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Originals

ACTIVE STRETCHING AND WORKING POSTURE CORRECTION TO IMPROVE PSYCHO-PHYSIOLOGICAL RESPONSE AMONG COMPUTER OPERATORS FOR HIGH SCHOOL STUDENTS

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ABSTRACT
Repetitive movement, static posture, inappropriate computer workstation and inadequate lighting are the most common issues that have been found during operating computers. The objective of this study was to evaluate the effect of active stretching and working posture correction in improving psycho-physiological responses among computer operators. The randomized pre-test and post-test control group design was applied in this study, involving 26 subjects as computer operators. The subjects were divided into two groups. Group 1 consisted of 13 subjects working with conventional conditions, and Group 2 consisted of 13 subjects who were given intervention. Interventions provided included active stretching for two minutes, after two hours working on the computer and correcting the wrong posture from sideways view into straight view. The psychophysiological response was measured by reaction time, musculoskeletal complaints, and eye fatigue. This study found that the mean difference of reaction time before and during computer working practice was statistically significant ($p < 0.001$). The mean difference of musculoskeletal complaints between groups was statistically significant ($p < 0.01$). The difference of the mean difference in eye fatigue between groups was not statistically significant ($p = 0.088$). Ergonomic intervention in terms of active stretching for two minutes after two hours of working time and neck-working postures correction improved the reaction time and decreased musculoskeletal complaints.
Keywords: reaction time; musculoskeletal complaints; eye fatigue

INTRODUCTION

The use of computers recently plays an important role in all aspects of life. However, the use of computers may lead to discomfort and various health complaints. Musculoskeletal complaints and fatigue are major problems in computer use. These complaints arose as a result of the lack of design and layout of work stations, work postures, and working practices (Shikdar and Al-Kindi, 2015).

Forced work postures may increase risk of trapezius muscle tension and musculoskeletal complaints (Muliarta et al., 2014; Park and Yoo, 2012). The occurrence of musculoskeletal complaints is also due to lack of a preventive program (Jahanimoghadam and Abdolalizadeh, 2016). Prevention efforts are needed to avoid the risk of developing computer usage-related health problems. Prevention can be done by providing active stretching and improving computer working practices.

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The improvement of computer working practices can be done by correcting the working posture which is characterized by decreased muscle tension. Occlusion of blood flow due to static working practices and repetitive movements can be minimized by active stretching for two minutes in every two hours of working time (Dhari, 2019).

In the previous study, stretching exercise has positive effects on pain relief, and on the other hand, increases behaviour and static balance in computer operators with a single leg balance test (Delshad and Pourhaji, 2018). The study of Shikdar and Al-Kindi (2015) conducted the observation on 40 workstations of 138 workers treated with ergonomic interventions and found that of the musculoskeletal problems seen among computer employees, 30 % was neck pain due to ergonomic deficiencies in computer workstation.

In the present study, ergonomic intervention in terms of active stretching for two minutes after two hours of working time and correcting working postures were given to high school students of computer science. The combination of both interventions were given simultaneously to get the optimal result. This study aimed to evaluate the effects of both interventions conducted simultaneously to improve psycho-physiological responses among computer operators based on changes in reaction time, musculoskeletal complaints and eye fatigue.

METHODS

Participants

This study was an experimental study with a pre- and post-test control group design. There were 26 participants as computer operators involved in this study. The participants were first-grade high school students of computer science subjects at Denpasar, Bali, Indonesia. The subjects included 26 computer operators consisting of 20 men (76.9 %) and 6 women (23.1 %). The age of all subjects was 15 years. Before starting this study, the purpose and methods of the study and the safety of the measurements were explained fully to the participants, their parents and teachers, and written consent to participate in the measurements was obtained. The study was conducted after receiving approval from the research ethics committee at the School of Medicine, Udayana University/Sanglah General Hospital

The participants were divided into two groups with simple random sampling. Both groups operated computers for three hours. Group 1 consisted of 13 subjects; they worked conventionally without given any intervention or restless continuous 3-hour task. Group 2 consisted of 13 subjects; they worked on a computer provided with active stretching for two minutes after working on the computer for two hours and with improved working posture of the neck. Participants of Group 2 worked on the computer without lateral cervical rotation, so that sternocleidomastoid muscle tension was reduced. Active stretching was given for two minutes after two hours of working as seen in Fig.1. Participants of Group 2 were given combination of both interventions simultaneously.

