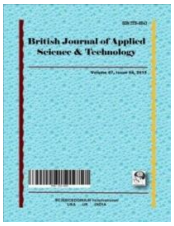

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The Effect of Three-Month Therapeutic and Ergonomic Exercise Based on Virtual Space on Musculoskeletal Disorder in Computer Users

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Authors' contributions

This work was carried out in collaboration between all authors. Author MBK designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Authors ARA, MS and MBK managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: One of the developed groups in the current society is computer users which has increased its importance taking daily development of computer among different social classes. Computer users are apt to musculoskeletal disorders; so the objective of the present study was to investigate the effect of three-month modification and ergonomic exercises based on virtual space on musculoskeletal disorder in computer users.
Material and Methods: In this semi-experimental study, 75 computer users were randomly placed in control group (ergonomic) and so were the same number in the experimental group (a combination including therapeutic and ergonomic exercises). The diagnosis and treatment of musculoskeletal disorders were received through virtual space in both groups. The control group

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was engaged in ergonomic therapeutic exercise and the experimental group received therapeutic exercise besides ergonomic therapeutic interventions. The pain and disability rates were evaluated before and after three-month intervention through Nordik's modified questionnaire. In order to analyze the findings Chi-squared test was applied.

Findings: Lumbago and neck pain decreased in the individuals suffered from waist and neck disorder in experimental group (athletic and ergonomic rehabilitation based on virtual space) comparing to control group both in 12-month and past 7 days evaluations ($p<0.01$). Moreover, the pain in shoulder, back, knee and ankle has significantly decreased in the experimental group comparing to control group in 12-month evaluation.

Conclusion: It can be inferred from the findings of the study that the application of therapeutic and ergonomic exercise based on virtual space leads to the improvement of chronic musculoskeletal disorders in computer users. Therefore doing such kinds of exercise is advised.

Keywords: Musculoskeletal disorders; therapeutic exercise; ergonomic; virtual space; computer users.

ABBREVIATIONS

Musculoskeletal disorders: *Musculoskeletal disorders (MSDs) consist of minor physical disabilities. This term is used to describe a variety of conditions that affect the muscles, bones, and joints. The severity of the MSD can vary. Pain and discomfort may interfere with everyday activities. MSDs are extremely common, and your risk increases with age. Early diagnosis is the key to ease pain while potentially decreasing further bodily damage.*

Therapeutic exercise: *any exercise planned and performed to attain a specific physical benefit, such as maintenance of the range of motion, strengthening of weakened muscles, increased joint flexibility, or improved cardiovascular and respiratory function.*

Ergonomic: *an applied science concerned with designing and arranging things people use so that the people and things interact most efficiently and safely —called also biotechnology, human engineering, human factors*

Virtual space: *A cyber spatial created electronically exclusively occupant by cyber objects.*

Computer users: *a person who uses computers for work or entertainment or communication or business*

1. INTRODUCTION

The computer has become one of the most effective and applicable instruments made by the human in the past few decades, in a way that most of the activities are difficult or even impossible to do without computer; so the number of the computers and their users has daily increased to such an extent that considering an office without computer and its user is impossible; hence the concerns regarding vocational musculoskeletal disorders, damages or musculoskeletal tissues disorders concomitant with risk factors in work setting have been raised [1-3].

For the people who spend much of their time working with computer, these disorders are a common problem [4,5]. Using the computer leads to the increase of the risks of pain, itch and anesthesia in the neck, shoulder, elbow, wrist and the hand [6-8]. Similarly, the reports stated that the prevalence of musculoskeletal disease is more in the employees who work with the computer than other staff and workers [9] and computer users are apt to develop musculoskeletal signs with 50% prevalence [10]. According to a report about those employees who work with the computer, 27% of them have pain in their necks and shoulders [11]. Repetitive movements, inappropriate body posture while working, stress resulting from local contact and static body posture are among the most important causes of creating musculoskeletal disorders which are made while working with the computer [12-16]. The only factor creating musculoskeletal disorders is not ergonomic exposures; however it depends on age, gender, individual sensitivities, daily working hours, mental stress, job satisfaction and physical fitness too [12-15,16]. Regarding musculoskeletal disorders resulting from working with computer and office works, numerous studies have been carried out around the world. A study which was conducted on an American sample indicated that the frequency of musculoskeletal disorders was 54% in computer users and the major difference in musculoskeletal disorders was observed among women in their necks and shoulders [17]. Many

studies have reported the existence of musculoskeletal disorder among computer users [18-24].

