Behaviour & Information Technology, 2014
Vol. 33, No. 3, 294–300, http://dx.doi.org/10.1080/0144929X.2012.695394

Promoting healthy computer use: timing-informed computer health animations for prolonged sitting computer users

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(*Received 5 April 2011; final version received 16 May 2012*)

Accompanying the increase in computer and Internet use worldwide, physical inactivity has become prevalent in most developed and developing countries. Extended computer use may contribute to symptoms such as visual impairment and musculoskeletal disorders. To reduce the risk of physical inactivity and promote healthier computer use, this study tries to develop a timed broadcast of health-related animations for users sitting at computers for prolonged periods. In addition, we examine the effects that the program has on the computer-related health beliefs and behaviour of participants. Before-and-after survey questionnaires were used for data collection. The results show that the animation program indeed had a positive effect when reminding participants to take a break and stretch their bodies. The program influenced the beliefs and behaviours of participants with regard to their health. The development and examination were documented and discussed within the context of health agencies planning the next steps in an effort to promote, develop and evaluate healthy computer use.

Keywords: animation; healthy computer use; physical activity; ergonomics; health promotion

Introduction

Accompanying the increase in computer and Internet use worldwide, physical inactivity has also become prevalent in most developed and developing countries (Adab and Macfarlane 1998). The development of modern technology brings convenience to our lives but removes physical activity from our daily routines, thereby putting our lives at risk. In fact, over the past decades the results from the Centers for Disease Control and Prevention (CDC) Behavioural Risk Factors Surveillance System show that more than 50% of American adults are not regularly active in physical activities (USDHHS 1996, CDC 2011). To date, even around 25–31% of adults each year reported no leisure-time physical activity (e.g. running, calisthenics, golf, gardening or walking) and the percentages stay as high as around 20% among the energetic 18–24 years old population. Comparatively, across the EU countries, an average of 41% of adults (aged 15 and above) did not engage in any moderate physical activity in a typical week (WHO Regional Office for Europe 2010).

A population-based prevalence study shows that on average children and adults in the USA spent 54.9% of their waking time, or 7 h 42 min per day, in sedentary behaviours, or leading a sedentary lifestyle (Matthews *et al.* 2008). Nowadays, sedentary behaviours refer to not only people with lack of physical activity, but also those in prolonged sitting (Van Uffelen *et al.* 2010). A sedentary lifestyle is damaging to one's health by increasing the risk of premature death and the risk of developing obesity, heart disease, cancer and other chronic health problems (Manson *et al.* 2004, Ford *et al.* 2005, Warburton *et al.* 2006, Hamilton *et al.* 2007). Therefore, over three decades the US Department of Health and Human Services has been trying to reduce the prevalence of no leisure time activity for US adults by setting a national health objective in each 10-year Healthy People initiative (USDHHS 2011).

Physical activity

Epidemiological studies suggest that the amount of physical activity is more important than the intensity (USDHHS 1996, Lakka and Laaksonen 2007, Wen *et al.* 2011). Physical activity does not need to be at a vigorous level. People can substantially improve their health and quality of life by including moderate amounts of physical activity in their daily lives. Activities can be arranged in a single session or proportionally. The types of physical activity can vary from day to day, from recreational sports to

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household chores, such as volleyball playing, brisk walking, jogging, stair climbing or mowing the lawn. Thus, even relatively mild forms of exercise from time to time are beneficial to people's health. Therefore, discovering the means to help people who tend to lead a sedentary lifestyle become more active and perform physical activities in their daily routine is important.

Health promotion intervention

For many years, there has been growing interest in promoting healthy behaviour, especially when prolonged sitting becomes a serious concern for office-based employees (Gilson *et al.* 2011). Various interventions have been provided to help with different targets, such as stop smoking, eat healthily, exercise regularly and reduce alcohol intake. Research efforts have been devoted to developing different types of health promotion programs, such as personal consulting and evaluation, monthly delivered information, group class and incentive rewards (Fielding *et al.* 1995). Meanwhile, the rapid growth of information technologies (especially the Internet) has also created opportunities for innovative health promotion. Research shows that computer-mediated communication has potential in disseminating interventions to increase physical activity (Fotheringham *et al.* 2000, Napolitano *et al.* 2003, Steele *et al.* 2007; Ciccolo *et al.* 2008).