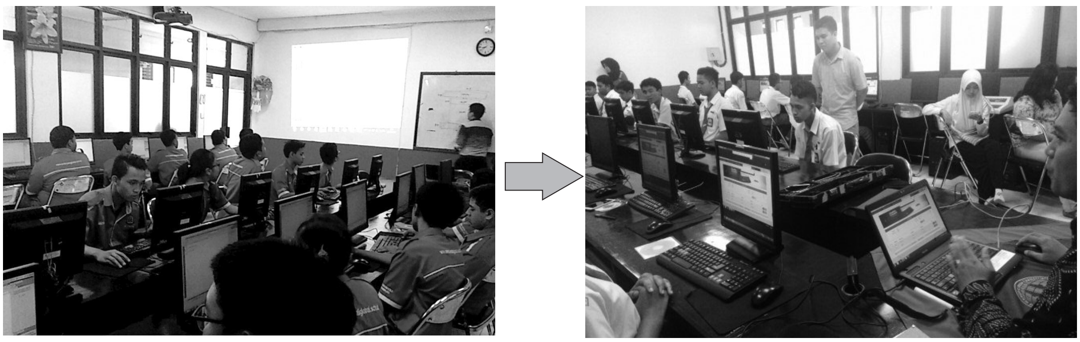
The participants' workstations were not ergonomic before the intervention was given. When lecture was given, participants looked sideways to see the presentation screen as seen in Fig. 2(a). Computer working practices also improved from lateral cervical rotation during looking at the screen board into a straight forward view as in Fig. 2(b).

Data collection

Reaction time, musculoskeletal complaints and eye fatigue were measured before and after computer working practices in Group 1 and Group 2. The reaction time was measured with a whole body reaction measuring equipment (TKK 1264-II, Takei, Japan). In this study, the simple reaction time was based on vision stimulation. Each participant performed three measurements of the reaction time. A Nordic body map questionnaire measured musculoskeletal complaints. The Nordic body map questionnaire applying the four-point Likert scale, was used to evaluate the musculoskeletal disorders in the workers. Every score has an operational definition described as follows: (a) Score 1: there was no disturbance felt by the workers (without hurt); (b) Score 2: there was a minor sore in the skeletal muscles (slight hurt); (c) Score 3: respondents felt a disturbance or pain in the skeletal muscles (hurt); and (d) Score 4: respondents felt a very

Fig. 1 Active stretching

This figure explains some examples of active stretching that can be done by computer operators. Participants were instructed to make active stretching movements for the upper neck and lower neck muscles (Fig. 1 a, b, c, d), right shoulder muscles (Fig. 1 g, h), upper waist and lower waist muscle (Fig.1 i, j, k, l).



a. Conventional computer working practice

b. Computer working practice with intervention

Fig. 2 Computer working practice improvement.

Figure 2.(a) shows the participant's workstation is not ergonomic. When lecture is given participants looked sideways to see the presentation screen. In this study, the participants are given intervention as shown in Fig. 2(b). In Fig 2(b), the presenting screen is removed and the lecture presented is displayed on each participant's computer so that it can reduce musculoskeletal complaints.

painful or sore disturbance in the skeletal muscles (very hurtful) (Tarwaka, 2010).

An eye fatigue questionnaire modified from the original version proposed by Ames et al. (2015) measured eye fatigue. Eye fatigue in this study was expressed as (a) headaches; (b) double vision; (c) tired eyes; (d) watery eyes; (e) dry eyes; (f) hot/burning eyes; (g) blurred vision; and (h) reading error (Ames et al., 2005).

Statistical method

This research aimed to test whether an intervention that was given had an impact on three variables (reaction times, musculoskeletal complaints and eye fatigue). First, a univariate test was done by calculating frequency of the complaints. Bivariate analysis in this study was used to evaluate the mean value of each variable.

Ethical approval

This study has been carried out as per ethical guidelines and approved by the Ethics Commission, School of Medicine, Udayana University/Sanglah General Hospital with an ethical clearance number 2219/UN.14.2/KEP/2017. The participants were provided with written and verbal explanation of the aims of the study, protection of privacy and freedom to decline participation and their consent was obtained prior to participation in this study.