The results of the research by the united states ministry of education implies that 97% of high school students, 91% pre-high school students and 80% of kindergarten children use the computer [25] and it shows that many people are working with computers in various jobs.

So it would be desirable to design and apply a method to diagnose, rehabilitate, treat, prevention and inform such people through available facilities in virtual space (internet) in order to provide efficient, suitable and cost-effective treatment for computer and internet users.

Therefore considering high frequency of vocational factors among computer users and high frequency of musculoskeletal disorders in this group, the importance of prevention and treatment of these disorders in work setting through computer seems necessary, so the objective of the present research is to compare the effect of two therapeutic and ergonomic methods based on virtual space on computer users suffering from lumbago.

2. MATERIALS AND METHODS

The present study is semi-experimental (with pretest-posttest design and control group) which was carried out in a three-month period. The statistical population of the present study included all computer users at Isfahan university, the entrance criterion whereof was at least 4 hours of working with the computer besides studying with non-specific low back pain. Through Cochran formula 300 individuals were selected via simple random sampling method from this population; afterwards, the advantages and facilities of this study were sent for them through e-mail aiming to explain completely the attendance condition to the study. Considering the entrance criteria introduction and full awareness of the subjects from the necessary condition in training course, 168 individuals expressed their readiness finally. The users were paired in case of type and method of engaging in abnormality, 18 of interested individuals were excluded from selected sample list and the study continued with 150 individuals.

2.1 Data Collection

In order to collect the demographic information, the researcher-made demographic digital questionnaire (including age, gender, and activity record) was made and then the Persian version of Nordik's electronic questionnaire (NMQ) [26], which was prepared on jotform.com site, was sent for the users through e-mail. The noticeable point is that Nordik's questionnaire divides disorders into two parts of seven days and twelve months before the research taking the time of disorder creation to the time of questionnaire filling out. At the end, 150 users started to fill out Nordik's questionnaire (general and specific to each of the disorders) and musculoskeletal disorders of their different body parts were achieved at pretest stage.

In this study the participants were randomly divided into control (ergonomic) and experimental (a combination of ergonomic and therapeutic exercises); that is, 150 participants were given codes from 1 to 150 and then even codes were attributed to the experimental group and odd codes were allocated to control group. Therefore the users were randomly divided into two groups of 75. The first group was trained the cases of ergonomic intervention modification and the second was provided with mentioned variable (therapeutic exercise) in addition to ergonomic interventions modification. The point to be mentioned here is that besides filling out Nordik's questionnaire, physical activity level and the severity of injuries as well as selected therapeutic method for both groups were carried out via distance communication and Yahoo messenger, skype and Yahoo mail software; so in order to homogenize the users in terms of software related to distance communication (Yahoo messenger software (V10), skype (v4.2) and Yahoo mail new system), the link to download them was placed in p30download.com site for the users and installation method and the manner of working with them were taught by e-books too. The exercises and ergonomic interventions modification cases were given through known sites in this regard in the form of flash formats (FLV) and image files (Gif). The manner and appropriateness of exercises administration was carefully followed through flash training films and playing exercises by an experienced operator and professionals in therapeutic exercise. The entrance of the people was informed and selective and all of them were taken digital agreement. The data analysis was done through SPSS 16 software and via applying

descriptive statistical methods (frequency and percentage) and at inferential level (Chi-squared test).

3. RESULTS AND DISCUSSION

The findings of Table 1 show the demographic features of computer users interested in participating in the study. The results indicate that both groups enjoy similar demographic features.

