ABSTRACT

USING THE ACTIVE WORKSTATION:
EFFECTS ON TYPING SPEED AND WALKING MECHANICS

by Rachel E. Funk

The current study investigates whether typing on a computer while walking (using the active workstation) results in decrements in performance on either task and also seeks to assess the effectiveness of two different dual task practice protocols. A significant difference in participants’ typing performance (WPM, p < .00; ACC, p < .03; ERR, p < .02; AWPM, p < .00) was found between baseline measurements and pre-test, as well as, significant changes in gait (knee height, p < .03; stride length, p < .00). Secondly, between baseline measurements and post-test, there was no significant improvement in typing performance in the massed practice group (p < .06), and a significant improvement in the distributed practice group (p < .00), while both groups exhibited significant increases in stride length. The initial result of walking while typing elicited a negative effect on typing performance and changed the gait pattern of the user, yet with distributed practice these variables reverted back towards baseline measurements.
USING THE ACTIVE WORKSTATION:
EFFECTS ON TYPING SPEED AND WALKING MECHANICS

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Using the Active Workstation: Effects on Typing Speed and Walking Mechanics

A recent report released by the Centers for Disease Control and Prevention (CDC) revealed that “more than 50% of U.S. adults do not get enough physical activity to provide health benefits,” and 25% are not active at all during their leisure time (CDC, 2008a, p. 2). Although higher levels of physical activity are recommended for maximum health and well-being, researchers have found that a small amount of activity is better than being sedentary. For example, Pescatello, Murphy, & Costanzo (2000) found that low-intensity habitual physical activity is sufficient enough to elicit improvements in blood-lipid and lipoprotein profiles, as well as, decreased blood glucose in older adults. Despite these findings, it still seems difficult for some adults to find time for physical activity. According to Zunft et al. (1999), the most common reasons cited by inactive adults for their lack of physical activity revolved around “work/study commitments.” Based on these research findings, it appears as if integrating physical activity into work and study commitments would be beneficial to many working adults.

Walking while working has become a popular concept, especially with the invention of the active workstation- a treadmill with a desk attached, as seen on Good Morning America, September 3, 2008. Although use of the active workstation may increase employees’ physical activity levels, recent concerns have been raised about humans’ ability to walk and perform tasks simultaneously. Research from the motor control and learning literature would suggest that dual tasks, specifically those that include walking, exert additional attentional demands and thus could have a negative effect on gait parameters, as well as, the performance of the second task. However, it is also possible that the negative effects of walking while working may be decreased with practice.

Due to a lack of research on both the initial and long term effects of walking while working on individuals; gait and work performance, the current study was designed to investigate these issues. To provide a context for this study, the research on the use of the active workstation in the workplace and on the effect of dual task engagement in gait mechanics and task performance is reviewed.

Results of Inactivity

According to the Center for Disease Control and Prevention (CDC) (2008b), physical inactivity can contribute to the prevalence of many chronic diseases and conditions, such as
obesity, type 2 diabetes, hypertension, heart disease, stroke and some cancers. Five of the six leading causes of death in 2002 were attributed to chronic diseases (CDC, 2008a). Data from 2005-2006 show that over 72 million people (20 years of age and older) were obese, which was two times the amount found thirty years earlier (CDC, 2008b).

In addition to the negative effects of physical inactivity on the health of individuals with obesity, inactivity also exerts a main effect on health care costs. Specifically, the cost for obesity in 2000 was approximately 117 billion dollars (CDC, 2008b). At that time health care costs linked to physical inactivity peaked at 76 billion dollars (CDC, 2008b). The CDC proposes that regular physical activity not only helps with weight control, but also “contributes to healthy bones, muscles, and joints; reduces falls among older adults; helps to relieve the pain of arthritis; reduces symptoms of anxiety and depression; and is associated with fewer hospitalizations, physician visits, and medications” (CDC, 2008a, p. 2). If just one person out of every ten were to start a walking program, 5.6 billion dollars would be saved in health care costs for heart disease (CDC, 2008b).

Given that obesity has become one of the bigger issues in American society, it is anticipated that this growing trend will continue to affect the population well into the next decade. More effective approaches are needed to control health care costs and to increase individuals’ health and well-being. In particular, increasing Americans’ level of physical activity would seem to be important. Since over 65% of the population (aged at least 16 years) were employed as of 2000, the workplace is where much of the population spends their time and would be a good place to target health promotion in employees (Clark, Iceland, Palumbo, Posey, & Weismantle, 2003). Moreover, Danna and Griffin (1999) suggest that health and well-being are important components in the workplace for both the employee and the employer.

Physical Activity and The Workplace

Thogerson-Ntoumani, Fox, and Ntoumanis (2005) conducted a study to examine relationships between participation in exercise and the well-being of employees. Specifically, well-being (physical self, work-related, and overall- termed “global” in this study) in the workplace was of interest and evaluated with a questionnaire. The study included 312 employees from the same workplace representing the full spectrum of sedentary to regular exercisers. The
different types of physical activities were standardized into groups based on intensity, duration, and frequency.