Regardless of whether the interventions are person-to-person or internet-based, most of the programs are mainly aimed at passively providing health information or exercise instruction, in which participants need to actively access the information or aggressively participate in the health promotion programs in order to achieve behaviour changes.

People who must sit in front of computers for prolonged periods of time at work might understand the importance of regular exercise but have a hard time reminding and encouraging themselves to engage in physical activity. Even those who have an exercise plan suffer from the difficulties involved in maintaining the routine and easily give it up when tied up by daily matters. In fact, they are often unaware of how long they have been sitting and working in front of the computer. Therefore, in this 'computer' era, greater efforts are needed to encourage a daily routine of physical activity and healthy computer use.

In light of the aforementioned problems, more and more governments and relevant organisations are turning their attention to strategies on structuring a healthy and supportive environment for promoting exercise in daily life. They have started to create an environment in which people can be passively induced for physical activity in daily life, instead of actively looking for assistance. They upgrade stairways to encourage stairway climbing and regularly broadcast exercise music during breaks at work. Research has suggested that the interventions that include changes to the established environment of a worksite may lead to both short- and long-term changes in levels of physical activity (Emmons *et al.* 1999, Leslie *et al.* 2000, Shimotsu *et al.* 2007, Crespo *et al.* 2011).

Ergonomics training

People with better health knowledge are more likely to choose healthy lifestyles. The positive correlation between health knowledge, attitude and behaviour has been well examined and documented in many studies (e.g. Kenkel 1991, Trichesa and Giuglianib 2005). In addition to the promotion of physical activity, knowledge of ergonomics is also critical to reducing health risks related to prolonged computer use. Research has shown that extended computer use may contribute to symptoms of visual impairment (commonly dry eyes), musculoskeletal injures (e.g. neck, shoulder and low back pain), skin problems or even emotional disorders (Demure *et al.* 2000). Therefore, as the use of computer technology becomes more pervasive, knowledge about the safety and comfort of computer use and regular exercise deserves more and better attention, especially for the habitual computer users to decrease the risk of computer-related injuries (Lewis *et al.* 2001, Ketola *et al.* 2002).

Despite the fact that computer-related health issues are critical, surprisingly little effort has been made regarding the design and development of relevant interventions. Several ergonomics training methods have been developed with regard to setting up effective computer workstations, including seating, lighting, chairs and desks, to increase the comfort, safety and productivity for prolonged sitting computer users at work. However, printed materials, seminars and lectures are the most common approaches for the delivery of information, with which computer users need to actively access or participate in the programs.

Several ergonomics training programs provide ergonomics software packages, designed to prompt computer users to take a break and guide them toward regular exercise. However, most of the software packages either contain only limited information or are instruction-oriented rather than motivational or encouraging. Some other studies evaluate the effects of proposed intermittent stretching exercises or investigate the work-pause pattern of computer users with musculoskeletal disorders (Van den Heuvel *et al.* 2003, Slijper *et al.* 2007, Marangoni 2010). So far, little is known about the effects of health animations on health belief and behaviour change from the perspective of prolonged sitting computer users.

Purpose of this study

In this study, we attempt to develop a timed health information broadcast and exercise animation program, with the help of computer timing-broadcasting software, for workers sitting at computers for prolonged periods at work. It examines the question of how such a system is designed and developed; and how the system influences the computer-related health beliefs and behaviour of participants.

A series of relevant health information and exercise animation clips (both in the form of text and figures) were designed and integrated into the timing-broadcasting program. Without too much instructional purpose, the program was aimed to motivate and induce physical activity and reduce the risk involved in extended computer use. The processes and necessary tasks of development and the effects of this intervention on exercise motivation or behaviour change are the focus of this study.