Findings of Table 2 imply that the pain in waist, neck, shoulder, back, knee, ankle has decreased in the individuals suffering from musculoskeletal abnormalities in the experimental group comparing to control group ($p<0.05$). If the frequency of experimental group is attended to in the posttest stage comparing to pretest, it is clear that the extent of reporting these disorders has decreased too. Further, the findings of the table indicate that in some parts like hips, elbow and wrist, an appropriate significance level has not been achieved, but generally as the table describes, practical significance of therapeutic method through virtual space has been confirmed at higher level in the posttest comparing to pretest stage which emphasize the great effectiveness of therapeutic method at the posttest stage. So the research hypothesis stating the effectiveness of therapeutic method through virtual space is confirmed.

Fig. 1 shows outstanding decrease in the upper limbs comparing to lower limbs and also it indicates a high degree of musculoskeletal disorders in the upper limbs comparing to the lower limbs in those with abnormalities in the past twelve months in the experimental group comparing to the control group ($p<0.05$).

Findings of Table 3 imply that the pain in the waist and neck in people with musculoskeletal abnormalities has decreased in the experimental group comparing to control group ($p<0.05$). If the frequency of experimental group is attended to at the posttest stage comparing to pretest the extent of reporting these disorders has been decreased. Further, the findings of the table indicate that in some parts like shoulder, back, hips, elbow, knee, ankle and wrist, an appropriate significance level has not been achieved in the past seven days, but generally as the table describes, practical significance of therapeutic method through virtual space has been confirmed at higher level in the posttest comparing to pretest stage which emphasizes the great effectiveness of therapeutic method at the posttest stage. So the research hypothesis stating the effectiveness of therapeutic method through virtual space is confirmed.

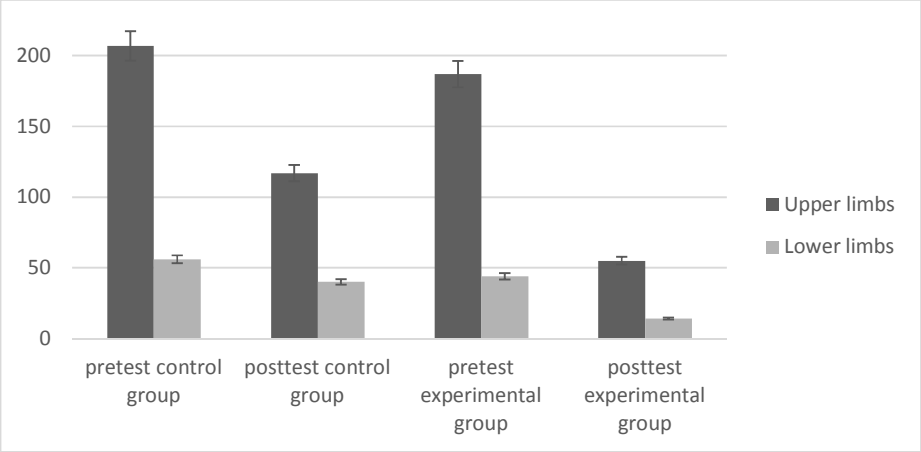

Fig. 1. The effectiveness of athletic therapeutic method in the experimental group comparing to the control group in the upper limbs and lower limbs in the past twelve months

Table 1. Computer users' demographic information

	Male	Female	Age	Height (cm)	Weight (kg)
Control group	34	41	24/08±2/97	160±4/3	77/04±3/65
Experimental group	35	40	24/04±2/27	160/05±4/5	79/06±4/54
Both groups	69	81	24/06±2/62	160/25±4/4	78/05±4/1

Table 2. A comparison of frequency, percentage and X2 and cramer's V amount, related to the effect of therapeutic exercise through virtual space on the pain of individuals with musculoskeletal disorders (12 months)