The researchers found an overall trend between all levels of physical activity and exercise and increased levels of physical well-being, as well as, work-related well-being. Over the broad spectrum of activity levels, those with higher levels of physical activity had a greater correlation with the well-being variables than those with lower levels of activity or none at all. However, the moderate exercisers had a much better well-being profile than the inactive group, indicating, “that moderate levels of physical activity may be enough for employees to feel better about their physical selves, more enthusiastic at work and report increased levels of life satisfaction” (Thogerson-Ntoumani, Fox, & Ntoumanis, 2005, p. 623). The authors also explain that since moderate activity levels produce positive changes in well-being, corporations should work towards implementing programs that stress lifestyle physical activity. The research and suggestions the authors provide give more evidence for the need for active workstations in the workplace. If even small amounts of physical activity (i.e. walking at a slower pace on the treadmill) can provide increased well-being in the user, the active workstation could be a useful tool in the workplace.

Even with this information regarding the positive influence on well-being that physical activity and exercise bring about, it seems difficult for employees to integrate activity into their lifestyles. At the corporate level, it also seems as though there are difficulties in creating health promotion programs. Kruger, Yore, Bauer, and Kohl (2007) wanted to find which components of a worksite health promotion program were seen as important to employees and what barriers kept employees from utilizing it. In July and August of 2004, a sample of 2,337 full time employees took a survey called HealthStyles. The group was weighted to reflect the U.S. census population based on gender, age, race/ethnicity, marital status, annual household income, geographic region, domestic size, and population density. The HealthStyles survey asked questions about their perceived use of employee wellness services and policies, which free wellness program elements they would most likely use at work, which barriers would keep them from participating in a wellness program at work, and which incentives would make them want to participate in the program. The survey also included demographic information, height and weight to be used for Body Mass Index calculation, and their level of physical activity.
Results showed that, if provided as a free service to employees, 80.6% would use fitness centers, 55.2% would use on-site exercise classes, and 36.3% would participate in sport leagues. The most common perceived barriers to using the provided services by this group were “no time during work” and “lack of time before or after work,” 42.5% and 39.4% respectively. The age group 18 to 29 years was more likely to feel ‘too tired’ and ‘no time before or after work’ than the 60 and over group. The authors also looked at the frequency distribution of barriers selected by the participants, with 44% choosing one barrier, 24% choosing two barriers, 15% choosing more than three barriers, and the rest not reporting barriers. The most common incentives for utilizing the worksite health promotion services were reported as time convenience (73.2%), location convenience (72.8%), and paid time off (69.6%).

In total the findings suggest that over 80% of their population agreed that they would use an on-site fitness center as a health promotional service. Over 89% agreed that they would be more inclined to exercise if the time spent doing so was included in their paid work week. Most of the participants felt that it was a lack of time that kept them from exercising. If employees could exercise during work without missing a portion of their pay check, they may be more interested in participating in organized exercise through the workplace, or other forms of physical activity.

Determined to find a way to increase activity during the workday, Edelson patented the ‘Adjustable portable exercise desk’ in 1993, which will be termed ‘active workstation’ in this review (US Patent No. 5,257,701, November 2, 1993). Further distributed by Details, A Steelcase Company, this device in its simplest form is a height-adjustable work surface set up in front of a treadmill with a maximum speed of two miles per hour (see Figure 1). The work surface can accommodate a lap top or a desk top computer, as well as any other necessary office supplies. The following section will review research that has been done on the effectiveness and feasibility of the active workstation.

The Active Workstation

Edelson created the ‘Adjustable portable exercise desk’ to allow a computer-based employee to walk on the treadmill while working at the computer. The invention attracted many researchers in the kinesiology and health area. Specifically, Levine and Miller (2007) investigated this device by measuring the energy expenditure of fourteen females and one male,
while walking at a low intensity on the active workstation. All subjects were considered sedentary (did not participate in regular exercise). Energy expenditure was measured at five different conditions, each for 20 minutes. The first condition was lying down without any movement, the second was sitting in an office chair, and the third was standing without movement. The fourth condition was broken down into three walking speeds (1, 2, and 3 miles per hour) all done on the treadmill for 15 minutes each. Finally, the fifth condition allowed the subjects to pick their own speed. They were to walk at their self-selected speed while typing a word document at the workstation for an hour. Energy expenditure was measured during 15 to 35 minutes of that hour and was measured by indirect calorimetry (Levine & Miller, 2007).