Method and process

Theoretical foundation

The second part of this study examined the question of how the program influenced the health belief and behaviour of participants. The health belief model (Rosenstock 1974) was adopted and adapted as the conceptual framework to examine the effects of the program on participants' computer-related health belief and behaviour.

In light of the health belief model, an individual first develops subjective perceptions concerning the risk of incurring a disease (i.e. perceived susceptibility) and recognises the possible adverse effects. At that point, they attempt to adopt particular actions. However, before the action is actually undertaken, he/she evaluates the corresponding actions for potential benefits (decrease in susceptibility and severity) and barriers (inconvenience, costliness, painfulness, etc.). Whether or not the actions are eventually put into action depends on whether pertinent 'cues' (e.g. advice from others, experience of illness and mass media campaigns) exist, and an individual's predisposition to such actions. The application of health belief models to examine the effects of health behaviour change can be found in various studies (Norman 1995, Norman and Brain 2005).

The participants and sampling

This study included 37 participants. The Department of Educational Technology (ET) at Chiayi University currently has approximately 60 full-time graduate students, including year 1, 2 and 3. Most of the graduate students are aged from 22 to 27 with a mean of 23 for females and 26 for males. Through a purposeful sampling approach, the graduate students at the Department of ET at Chiayi University, who normally work more than 5 h a day in front of computer, were the targeted population for this study. Thirty-eight students participated in the project at the beginning. One participant withdrew from this study during the post-test stage. Data of the 37 valid samples were retained for further analysis.

The development of the animations

Thirty-seven animation clips were developed for this study (for visual examples, see Figure 1) by the researcher, the health and physical activity experts and several animation freelancers. Each clip lasts about 15–20 s. 'Proper setup of the equipment (seating and monitor, keyboard and mouse placement)' and 'stretch/massage/exercise breaks' to healthy computer use were addressed for the key content of the animations. The 'stretch/massage/exercise breaks' targeted several body areas of symptoms, including eyes, neck, shoulder, hands, back and legs.

The animation focuses on delivering information dedicated to increasing safety computer use. By showing the consequences of extended computer use and actions for preventing the problems, the program was designed in such ways to motivate and encourage comfortable environment setup, rest breaks and physical activity among people using computers for extended periods. Considering that the video and 3D animation occupy relatively more computer resources, 2D computer animations with background music, in both textual and graphic format, were the media chosen for the delivery of health messages.

The implementation process

After recruiting participants, the researchers installed the animation program on the participants' computers in the lab (or at work). The entire execution time for the research was one week. The animation program would be initiated and remained active every time the participants turned on their computers, which had been configured to randomly play one animation clip per hour. In other words, every hour the animation would pop-up on the screen with background sound and music, unless called off manually. Each participant was contacted briefly to check if there were any problems with the