	The statistical index tests	groups	Frequency	percentage	X2 statistic	probability ratio	Cramer's V	significance level	Eta statistic
Waist	pretest	control	66	44	0/231	0/231	0/039	0/631	0/039
		Experimental	64	42/7					
	posttest	control	27	18	7/796	7/954	0/228	*0/005	0/228
		Experimental	12	8					
Neck	pretest	control	37	24.7	0.429	0.429	0.053	0.0513	0.053
		Experimental	31	22					
	posttest	control	26	17.3	9.35*	9.61*	0.250*	0.002*	0.250*
		Experimental	10	6.7					
Shoulder	pretest	control	31	20.7	0.111	0.111	0.027	0.739	0.027
		Experimental	29	19.3					
	posttest	control	25	16.7	7.164	7.314	0.219	0.007	0.219
		Experimental	11	7.3					
Back	Pretest	control	47	31.3	0.691	0.691	0.068	0.406	0.068
		Experimental	42	28					
	posttest	control	29	19.3	9.700	9.928	0.254	0.002	0.254
		Experimental	12	8					
Hips	pretest	control	19	12.7	1.430	1.437	0.130	0.232	0.098
		experimental	13	8.7					
	posttest	control	11	7.3	2.519*	2.575*	0.130*	0.113*	0.130*
		experimental	5	3.3					
Elbow	pretest	control	4	2.7	0.883	0.893	0.077	0.347	0.077
		experimental	7	4.7					
	posttest	control	3	2	0.207*	0.208*	0.037*	0.649*	0.037*
		experimental	2	1.3					
Knee	pretest	control	22	14.7	0.545	0.546	0.060	0.460	0.060
		experimental	18	12					
	posttest	control	18	12	7.143	7.424	0.218	0.008	0.218
		experimental	6	4					
Ankle	pretest	control	15	10	0.176	0.176	0.034	0.675	0.034

	The statistical index tests	groups	Frequency	percentage	X2 statistic	probability ratio	Cramer's V	significance level	Eta statistic
		experimental	13	8.7					
	posttest	control	11	7.3	5.042	5.331	0.133	0.025	0.183
		experimental	3	2					
Wrist	pretest	control	15	10	0.041	0.041	0.016	0.840	0.016
		experimental	16	10.7					
	posttest	control	6	4	1.064	1.083	0.084	0.302	0.084
		experimental	3	2					

Table 3. A comparison of frequency, percentage, and X2 and Cramer's V amount, related to the effect of therapeutic exercise through virtual space on the pain of individuals with musculoskeletal disorders (past seven days)

	The statistical index tests	Groups	Frequency	percentage	X2 statistic	probability ratio	Cramer's V	significance level	Eta statistic
Waist	pretest	Control	42	28	1.000	1.001	0.082	0.317	0.082
		experimental	48	32					
	posttest	control	25	16.7	5.075	5.143	0.184	*0.024	0.184
		experimental	13	8.7					
Neck	pretest	control	27	18	0.480	0.480	0.057	0.488	0.057
		experimental	23	15.3					
	posttest	control	16	10.7	8.308*	8.819*	0.235*	0.004*	0.235*
		experimental	4	2.7					
Shoulder	pretest	control	8	5.3	0.923	0.929	0.078	0.337	0.078
		experimental	12	8					
	posttest	control	5	3.3	2.778	3.022	0.136	0.096	0.136
		experimental	1	0.7					
Back	pretest	control	36	24	1.714	1.718	0.107	0.190	0.107
		experimental	44	29.3					
	posttest	control	23	15.3	2.906	2.929	0.139	0.088	0.139
		experimental	14	9.3					
Hips	pretest	control	8	5.3	923.	0.929	0.078	0.337	0.078
		experimental	12	8					
	posttest	control	5	3.3	1.349*	1.391*	0.095*	0.246*	0.095*