The Levine and Miller (2007) reported that all of the subjects tolerated the treadmill and that there were no injuries, falls, or unsteadiness. They observed that the subjects didn’t have a problem getting used to working while walking, and that it only took two to three minutes to get acclimated. (Levine & Miller, 2007) The results found a linear relationship between energy expenditure and walking speed. They also found that energy expenditure was greater in walking at 1 mph, 2 mph, and 3 mph over standing still, by 116 (23), 172 (37), and 225 (55) kcal/h, respectively. The subjects’ self-selected speed averaged 1.1 (0.4) mph. The mean energy expenditure while walking and working was 191 (29) kcal/hour. Compared to sitting in an office chair, this value is approximately 119 (25) kcal/h greater (Levine & Miller, 2007). Doing simple calculations, one can see that by using the active workstation for three hours per day, approximately 1500 extra kilocalories (average of 100 kilocalories/hour x 3 hours x 5 days) would be expended in a typical work-week. Thus, a loss of 1 pound (3500 Kilocalories) in a little over two work-weeks is possible (Powers & Howley, 2007). The results of this study, provided support for the idea that the active workstation can make it possible for sedentary workers to expend an increased amount of kilocalories throughout their day without taking time away from work.

In a subsequent study, Thompson, Foster, Eide, and Levine (2007) conducted additional research to address the feasibility of the active workstation. Based on the results from the previous study, the researchers questioned if productivity of the user would be effected by using the active workstation and if he or she would actually use it during the work day. Eight employees were chosen from the Executive Health Program at the Mayo Clinic from four of the main occupations- nurses, clinical assistants, secretaries, and appointment secretaries. Daily steps
were measured with the StepWatch Activity Monitor system (Cyma, Mountlake Terrace, WA, USA) throughout the six week time frame. For the first two weeks, steps were measured while the employees performed their jobs as usual. The next two weeks included the acclimation of the active workstation, with the following two weeks incorporating the active workstation into their work day. A survey of 10 questions was also given to the participants searching for their opinion of the feasibility of the active workstation and their productivity while using the active workstation.

During the two week acclimatization period, participants increased their steps from 2200 to 4000, counting the steps done only during the working hours. This increased to 4200 during the working and walking period (Thompson et al., 2007). It should be noted there was variation in the number of steps for each participant, however the number of steps increased for all participants anywhere between 1.5 and 2 times during the workday (Thompson et al., 2007). Since the participants were allowed to use the active workstation at their leisure, the amount of time spent on the treadmill ranged from 30 minutes to two hours, with no participant exceeding four hours in the workday. The survey results indicated that the participants thought that they would use the workstation if it was available to them; they said it wasn’t too noisy for the workplace; some felt energized while others felt tired after use; and all felt that the workstation did not have an effect on productivity. The users reported that after some practice, they could continue their normal work activities, type just as fast, and talk on the phone as usual.

After finding that the participants with back pain reported the active workstation reduced their pain, Thompson et al. (2007) suggested, “If this holds true in larger studies in which back pain was formally measured, walking (active) workstations could have major benefits beyond weight issues.” (Thompson et al., 2007, p. 227) Therefore, more research is needed to find the long term effects of the active workstation on weight loss, as well as, the possibility of the prevention of or risk for injury. Future research will also need to include a greater number of participants and a smaller acclimatization period since it is not reflective of a normal work environment.

Levine and Miller (2007) and Thompson, Foster, Eide, and Levine (2007) both have shown that the active workstation has potential to be very beneficial in the workplace. The first study supports the idea that the active workstation is effective in providing a means of receiving the caloric benefits of low-intensity physical activity while at work. Thompson et al. (2007)
found some of their participants were able to double the amount of steps taken per day by using the active workstation, with no communication of having negative effects on productivity. However, more quantitatively substantial research is necessary to test whether humans are in fact able to perform work-required tasks while walking.

Very recently, John, Bassett, Thompson, Fairbrother, and Baldwin (in press) wanted to find if there were any differences between sitting and walking on the active workstation when participants took several cognitive and motor skill tests. The tests measured selective attention and processing speed (Stroop test), fine motor skills (typing speed, mouse clicking/drag and drop speed), math problem solving and reading comprehension (GRE sub-sections). Their results indicate that the treadmill walking did not affect selective attention and processing speed or reading comprehension, however it did result in a decrease in fine motor skills and math problem solving (71.4 vs. 64.3%). Specifically, the typing test results indicated a decrement in adjusted words per minute (40.25 seated versus 36.95 walking). The decrements in typing performance were not that large, bringing into question if this was simply related to variance in typing ability of the participants or if it was an effect of dual tasking.

While the active workstation may increase levels of physical activity, there are concerns with the notion of how humans are able to perform two tasks at once and if one or both tasks have decreases in performance. Specifically, productivity of the employee could be compromised if dual task interference occurs while walking and working at the active workstation. To examine the effects of dual task engagement on work performance, the research and theory from the motor control literature is reviewed in the next section.

**Attentional Demands of Dual Task Walking**

When asked to carry out two separate tasks at the same time, the performance of one or both tasks is usually compromised. This decrement in performance is often seen on the secondary task, since most of the attention is given to the primary task. However, if the primary task does not require as much attention, the human is able to allocate more attention to the performance of the secondary task. In this section, theories related to the reallocation of attention in dual tasks will be discussed.