RESULTS

This preliminary study data of 26 participants as computer operators found that the five most common complaints before intervention were pain on the upper neck (96 %), lower neck (92 %), right shoulder (72 %), lower waist (72 %) and upper waist (64 %). This study also found that eye fatigue of control participants before intervention were associated with headaches (33.3 %), double vision (18.52 %), tired eyes (40.74 %), watery eyes (33.33 %), dry eyes (11.11 %), hot/burning eyes (29.63 %), blurred vision (33.33 %) and reading error (40.74 %).

Reaction time before work (pre-test) in Group 1 was about 159.1 ± 10.0 ms and after working practices (post-test) about 264.1 ± 18.3 ms. There was deceleration of reaction after working practice were tested with Shapiro-Wilk test and obtained normal distributed data ($p > 0.05$). A paired sample *t*-test tested the mean difference of both groups and the difference was statistically significant ($p = 0.001$). There was deceleration of reaction time of 105 ms after computer working practices in conventional computer working conditions.

The reaction time before computer working practices in Group 2 was 150.0 ± 13.5 ms and after computer working practices 192.3 ± 17.5 ms. There was deceleration of reaction time of about 42.3 ms after computer working practices in working conditions with intervention. Data distribution in both groups was tested by using the Shapiro-Wilk test and normal distribution of the data was obtained ($p > 0.05$). The mean difference of both groups was tested by the paired samples *t*-test and the difference was statistically significant ($p < 0.001$). There was deceleration of reaction time of about 42.3 ms after computer working practices with intervention.

The distribution of reaction time data before computer working practices in Group 1 and Group 2 was tested with the Shapiro-Wilk test and found to be normally distributed data ($p > 0.05$). The mean difference of the reaction time before computer working practices between Group 1 and Group 2 was tested by the independent samples *t*-test and no significant difference was found ($p = 0.061$).

The distribution data of group reaction time of Group 1 and Group 2 were tested with the Shapiro-Wilk test and found to be normally distributed data ($p > 0.05$). The mean difference of reaction time of about 62.7 ms between Group 1 and Group 2 was tested with the independent samples *t*-test and found statistically significant ($p < 0.001$). The results of this study showed that the deceleration of reaction time in Group 1 (105 ms) was longer than that in Group 2 (42.3 ms).

The musculoskeletal complaints score before computer working practice in Group 1 was 32 ± 2 and after computer working practice was 39.9 ± 1.9. Distribution of data before and after computer working practice was tested by using the Shapiro-Wilk test and the data were not distributed normally ($p < 0.05$). The Wilcoxon sign rank test tested the mean differences of both groups. There was an increase in the musculoskeletal complaints score of about 7.9 after computer working practice with general computer working conditions with statistically significant differences ($p < 0.001$).

The musculoskeletal complaints score before computer working practice in Group 2 was 31.1 ± 1.5 and that after computer working practice was 33.2 ± 1.5. Data distribution in both groups was tested by using the Shapiro-Wilk test and the data were normally distributed ($p > 0.05$). The mean difference of both groups was tested by the paired samples t-test. The difference between the groups was statistically significant ($p < 0.01$).

The distribution of the musculoskeletal complaints score before computer working practice in Group 1 and Group 2 was tested by the Shapiro-Wilk test and found to be no normally distributed data ($p < 0.05$). The mean difference of the musculoskeletal complaints score before computer working practice between Group 1 and Group 2 was tested by the independent samples t-test, and no statistically significant difference was found ($p = 0.140$). It means that before working the Group 1 and Group 2 were similar in origin.

The data distribution of the musculoskeletal complaints score of Group 1 and Group 2 was tested by the Shapiro-Wilk test and found to be no normally distributed data ($p < 0.05$). The difference of the score mean difference between Group 1 and Group 2 was tested by the Mann Whitney U test. In this study, there was a statistically significant difference of the musculoskeletal complaints mean of about 5.8 ($p < 0.001$). The results of this study showed that the difference between the pre and post scores in Group 1 was higher than the difference in the pre and post scores in Group 2.

The eye fatigue score before computer working practice in Group 1 was 16.4 ± 2.9, and after computer working practice the score was 20.3 ± 2.5. Distribution of the data before and after computer working practice was tested by using the Shapiro-Wilk test and the data were not normally distributed ($p < 0.05$). The mean differences between the two groups were tested by using the Wilcoxon sign rank test. There was a mean increase in the eye fatigue score of 3.9 after working in conventional computer working conditions and the difference between both groups was statistically significant ($p = 0.001$).