	The statistical index tests	Groups	Frequency	percentage	X2 statistic	probability ratio	Cramer's V	significance level	Eta statistic
		experimental	2	1.3					
Elbow	pretest	control	8	5.3	923.	0.929	0.078	0.337	0.078
		experimental	12	8					
	posttest	control	5	3.3	2.778*	3.022*	0.136*	0.096*	0.136*
		experimental	1	0.7					
Knee	pretest	control	20	13.3	0.585	0.586	0.062	0.444	0.062
		Experimental	16	10.7					
	posttest	control	14	9.3	3.692	3.784	0.157	0.055	0.157
		experimental	6	4					
Ankle	pretest	control	8	5.3	0.253	0.253	0.041	0.615	0.041
		experimental	10	6.7					
	posttest	control	6	4	2.113*	2.206*	0.119*	0.146*	0.119*
		experimental	2	1.3					
Wrist	pretest	control	13	8.7	0.667	0.668	0.067	0.414	0.067
		experimental	17	11.3					
	posttest	control	9	6	1.261	1.277	0.092	0.262	0.092
		experimental	5	3.3					

Fig. 2 shows outstanding decrease in the bust comparing to lower limbs and also it indicates a high degree of musculoskeletal disorders in the bust comparing to the lower limbs in those with abnormalities in the past seven days in the experimental group comparing to the control group ($p<0.05$)

3.1 Discussion

The objective of the present study was to investigate three-month effect of selected modification exercises and ergonomic interventions through virtual space on computer users with muscular-skeletal disorders. In this study the largest frequency of muscular-skeletal disorders was reported to be related to working with waist which was similar to the study by Karimian et al. [26], Bos et al. [27], Choobine et al. [28] and Alexopoulos et al. [29]. Moreover, Mir Mohammadi et al. [30] in a study conducted on computer users have noted backache as the commonest muscular-skeletal disorders. In the research by Bayat [31] on computer users about 26% of the people had muscular-skeletal disorder. In this research the lumbago was among the commonest muscular-skeletal disorders in computer users. It is completely expectable considering the exposure type of these people while sitting on the chair and the type of the seat and incorrect sitting posture on the chair; in order to avoid this impairment ergonomic trainings and also using appropriate exercises are suggested.

In the current study it was observed that modification exercises and ergonomic interventions which were carried out during 3 months caused the significant decrease in waist, neck, shoulder, back and knee disorders which is along with the studies by Waddell [22], Deirdre et al. [23], Karimian et al. [26] and Bayat [31]. The present study showed that the exercises specialized to muscular-skeletal disorders in virtual space and also ergonomic interventions associated with upper limbs (waist, neck, shoulder, back) and lower limbs (knee) have had positive effects on users and it caused disorder decrease in that part. Simultaneous doing of modification exercises and ergonomic intervention of this part, therapy period, repetition and intensity of exercises are among the reasons of this issue. Viljanen et.al stated that the exercises should be compressed enough (half an hour, three times a week for several months) to be sufficiently effective on decreasing disorders [32-34].

It was observed in this study that the three-month exercise plan leads to significant decrease in neck disorders which is consistent with the results of other studies [25,35,36]. It seems that the current exercise plan which was among isometric exercises and was made by animated films provided from flash software and also ergonomic interventions related to the neck, had very positive effects on the subjects and caused decrease in neck disorders.

Considering the existence of an expert in this field and investigating the disorder through voice and image chats and pre-made training exercises through flash software, during three