Yogevo-Seligmann, Hausdorff, and Giladi (2008) review the importance of attention as it relates to the performance of gait during dual task walking. Attention during dual tasking is the
capacity to properly allocate attention between simultaneously performed tasks. Attention can be divided into separate categories, including focused or selective, sustained, alternating and divided. Concentration is common name for focused or selective attention; it enables the user to filter the distractions from the useful information in order to maintain the attention given. Sustained attention is the ability to maintain attention to a task over a longer period of time. Alternating attention refers to the ability to quickly shift attention from one task to another. Lastly, divided attention is carrying out more than one task at a time concurrently. (Yoge-Seligmann, Hausdorff, & Giladi, 2008)

Many studies have tested whether gait requires attention (Beauchet, Dubost, Herrmann, & Kressig, 2005; Beauchet, Dubost, Aminian, Gonthier, & Kressig, 2005; Dubost, Kressig, Gonthier, Herrmann, Aminian, Najafi, et al., 2006; Dubost, Annweiler, Aminian, Najafi, Herrmann, & Beauchet, 2008; Grabiner & Troy, 2005; Hollman, Kovash, Kubik, & Linbo, 2007; Laessoe, Hoeck, Simonsen, & Voigt, 2008; Yoge-Seligmann, Hausdorff, & Giladi, 2008). The dual task paradigm is often used to test this question because it involves challenging the capacities of attention, specifically divided attention. The authors explain that gait is no longer considered an “automated motor activity that utilizes minimal higher-level cognitive input” (Yoge-Seligmann, Hausdorff, & Giladi, 2008, p. 329). If this is true, then performing an additional task simultaneously should have a negative effect on gait or the performance of the other task.

This interference that occurs when performing simultaneous tasks can be explained by three different theories: capacity sharing model, the bottleneck theory and the multiple resource theory. The capacity sharing model (Kahneman, 1973) speculates that humans have a limited capacity of attentional resources, resulting in a deterioration performance of at least one of the two attention-demanding tasks. According to this model, the dual task interference is caused by the notion that the tasks performed require more resources than one has available. The way in which attention is divided between the two tasks depends on task complexity, familiarity, and importance. This theory assumes that it is possible to willingly distribute attention to one of the two tasks, even when both are close to automaticity. Thus, if the attentional limit was exceeded during dual task walking, either the performance of the additional task, some parameter of gait, or both would be altered (Kahneman, 1973).
The bottleneck theory (Broadbent, 1958; Cherry, 1953) proposes that if similar tasks (managed in the same neural region) are performed concurrently, ‘bottleneck’ interference occurs because they compete for the use of the same pathways. The bottleneck is like a funnel that can only process one task at a time, delaying the second task until the first task has been processed. Therefore, difficulties are faced when two similar or difficult tasks are performed simultaneously because only one task can be concentrated on at a time. In relation to dual task walking, if the second task is managed in or near the same neural region walking is managed, the result could be slowed gait or a delay in performance of the second task. (Broadbent, 1958; Cherry, 1953)

The multiple resource theory (Wickens, 1984) suggests that a number of resources may be needed to process multiple tasks. These resources define the information flow through some or all stages of processing. The resources are characterized by a distinct perceptual property and can be used in parallel or consecutively in order to process information. Each resource has its own capacity and effort to improve the performance. Therefore when tasks are combined, the interference of tasks is dependent on the extent to which the tasks use the same resources. (Wickens, 1984)

These concepts and theories are important in the research done on dual task walking. In Yogev-Seligmann, Hausdorff, and Giladi’s (2008) review, it is noted that there is a substantial body of evidence that indicates gait needs attention. While there are many factors that go into the relationship between walking and cognitive function, it is now well known that gait does in fact utilize executive function and attention. In addition, several studies have been done to show the changes in gait patterns in response to dual tasking. The following section will review and discuss the recent research that has been done in this area. Similar concepts will be discussed in the section following that will look more in depth into how practice can enhance performance by reducing the issues that come along with the effects of executive function and attention on gait.

**Dual Task Paradigm Research**

Published in 2005, Beauchet, Dubost, Herrmann, and Kressig wanted to look at the role of attention in the control of gait rhythm. The purposes of the study were to use the secondary task of backwards counting to provoke any significant changes in gait and to find if stride-to-stride variability could be related to any dual tasking gait changes. In this study they measured
the coefficients of variation of stride velocity, stride time, and stride length using a 20 meter walkway and the Physilog® system (Beauchet et al., 2005).