The eye fatigue score before computer working practice in Group 2 was 15.0 ± 4.0 and after computer working practice 17.8 ± 2.9. Data distribution in both groups was tested by using the Shapiro-Wilk test and the data were normally distributed ($p > 0.05$). The mean difference between both groups was tested by using the paired samples t-test. There was an increase in the eye fatigue score of 2.8 and the difference was statistically significant ($p < 0.001$).

The data distribution of the eye fatigue score before computer working practice on Group 1 and Group 2 was tested with the Shapiro-Wilk test and found to be no normally distributed data ($p < 0.05$). The difference in mean score of eye fatigue before work between Group 1 and Group 2 was tested by the Mann Whitney U test. There was no statistically significant difference of eye fatigue between the mean difference score of Group 1 and Group 2 ($p = 0.370$).

The data distribution of the eye fatigue score in Group 1 and Group 2 was tested by using the Shapiro-Wilk test and no normally distributed data were obtained ($p < 0.05$). Due to non-normally distributed data, the mean difference between Group 1 and Group 2 was tested by using the Mann Whitney U test. In this study, there was no statistically significant difference of the eye fatigue score mean difference ($p = 0.088$).

The differences between the two groups of this study were influenced by the combination of both interventions. Table 1 shows the different test results of average reaction time, musculoskeletal complaints and eye fatigue before and after computer work in Group 1 and Group 2. Table 2 shows several tests to compare reaction time, musculoskeletal complaints and eye fatigue between Group 1 and Group 2.

Table 1. Mean difference testing of reaction time, musculoskeletal complaints and eye fatigue in Group 1 and Group 2.

	Group	Pre (X ± SD)	Post (X ± SD)	Mean difference	*t*	*z*	*p*
RT	1	159.1 ± 10.0	264.1 ± 18.3	105		-12.288	0.000
	2	150.0 ± 13.5	192.3 ± 17.5	42.3	-8.913		0.000
MC	1	32.0 ± 2.0	39.9 ± 1.9	7.9		-9.064	0.000
	2	31.1 ± 1.5	33.2 ± 1.5	2.1	-3.202		0.009
EF	1	16.4 ± 2.9	20.3 ± 2.5	3.9		-11.112	0.000
	2	15.0 ± 4.0	17.8 ± 2.9	2.8	-5.838		0.000

Note: RT= reaction time, MC= musculoskeletal complaints, EF= eye fatigue

Table 2. Mean difference testing of reaction time, musculoskeletal complaints and eye fatigue between Group 1 and Group 2.

	Group 1 (X ± SD)	Group 2 (X ± SD)	Mean difference	*t*	*z*	*p*
RT Pre	159.1 ± 10.0	150.0 ± 13.5		1.987		0.061
Mean diff. RT	105 ± 22.4	42.3 ± 15.8	62.7	5.961		0.000
MC Pre	32 ± 2	31.1 ± 1.5		1.536		0.140
Mean diff. MC	7.9 ± 2.2	2.1 ± 2.1	5.8		-3.682	0.000
EF Pre	16.4 ± 2.9	15.0 ± 4.0			-0.896	0.370
Mean diff. EF	3.9 ± 1.4	2.8 ± 1.6			-1.704	0.088

Note: RT= reaction time, MC= musculoskeletal complaints, EF= eye fatigue

DISCUSSION

The use of the computer causes physical and mental fatigue. Psychologically, fatigue is characterized by prolonged reaction time. Static, repetitive and monotonous work leads to prolonged reaction time. This is in line with research conducted on computer users in Bali who used computers for 150 minutes and experienced increasing fatigue (Muliarta et al., 2014).