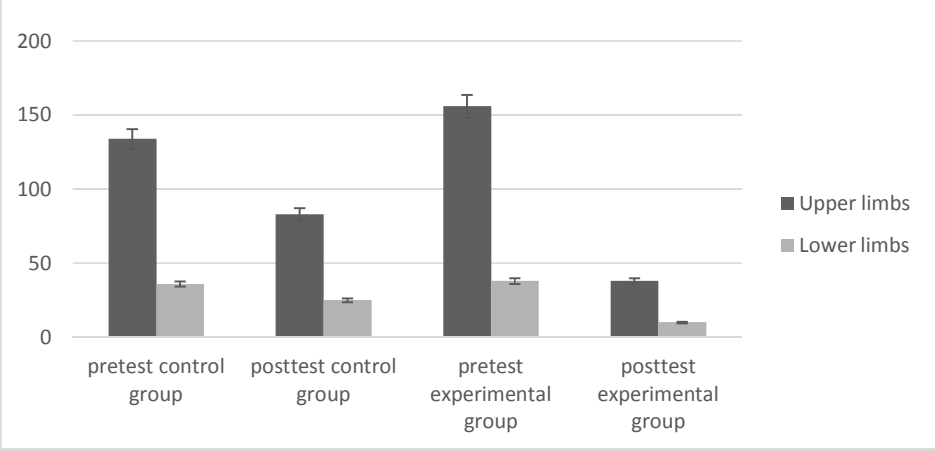

Fig. 2. The effectiveness of athletic therapeutic method in the experimental group comparing to the control group in the upper limbs and lower limbs in the past seven days

months, there was a significant decrease in the waist of computer users; as a result, exercise plan specialized for waist which was done from flexional exercises and with the emphasis on reinforcing the muscles of stomach and back extensors and also ergonomic interventions related to this part caused an outstanding decrease in lumbago. These findings are along with the results by Karimian et al. [26] and Rezvani indicating the effectiveness of the exercises in decreasing subjects' waist disorders [37].

Another study investigated the muscular endurance and anthropometric features as alarming signs in chronic lumbago and also the necessity of therapeutic exercise continuance after stopping the pain which proves the decrease of disability and the increase of upper limbs and lower limbs extensors extensors' endurance [38]. Moreover, therapeutic method in this research is consistent with Manich et al. applied method, since they believed that the exercise plan of patients with lumbago should be compressed and continued more than two months in order for the pain to be decreased significantly [39]. Those suffering from lumbago might be influenced by mental and social factors besides physical factors [40].

Three-month modification exercise plan based on virtual space and ergonomic interventions cause a significant decrease in users' shoulder pain. The research implies the existence of relationship between vocational tensions and mental factors in upper limbs and shoulder [41]. Hence the nature of exercise plan specialized for upper limbs should emphasize on decreasing stress and mental pressures besides muscles reinforcement and flexibility. Considering the fact that exercise plan specialized to shoulder in the current study has emphasized on muscles reinforcement and flexibility, there seems that the exercises are confirmed regarding behavioral sciences and are designed according to good scientific principles; therefore, they have caused the improvement of subjects' status and they are the same as the results of the studies by Mc Klore et al. [42], Larson et al. [43] and also the European society of working safety and hygiene [44].

In the back, knee, and the ankle, like other body parts, it was observed an outstanding improvement following modification exercises based on virtual space which confirms previous studies in this regard. Generally it seems that the increase of muscular power and also body flexibility following specific exercises and intervention have had noticeable effect on decreasing the pain and improving muscular-skeletal disorders.

4. CONCLUSION

It can be concluded from the findings of the study that combinatory plan (therapeutic and ergonomic exercise) leads to the improvement and decrease of pain in waist, neck, shoulder, back, knee and the ankle in computer users. So doing such exercises is advised to avoid such disorders.

Taking high prevalence and outbreak of pains and musculoskeletal disorders related to computer users, there is great attention to ergonomic sciences in developed countries today, but unfortunately these studies are rare in developing countries such as Iran.

5. SUGGESTIONS

It is suggested to avoid the incidence of computer users' musculoskeletal disorders to a large extent and be able to pave the way for increasing efficiency and decreasing rehabilitation, therapeutic and other related costs in this regard through virtual space (internet) by addressing to athletic activities and paying specific attention to modification exercises and observing exercises' scientific principles besides ergonomic factors and standards which should be taken into account in making tools and equipments to prevent vocational risks. Moreover, the future researchers are suggested to apply clinical diagnosis and medical examination besides using digital questionnaires for repeating this study.

6. LIMITATIONS

Considering the fact that diagnosis of chronic pain in virtual space was carried out according to individual criteria in the form of self-declaration, this sampling method can be assumed as a kind of limitation for the generalized.

CONSENT

All authors declare that ‘written informed consent was obtained from the computer users (or other people) for publication of this case report and accompanying images.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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