The results show a significant change in gait and backward counting performance from the dual task effect (Beauchet et al., 2005). The amount of enumerated numbers decreased significantly while walking compared to sitting. The stride time increased and was variable across subjects, with a coefficient of variability from 1.8 to 2.1 percent. The stride velocity decreased from 130 cm/s to 123 cm/s during the dual task. However, the researchers explain that the increase in stride time was caused by the decrease in velocity, and vice versa, therefore the change in gait was not directly attributable to the dual task (Beauchet et al., 2005). It should be noted that the secondary task used might not have required as much attention as tasked performed in the workplace. Counting backwards while walking is a relatively easy task, thus not requiring great splits in attentional demand. The authors suggest that future studies should include more difficult dual tasks to find if gait is affected differently. Another limitation to this study was the number of steps that were analyzed, which averaged 20. Other research explains that in order to get an accurate assessment of variability in step kinematics, there must be at least 400 steps taken (Owings & Grabiner, 2003).

Dubost, Kressig, Gonthier, Herrmann, Aminian, Najafi, & Beauchet (2006) performed a similar study to re-evaluate dual task related gait changes. One of their purposes for the study was to find whether walking at a slow speed or walking while performing another task affected stride time variability. The other purpose was to ascertain whether stride time variability found while dual-task walking was related to the decrease in speed or the addition of the attention-demanding task. This study’s secondary task had the subjects enumerate animal names off the top of their head at a self-selected time and rhythm. This was done while sitting in a chair (control), as well as, while walking at a comfortable speed of their choosing (between 0.8 m/s and 1.4 m/s) and a slow self-selected speed (towards lower end of the range.) The researchers also took baseline walking measurements, where they did not perform the verbal fluency task.

The researchers found an increase in stride time and a decrease in stride velocity with the addition of the secondary task. Thus, they found a significant effect of the verbal fluency task on the variance of stride time and decrease in stride velocity. The authors explain that these results support the idea that the stepping mechanism in gait is not entirely automatic. This is different from the previous study mentioned, however many reasons could be provided as to why their
results are different. The task used in this study seemed slightly more difficult than the other secondary task previously mentioned, which could be a reason effects on gait were found. Also, the tempo of walking in this study was controlled whereas the previous study participants were free to walk at whatever speed they felt able. Similar to other studies done on a walkway there were only 20 strides analyzed, which is far less than what Owings & Grabiner (2003) suggest should be used in finding stride variability.

Hollman, Kovash, Kubik, and Linbo (2007) sought to examine the differences in gait amongst the three age groups (20 to 35, 40 to 55, and over 70 years of age) during normal and dual task walking conditions. Specifically, the areas of interest were reductions in gait velocity, stride-to-stride variability in gait velocity, and the errors made in the cognitive task. The GAITRite® (an electronic walkway 8.3 meters long and 0.9 meters wide) instrumentation collected the spatial and temporal gait parameters using video- and computer-based motion analysis. The subjects were tested under two different conditions- simply walking at their own preferred pace, and walking while spelling a five letter word backwards. Different words were given for each trial, with each error being counted.

Gait velocity was found to be slower in the dual task condition than in simple walking task for all subjects. The older group had the slowest velocity while the younger and middle group did not show a significant difference. In the older group a negative correlation was found between increased errors in the cognitive task and gait velocity, while a positive correlation was found between increased errors in the cognitive task and stride variability. No correlation with the cognitive task performance was found in the younger two groups. The stride-to-stride variability was significantly different in the middle-aged and older groups, as they both increased by a larger amount than the younger group. (Hollman et al., 2007). These gait changes are similar to previous studies, showing that “attention-demanding tasks have a destabilizing effect on gait and that attentional processes are involved in walking” (Hollman et al., 2007, p. 117). The authors also explain that the gait changes represent a “coping mechanism” in order to handle the cognitive challenge of a dual task activity. When stability is challenged, it is thought that people take a slower speed in order to preserve the walking task. It is important to note that the addition of an attention-demanding task to walking could destabilize gait patterns, depending on the task and the age of the subject (Hollman et al., 2007). Again only 11 to 20 strides were analyzed in this study, suggesting that the use of a longer walk way or a treadmill would be more
beneficial for the variability results. Because this was a cross-sectional study, it remains to be seen how the long-term effect of dual tasking on gait is influenced by aging.

Dubost, Annweiler, Aminian, Najafi, Herrmann, and Beauchet (2008) studied a population to find if stride time and stride length variability could be increased by walking while enumerating animal names. The researchers measured gait mechanics of simply walking at the self-selected speed (for 20 meters), walking and enumerating the animal names at the self-selected speed and rhythm (attempting to perform both tasks equally as well), and the verbal task while sitting in a chair. Opposite of other research reviewed, significant changes in gait were found but not in the cognitive task. Stride velocity decreased, the stride time and coefficient of variation increased, and the stride length parameters did not change. The authors concluded that the dual task related changes in the variability of stride time could be explained by the cognitive task. This conclusion suggests that attention is needed for the control of the rhythmic stepping mechanism used in walking at a self-selected speed. (Dubost et al., 2008)

The findings from these studies suggest that the stepping mechanism is not entirely automatic. Utilizing the dual task paradigm, research has found that by completing a cognitive task while walking, significant changes in gait mechanics and secondary task performance occur. With this understanding, it comes to question how practicing dual tasks has an effect on the interference between the two. If the participants were able to ‘get used to’ doing the two tasks at once, would they have a better performance? Can dual tasking be learned with practice? The following section reviews the current literature on the effects of practice and training on dual task walking.