Less ergonomic computer use will cause musculoskeletal complaints. This is due to the repetitive movement, static posture and tedious work. The most common musculoskeletal complaints are: pain in the upper neck (96 %), lower neck (92 %), right shoulder (72 %), lower waist (72 %) and upper waist (64 %). This is also in accordance with what was found by a study on computer uses in Pakistan (Haroon et al., 2018). This study found that the use of computers for more than three hours a day increased the incidence of musculoskeletal complaints, especially neck pain. The research conducted on children aged 12-16 years found that the use of computers for two hours or more every day increased the risk of musculoskeletal complaints on almost all parts of the body (Hakala et al., 2012). The most common musculoskeletal complaints were found in the neck-shoulder (21 %), head (20 %) and eyes (14 %). Decreasing the tension of the sternocleidomastoid muscle by active stretching and improved computer working practice can reduce musculoskeletal complaints. The active stretching may cause this effect by increasing blood flow in and out from active muscles, so it may prevent the lactic acid build-up. Repeated movement and prolonged static posture cause contractions of the sternocleidomastoid muscle, and the pain may occur due to the build-up of lactic acid. Improved computer working practice and active stretching reduce the build-up of lactic acid. Stretching performed at the workplace has been shown to reduce work-related musculoskeletal disorders (Gasibat et al., 2017).

Muscle fatigue occurs during sustained exercise when the Ca+ concentration changes and glycogenolysis are enhanced. In the study (Ishii and Nishida, 2013), the deoxy-Hb level decreased with increasing exercise intensity, and blood lactate concentrations increased at 30 % and 50 % MVC (Maximal Voluntary Contraction), suggesting that the maximal voluntary contraction levels limited muscle blood flow and enhanced glycolysis, resulting in muscle fatigue in terms of muscle metabolism.

Each stretching session contributed to a significant increase in antegrade and retrograde blood flow, while the MBF response was not significantly altered, which shows that skeletal muscle stretching in humans does not change blood flow but can cause dramatic changes in the biphasic nature of blood flow.

Heart rate increases in accordance with strain intensity and is time dependent, whereas blood pressure does not change significantly. That indicated the role of mechanical responsive afferent feedback arising from the muscles in initiating rapid adjustments in blood flow control (Kruse, 2015).

Doing active stretching after operating the computer may help to relax the whole body. Active stretching may help to speed up the delivery of amino acids to the muscles and remove lactic acid out of the muscles to allow for faster repair time. Active stretching allows the muscles to relax some time so that the lactic acid has a chance to leave the area (Marek et al., 2005). An exercise and stretching of the hands and wrists of computer operators may prevent musculoskeletal complaints (Trujillo and Zeng, 2006). Stretching should be used as a part of an integrated program with modification of tasks and environment in reducing musculoskeletal complaints (Costa and Vieira, 2008).

Computer usage may also cause eye fatigue. The use of tablet computers for an hour alone was found to have increased eyestrain (Kim et al., 2017). Using a computer with more frequent mini-breaks is preferable rather than long rest periods with long intervals between the rest. Human eyes need to adjust themselves to see objects from different distances. If the computer operator needs to view the computer screen while looking at a paper on the table from time to time, the eyes have to adjust constantly. The words and images on a computer screen are difficult for the eyes to focus on due to their poor edge resolution. The eyes tend to change the focus to a resting point and then refocus on the screen. Therefore, constant focusing and refocusing are required. These continuous changes take place thousands of times a day when a computer operator stares at a computer screen for hours, which then stresses the eye muscles leading to eye fatigue and discomfort causing headaches (Ranasinghe et al., 2016).

In this present study, the computer of participants used antiglare screens and adjusting brightness. Use of antiglare filters over VDT screens has been associated with shorter, less frequent and less intense eye complaints in some studies (Kanitkar, 2005). Significantly lower prevalence of visual complaints in the subjects who used antiglare screen was also observed (Shrivastava and Bobhate, 2012). Another study showed that students using a computer in a very bright or dark room were more prone to visual fatigue symptoms. The incidence of headache was more when the computer screen was very bright and complaints of dry eyes were more among students using a darker screen. It has been suggested that screen brightness and contrast should be adjusted to provide balance with room lighting and maximum visibility (Chiemeke et al, 2007). Based on this data, it is possible to show the results of this present study that there was no statistically significant difference of the eye fatigue score mean difference.

This study could not compare which of active stretching and improvement of the working conditions is better. The combination of both interventions contributed to the results of this study. We only suggest that in order to get an optimal result, both interventions should be done simultaneously.

CONCLUSIONS

Ergonomic intervention with active stretching and improvement in the working conditions decreased musculoskeletal complaints and improved the reaction time.

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CONFLICT OF INTEREST

The authors declared no potential conflicts of interest concerning the research, authorship and/or publication of this article.

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