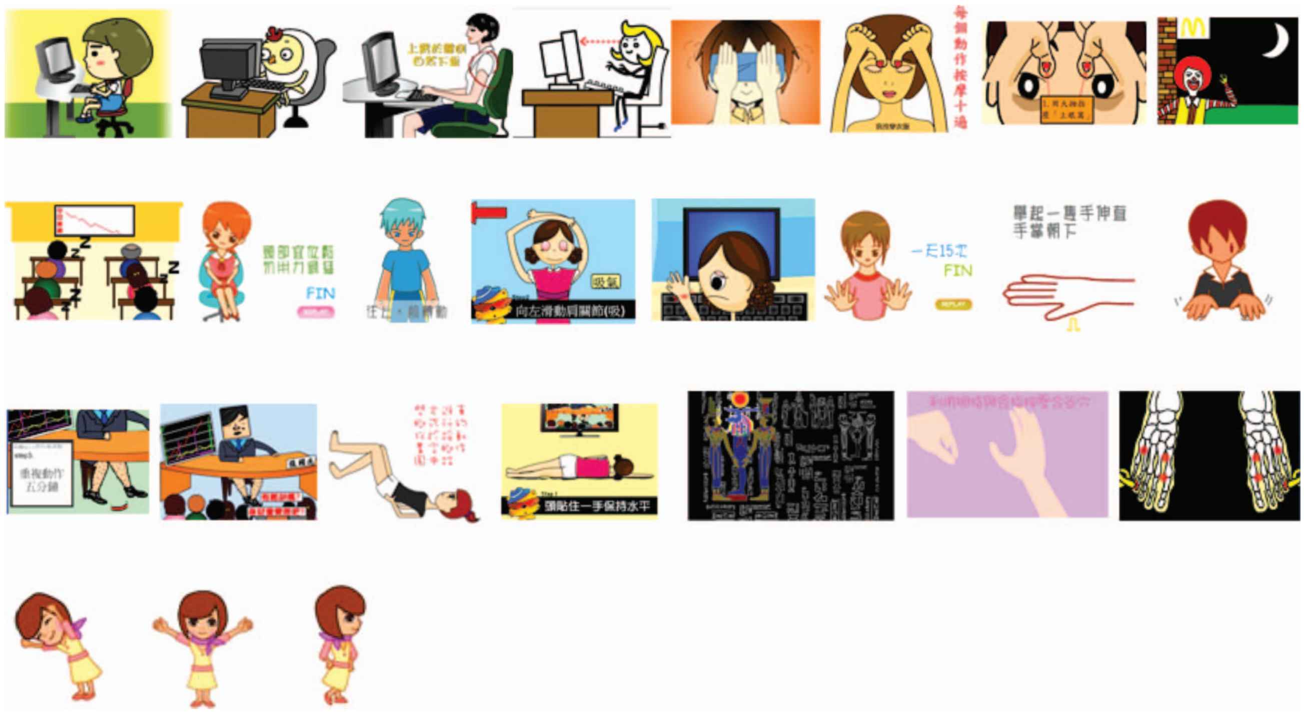

Figure 1. Examples of screen snapshots of the developed animations.

implementation program after the first day of experimentation.

Data collection

Before-and-after web-based surveys were used for data collection. The surveys used self-reported questionnaires, which is one of the effective and common ways to evaluate health and exercise behaviour (Gionet and Godin 1989, Schechtman 1991). The surveys collected participants' computer-related health beliefs and behaviour before and after the implementation of the intervention.

The questionnaire comprised 42 five-point Likert scale items. The first part of the questionnaire asked about participants' demographic information including gender, age, department, level and time and main activities for using computers every day. The second part asked participants about their computer-related health beliefs including the perceptions of susceptibility and severity of symptoms, and benefits and barriers of actions. The third part asked participants about their computer-related health behaviour (for both notion and action) – sitting posture, facility placement, break and stretch/massage/exercise for eyes, neck, shoulder, hands, back and legs, etc. The questionnaires about computer-related health issues were designed parallel to the categories of the developed health animation contents.

Results and discussion

The participants' responses to the health belief and health behaviour related questions were measured and scored on a Likert five-point scale with 'strongly disagree' scored for 1 and 'strongly agree' for 5.

Table 1 shows that overall, the difference of means between pre-test (3.63 ± 0.492) and post-test (4.01 ± 0.713) reached statistical significance ($t = -2.745$, $p = 0.009$), indicating that the implementation of time-broadcasting health animation exerted a meaningful impact on the health beliefs of participants. In general, participants had a higher level of susceptibility to all discomforts except leg pain for the post-test. The more awareness of the symptoms via the program may be ascribed to the stronger reminding function of the program and the problem-oriented presentation styles partially embedded in some of the animation clips. The participants may be aware of the unhealthy life style for the extended computer use, but didn't really pay attention to or take a closer look at the possible consequences till being reminded. It is understandable that, for the first week of the program experience, a higher level of awareness of the symptoms was reported. However, whether the increase will decline after longer experience of the program cannot be observed in this study and entails further research.

The participants reported high scores in the benefits of adopting health behaviour at the beginning of the study and didn't change significantly over the course of the study. Given the thought that all the participants were graduate students, highly educated people, it is not too surprising that they were quite aware of the benefits of healthy behaviours already. They also reported a relatively high level of barriers to adopting healthy behaviour due to exhaustion and a lack of facilities for the post-test.