**The Effects of Practice and Training on Dual Task Walking**

Research has suggested that practice could enhance dual task performance. Schumacher, Seymour, Glass, Kieras, and Meyer (2001) provided strong evidence that after considerable practice, two tasks could be performed simultaneously with little cost to either task. Practice enabled participants to evenly share the capacity of attention between two concurrent tasks (Schumacher et al., 2001). Similarly, Ben-Shakar and Sheffer (2001) have shown that with practice, dual task performance may become more automatic and less controlled, suggesting interference might not even take place. An easy task leaves more spare capacity than a difficult one, therefore practice could decrease task difficulty and therefore decrease capacity demands.
Finally, Pashler, Johnston, and Ruthruff (2001) argue that in performing dual tasks (either similar or different) attention is attracted to tasks whose properties are strongly different and therefore interference might be less.

Because of the common finding that performance is decreased on one or both activities during concurrent tasks, Pellecchia (2005) was interested in finding how different dual task training strategies influenced performance. Should the two tasks be practiced at the same time or at separate times? Pellecchia (2005) explains the different perspectives that exist on how training can eliminate attentional demands during dual tasks. The first is the resource and capacity theory of attention, which proposes that a decrease in dual task interference should occur with training on one component of the dual task. A skill may become more automatic with more practice. With greater automaticity, there are reduced attentional requirements for the practiced task, thus providing more attentional resources accessible for the second task. Thus, one component of the dual task should be practiced (part practice).

The second perspective is the action-selection theory, which proposes that dual task skills are best gained through dual task practice (whole practice). This theory challenges the idea that dual task attentional needs are simply the sum of the attentional needs of each component of the task. Allocating attention is “similar to distributing the pieces of a pie” (Pellecchia, 2005, p. 240). According to Neumann (1987) two tasks performed at the same time are not independent actions. This way of thinking assumes that the motor system integrates concurrent tasks by way of action planning, and that coordination is acquired with practice. The initially separate skills become integrated into a higher order skill, so that the situation is not a dual task anymore. (Neumann, 1987)

Thus, Pellecchia (2005) tested two hypotheses- first that postural sway will be greater when doing concurrent cognitive and postural tasks before training than when the postural task is completed alone, and second that those who undergo dual task training will have better performance when completing the concurrent tasks, than those who complete single-task training or no training.

Participants were randomly assigned to one of three treatment groups- no training, single-task training, or dual task training. The single task required standing quietly, with arms by sides and feet together, on a foam disk (to challenge postural sway) placed on top of an AMTI Accusway system (Advanced Medical Technology, Inc., Watertown, MA) which consisted of a
force plate that measured the center of pressure. The second task used was a cognitive task that required the participants to count backwards by threes from a three-digit number.

First, all three groups were pretested under both the single-task and dual task conditions. Second, the participants in the single-task and dual task groups underwent the training protocol, while the no-training group did not. The single-task and dual task training groups had three separate training sessions on three different days. The single-task training group performed five 30 second trials of counting backwards by threes, each trial starting with a new randomly selected three digit number. Then that group practiced the postural task, five trials of 30 seconds. The dual task training group performed five, 30 second trials of the postural and cognitive tasks done at the same time. One week later, all three groups were post-tested under the same conditions as pretesting.

The results show greater postural sway under the dual task than the single-task conditions in the no training and single-task training groups. However, the dual task training group demonstrated no difference in postural sway under the two conditions. (Pellecchia, 2005) This suggests that the influence of the additional cognitive task on the coordination of postural sway was eliminated specifically following dual task training (whole practice), but not after single-task training (part practice). The author explains that this contradicts the prediction of limited resource or capacity theories of attention and therefore is consistent with the action-selection view of attention. However, other research would argue that in order to be effective, the type of practice (part versus whole practice) depends on the nature of the task (Schmidt & Lee, 2005).

Pellecchia’s (2005) research gives great insight to the influences of practice on performance in dual task conditions. Ruthruff, Van Selst, Johnston, and Remington (2006) also suggest practice can reduce the interference involved in performing two tasks at the same time. They question if the change in performance is caused by this reduction or if the central bottleneck (Cherry, 1953; Broadbent, 1958) is eliminated. However, Ruthruff et al. (2006) explain there are other ways to complete both tasks without hindrance. One way is for the task that is slowing the process down to be automatized through practice. Another way is similar to the notion presented earlier by Neumann (1987) that the tasks could be re-organized in such a way to make the previous two tasks now into one task, eliminating competition for attention.

