sessions of a 20-min computer typing task. Strøm, Røe and Knardahl demonstrated a significant correlation in induced pain and EMG amplitude during computer work over time in workers with neck and shoulder pain [13]. Although these rest-break interventions could not reduce muscle activity during a computer work task, the present results demonstrate a favourable effect of rest-break intervention in terms of preventing further development of MSDs in VDU operators with neck and shoulder complaints.

In addition, regarding Hägg's Cinderella hypothesis [37], neck and shoulder disorders result from the overuse of low threshold motor units during sustained work, e.g., computer work. This implies that a change in activity from a VDU task to a specific activity of the neck and shoulders during breaks could provide some muscle relaxation for symptomatic VDU operators. Proper recovery of muscles is believed to be a crucial condition for avoiding MSDs. In this context, the general purpose of exposure variation is to give the motor units that would otherwise be overloaded an opportunity to relax [17].

4.1.2. MF

The parameters examined in the present study were considered on the basis of physiological and psychological aspects. According to EMG parameters, MF and RMS was split into three intervals with respect to physical work exposure in 60 min of work for time changes to localized fatigue. The results of EMG measurements showed that there were no signs of fatigue in the neck and shoulder muscles in any type of activities during breaks. There was no significant increase in EMG amplitude or decrease in MF in the neck and shoulder muscles. This means that any type of activity during breaks has a beneficial effect in preventing fatigue in the neck and shoulder muscles in symptomatic VDU operators. The findings also presented no trend of decreasing MF or increasing

RMS of UT, LT, AD and CES over time between three sessions of a 20-min computer typing task. Therefore, adding a 3-min rest break every 20 min shows a favourable effect on avoiding fatigue in the neck and shoulder muscles among symptomatic VDU operators. However, a change in the rest-break scheme including more frequent or longer breaks would lead to different results.

4.2. Muscle Discomfort

Repeated ANOVA for the difference in muscle discomfort scores presented that there was a time effect among all parts of the neck and upper limbs. There was a reduction in muscle discomfort immediately after each break compared with the discomfort score at the end of each 20-min working session in all body parts of all groups of subjects. On the basis of this finding, the benefit of rest-break interventions in terms of their effect on a reduction in muscle discomfort in the neck and shoulders is unquestionable. This is in step with van den Heuvel, de Looze, Hildebrandt, et al., who found that symptomatic computer workers receiving rest-break interventions with additional breaks and performing physical exercises recovered from complaints better than the control group who had no breaks [38]. Further, rest breaks had a beneficial effect in reducing the level of muscle discomfort [39, 40]. In addition, Lacaze, Sacco Ide, Rocha, et al. reported that active breaks with stretching and joint mobilization reduced muscle discomfort significantly better than passive breaks [41]. The positive effect of dynamic contractions on a lower level of discomfort after rest-break intervention could result from increased muscle oxygenation [28].

4.3. Productivity

Regarding the effect of rest-break intervention on productivity (as measured with words per minute), the study found that the subjects in the reference group were not more productive than the others. There was a trend of reduced productivity after 60 min of typing compared with baseline in all groups. However, there were no statistical differences in productivity in all groups. This means that any type of activity during rest-break interventions does not have a detrimental effect on productivity of symptomatic VDU operators. Thus, the finding is consistent with other studies, where there was no improvement in productivity, but no significant adverse effect on work performance in healthy operators, either [40, 42, 43].

4.4. Active Versus Passive Breaks

Samani, Holtermann, Søgaard, et al. reported that active pauses contributed to a more variable muscle activity pattern during computer work than that of passive pause [44], whereas Blangsted, Søgaard, Christensen, et al. reported that passive breaks were insufficient for attaining complete relaxation of the trapezius muscle [45]. Therefore, the present study aimed to determine the effect of two active breaks (with stretching and dynamic contractions), and a passive break (reference group) on EMG amplitude, MF, discomfort in the neck and shoulder muscles, and productivity. The results demonstrated that there were no significant differences between the type of activities during breaks. This is in line with Crenshaw, Djupsjöbacka and Svedmark, who investigated the effects of active (dynamic wrist extension exercises against resistance) versus passive (relaxing while seated with hands in the lap) pauses after each 20 min of computer mouse work on EMG of the extensor carpi radialis muscle [28]. They reported that there was no difference between pause types on EMG amplitude and MF during computer mouse work.

5. CONCLUSION

Rest breaks with a variation in activities did not decrease the level of activity in the neck and shoulder muscles during computer work; however, it was found that muscle activity did not result in any sign of fatigue throughout the computer task. Further, any type of rest-break interventions had a positive effect on the recovery of muscle discomfort in VDU operators with complaints in the neck and shoulders. No adverse effects on productivity were observed when rest breaks were provided. In conclusion, there were no significant differences in muscle activity, muscle discomfort or productivity when comparing active breaks and breaks with no activity for 60-min computer work in symptomatic VDU operators.

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