As demonstrated in Table 2, the difference of means between pre-test (3.38 ± 0.623) and post-test (3.84 ± 0.697) also reached statistical significance ($t = -2.866$, $p = 0.007$). Further, 'beware sitting posture,' 'keep distance from monitor,' 'short break-action,' 'eye massage-notion,' 'eye massage-action,' 'eye movement-notion,' 'eye movement-action,' 'neck stretch-notion,' 'shoulder stretch-action,' 'hand

Table 1. Scores of health beliefs before and after the intervention.

Health belief	Pre-test Mean	Pre-test s.d.	Post-test Mean	Post-test s.d.	*t*-value	*p*-value
Experience dry eyes	3.135	0.8870	3.676	1.0555	−2.245	0.031*
Experience eyesight deterioration	3.000	1.0274	3.730	1.0179	−3.459	0.001**
Experience shoulder/neck soreness	3.594	0.9268	4.081	0.6308	−2.233	0.032*
Experience hand pain	2.973	1.1423	3.567	1.0939	−2.301	0.027*
Experience back pain	3.297	1.0237	3.946	0.8481	−3.402	0.002**
Experience leg pain	3.135	0.9476	3.514	1.1696	−1.772	0.085
Barriers to adopting health behaviour…						
Too busy	3.270	1.0711	3.541	0.9602	−1.240	0.223
Too exhausted	3.081	1.1397	3.676	0.9145	−2.653	0.012*
No company	3.487	1.0960	3.703	1.0237	−0.822	0.417
No available facilities	3.081	1.2776	3.568	0.9872	−2.347	0.025*
Benefits of adopting health behaviour…						
Less illness	4.460	0.6496	4.595	0.5991	−0.896	0.376
Enhanced working efficiency	4.189	1.1015	4.432	0.8347	−0.964	0.341
Improved thinking capability	4.216	0.9468	4.460	0.6496	−1.245	0.221
Relief of stress	4.351	0.9194	4.432	0.8007	−0.386	0.702
Improved sleep quality	4.351	0.7156	4.460	0.5052	−0.751	0.457
Stay young	4.389	0.7664	4.361	0.6393	0.177	0.860
Overall	3.627	0.4925	4.014	0.7132	−2.745	0.009**

*$p < 0.05$, **$p < 0.01$.

Table 2. Scores of health behaviours before and after the intervention.

Health behaviour		Pre-test mean	Pre-test s.d.	Post-test mean	Post-test s.d.	*t*-value	*p*-value
Correct sitting posture		2.8649	0.97645	3.8919	0.69856	−4.650	0.000***
Correct monitor placement		3.5676	0.98715	4.0270	0.68664	−2.180	0.036*
Short break	Notion	3.7568	0.98334	4.0541	0.84807	−1.318	0.196
	Behaviour	3.2432	0.98334	3.7568	0.83017	−2.054	0.047*
Eye fomentation	Notion	3.0270	1.42374	3.3514	1.08567	1.128	0.267
	Behaviour	2.1351	1.05836	2.4865	1.04407	−1.448	0.156
Eye massage	Notion	3.4324	1.11904	4.0270	0.64492	−2.693	0.011*
	Behaviour	2.9730	1.09256	3.7297	0.80445	−2.964	0.005**
Eye movement	Notion	3.0000	1.20185	3.6486	0.97799	−2.157	0.038*
	Behaviour	2.4324	1.09394	3.1892	0.99549	−2.648	0.012*
Neck stretch	Notion	4.0811	0.95389	4.4324	0.50225	−2.124	0.041*
	Behaviour	3.9730	0.83288	4.2432	0.54800	−1.763	0.086
Shoulder stretch	Notion	4.1081	0.84274	4.3514	0.58766	−1.425	0.163
	Behaviour	3.8378	0.89795	4.2703	0.56019	−2.592	0.014*
Hand stretch	Notion	3.7297	1.04479	4.1892	0.51843	−2.750	0.009**
	Behaviour	3.4324	0.98715	4.2703	0.72597	−3.103	0.004**
Back stretch	Notion	3.7838	1.08359	4.0811	0.75933	−1.453	0.155
	Behaviour	3.4595	1.09531	3.7568	0.76031	−1.480	0.148
Leg stretch	Notion	3.5676	1.01490	3.7838	0.94678	−1.071	0.291
	Behaviour	3.2703	0.96173	3.5946	0.89627	−1.707	0.097
Overall		3.3838	0.62272	3.8446	0.69690	−2.866	0.007**