Although it is understood that dual task practice does increase performance in dual task situations, other questions still remain- Is the ability to integrate tasks a unique skill? How
largely does dual task practice transfer to other motor and cognitive activities? What is the best practice schedule for dual tasks? The first two questions will not be addressed in the rest of this section, however the third question is address with research done by Shea, Lai, Black and Park (2000).

Shea, et al. (2000) assessed the effects two different types of practice sessions on the learning of motor skills. For one of the practice groups, the seven sessions were separated by 20 minutes (massed) while the other group’s seven practice sessions were separated by 24 hours (distributed). Two experiments were performed under the same concept but with different tasks. The first included a continuous dynamic balance task in which feedback was provided for the entire duration of each trial. The other used three variations of a key-press timing task in which the participants were instructed to press four different keys on a keyboard (numeric portion) in a certain sequence. In both experiments, a retention test (no feedback) was administered 24 hours after the completion of practice.

The study found that the distributed practice groups had better performance during the remaining practice sessions. The retention tests indicated that the distributed practice group also had enhanced learning. The authors conclude that the longer inter-session intervals during practice not only incremented performance but had long term effects on learning. However other research would argue that massed practice would illicit better performance than distributed practice (Schmidt & Lee, 2005). Therefore, both practice schedules will be evaluated in the current research study.

Conclusion

In conclusion, the research reviewed in the previous sections has revealed several major findings. First, the current inactivity level of the population is an issue that must be resolved. Second, since low-intensity habitual physical activity is a sufficient way to gain health benefits, encouraging the population to participate in such activities may generate positive results. Third, a common place that low-intensity physical activity should be performed is the workplace, via the active workstation. The active workstation could allow the user to walk while completing any work-related tasks. Fourth, although the active workstation may be very effective and convenient, there are still questions regarding its feasibility in the workplace. One of the primary concerns is its effects on individuals’ gait mechanics and work productivity. The coordination
and ability for humans to walk and perform tasks simultaneously was addressed in much of the research reviewed. Dual task paradigms have been used to investigate the amount of attentional demand required to maintain normal gait.

Although much has been done in the area of research dealing with dual task walking interference, many secondary tasks have not yet been studied. With the invention of the active workstation, it seems as though tasks that are commonly used in the workplace should be tested. For example, typing on a computer is common in many work settings and is considered a cognitive and fine motor task. It has not yet been researched whether walking and typing would illicit interference on one or both tasks. This research is important in that the productivity of employees could be compromised by the attentional cost of doing two things at once. It is also unknown if the changes that might be seen in gait mechanics during dual task walking could cause risk for injury over time. However, it seems as though practice could illicit positive changes to the dual task and therefore reduce these risks to employers.

Thus, the first issue to be addressed in the current study is to determine if typing on a computer while walking had decrements in performance on either task. It was hypothesized that stride length and knee angle would decrease during the dual task, while knee height would increase, resulting in a marching-like motion. It is also hypothesized that typing performance will decrease during the dual task. The second purpose was to assess the effects of practice on the dual task of typing while walking. Based on research and theory, it is hypothesized that practicing typing while walking will have a positive effect on the performance of the typing task and gait parameters, and that the distributed practice group will have better performance after practice.

Method

Participants

Nineteen employees from Miami University were recruited for this study. A mass e-mail was sent to the administrative list-serv at Miami University, in hopes of recruiting participants with administrative-like positions. These positions were assumed to be relatively inactive, as well as requiring a greater amount of typing throughout the day. The population was recruited based on the following inclusion criteria- any ethnic background or gender, over the age of 18 years, and weighed less than 350 pounds per weight requirement of the device. The participants
were also expected to be able to type at least 50 adjusted words per minute and able to walk comfortably at one mile per hour. The sample was well distributed across age ranging from 24 to 59, with a mean of 42.5 (11.4). The average BMI of the participants was 31.9 (6.4), ranging from 20 to 44.

Study Design

An experimental pretest/posttest randomized groups design was used. Study participants were randomly assigned to one of two practice conditions. All participants completed both pre and post tests of typing speed and accuracy while sitting and walking on a treadmill. The complete study design was a 2 X 2 (Practice Condition by Time) Mixed Model ANOVA with repeated measures on the second factor. The dependent variables were typing speed and accuracy along with selected measures of gait.

Procedures

This study was divided into three phases—pre-test, practice, and post-test. In the pre-test phase, all participants were brought to the lab. The pre-testing began with the informed consent and measurement of participants’ height and weight. Participants also completed a demographic questionnaire that asked about their age, number of hours at work, and the number of days per week they exercised.