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

stretch-notion' and 'hand stretch-action' reveal significant difference between pre- and post-test means. Generally, these behaviours were simple upper trunk exercises. On the contrary, the insignificant items of behaviour were those which required more space for exercise or standing up from a sitting position.

Conclusion and suggestion

The results showed that the program affected the participants' computer-related health beliefs and behaviours throughout the one-week experiment. Basically, participants viewed the primary function of the program as a reminder to perform physical activity. The program was developed with an orientation toward igniting habits of healthy computer use. Most of them didn't exactly follow the instructions or steps of the showed clips. However, they did stretch, massage, take breaks and check positions in their own way when the animations pop-up. Compared to other rest or exercise break software, the participants felt that the developed program was more interesting to view and easier to follow. Especially, the 'massage' content animation clips were found mostly welcome and effective for motivating actions, compared to traditional 'stretch' content clips.

Participants proposed several suggestions about the design and content of the program, such as stopping the program if the computer were idle for a certain period of time; each pop-up clip should automatically fade-out if there is no further operation (e.g. cancel or replay) after a while; the background sound should fade-in in order to avoid startles by sudden sound; adding some negative or threatening messages to alert the participants about the possible negative consequences if the suggested exercise or the like was not taken, etc. Although some of the participants stated that break programs somehow are disturbing, they still claimed the needs for them. As we may not enjoy brushing teeth every day, we definitely need to get used to it to prevent rotted teeth. They may not profoundly engage in the break programs, but they certainly need some mechanism to help them build up a routine habit for healthy computer use.

The relatively mild forms of exercise appeared to have more potential for influencing behavioural change, which implies that the purpose of developing the program should not be to promote vigorous activity. Instead, easy-to-perform, on-seat exercises could be scheduled more frequently within the program because research shows that moderate levels of activity from time to time are still beneficial to people's health.

The participants reported more barriers on 'no available facilities' during the experiment. Corresponding solutions for creating a supportive environment such as policy and facility issues are critical to sustaining the behavioural changes. For example, tea-time breaks may help with the level of comfort of taking a break; hot towels on-site may dramatically improve one's willingness to actually 'do' the eye care because most of the participants were 'aware' that their eyes were 'hot and compressed' but few demonstrated 'actions' toward that end; fitness equipment such as dumbbells on-site may do a better job of promoting higher levels of physical activity.

In this initial study, although the health belief and behaviour changes were found to be significant, the experiment was conducted for only one week. Any changes may be partially due to the novel experience of the program. It would be a great of interest to have the examination continue for another week or two. The scope and depth of the study was limited. A larger scale program with animations designed and produced for planned health content is necessary for further development. A longitudinal approach would also be necessary for following up to determine the influence of the program on health outcomes. A qualitative approach to the examination of the impacts of the program may be a better approach for future experiments.

Overall, this study calls attention to the negative effects of extended computer use and suggests that increased effort be made regarding the immediate needs of promoting healthy habits. Compared to other break software studies, this study designed a break program focusing on younger generations and examined its impact and effectiveness. This study also tried to advocate more attention on preventing instead of curing for the problems of extended computer use. Along with the increasingly severe problems associated with extended computer use, we need to soon figure out a way to 'install' a habit for healthy computer use.

Acknowledgements

This work was supported by the National Science Council under the Grant NSC 98-2511-S-415-009-MY2. The authors sincerely appreciate the editor and anonymous reviewers' comments and suggestions.

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