All participants then completed a typing test under two different postural conditions: while sitting and while walking using the active workstation (see Figure 1 for apparatus). The typing test used was the Mavis Beacon Teaches Typing V 2.0. This software provided words per minute (WPM), percent accuracy (ACC), number of errors (ERR), and adjusted words per minute (AWPM) at the end of the test. The tests were chosen based on the speed at which the participant was able to type, attempting to keep all tests around 4 to 6 minutes long. Subsequent typing tests taken by the participants during the experiment were different, to control for any learning effect.

In order to measure the parameters of gait, participants were videotaped with a digital video camera (only to film side view from the waist down) while walking on the workstation. To aid in video analysis retroreflective markers were taped to the subject’s tight fit clothing at known body landmarks of the hip, knee, ankle and the tip of their shoe. Before each test the
camera was calibrated by videoing a one meter by one meter, L-shaped metal rod. The video was then digitized using motion capture software to calculate peak knee height (highest point of gait cycle) and knee angle (peak knee flexion). Step length was found by finding the number of steps taken per minute. Since all participants walked at one mile per hour (26.82 meters/min), the step length was calculated by dividing 26.82 m/min by the number of steps per minute.

For both groups, the typing test was explained and a seated practice test was administered. Then, the participants took the seated typing pre-test, followed by the placement of the reflective markers. After calibration of the video camera, each participant was to walk in a ‘normal’ fashion at one mile per hour for three minutes while video was taken of their baseline walking mechanics. The walking pre-test was then administered.

Following the pre-test procedures, subjects were randomly assigned to one of two practice conditions (see next section). At the conclusion of the practice sessions, all subjects were once again assessed for typing speed and accuracy as well as gait parameters. The same assessment procedures as were used in the pre-test were followed for this post-test time period. An outline of the study procedures is provided in Table 1.

Practice Conditions

Participants were randomized in to one of two practice groups (A- massed practice or B-distributed practice), in which the participants practiced typing and walking on the active workstation. Group A completed three, ten minute consecutive practice sessions separated by typing tests. For each practice session, these participants were asked to type spontaneously in a word document that would be discarded after use. Those that were not comfortable with this were allowed to type using the Mavis Beacon software. Group B returned to the lab for three consecutive days in which they completed 15 minutes of practice on each day. Their practice consisted of two 7-8 minute long typing tests, based on their baseline typing speed. The actual practice time was approximately equal between the groups as the typing tests are counted in this sum for both groups.

Statistical Analysis

All data were collated and entered into an SPSS data file. Descriptive statistics were calculated and results were inspected for normality and linearity. Main study analyses were
conducted to examine the effects of postural condition (sitting and walking) and practice type on the typing performance and gait of study participants. Specifically, a series of paired samples t-tests were performed to compare postural conditions while typing as well as gait kinematics between baseline walking and dual task walking. In addition, a series of 2 X 2 (Practice Condition by Time) Mixed Model ANOVAs with repeated measures on the second factor were conducted to assess the effects of the two practice conditions on participants typing performance and gait parameters.

Results

The first purpose of the current study was to determine if typing on a computer while walking resulted in decrements in performance on either task. It was hypothesized that stride length and variability would increase during the dual task. It was also hypothesized that typing speed would decrease during the dual task. The second purpose was to assess the effects of practice on the dual task of typing while walking. Based on research and theory, it was hypothesized that practicing typing while walking would have a positive effect on the performance of the typing task and gait parameters.

A variety of statistical procedures were used to analyze the data. The results of these analyses are presented in the following sections, beginning with the descriptive data and then proceeding to the results for the two study purposes.

Descriptive Results

The descriptive data corresponding to participants demographic and physical characteristics are summarized in Table 2. As these results show, there was a wide range in age in the participants, from 24 to 59 years. The calculated BMI ranged between 20 to 44 kg/m², and averaged 31.9 (6.44) which is considered obese per the CDC’s recommendations (CDC, 2009). The results from the questionnaire showed that the participants ranged in seated hours during their work days from 3 to 11, however most were close to the average of 6.76 (1.74) hrs. The number of days per week of exercise reported averaged 2.84 (2.09), ranging from zero to seven days per week. Overall the sample seems somewhat sedentary, with many hours spent sitting at work.
Study Purpose #1

The first purpose for this study was to determine if study participants' typing scores and gait parameters would be affected by their performance on the typing task while walking on the treadmill. In the pre-test phase of the study, participants completed a typing test under both sitting and walking conditions. Typing performance was measured using four different scores: typing speed in words per minute (WPM), percent accuracy (ACC), number of errors made during test (ERR), and adjusted words per minute (AWPM). Descriptive data for participants' typing performance while sitting and walking are presented in Table 3. To compare participants' scores across the two conditions, a series of paired samples t-tests were conducted. As the results in the last column in Table 3 show, there were significant differences in participants' performance on all four measures of typing performance. Specifically, participants' typing speed, percent accuracy, and adjusted words per minute decreased significantly from the sitting to walking condition while their number of errors significantly increased. Thus, the task of walking while typing had a negative effect on typing performance.

To examine the effects of walking while typing on participants' gait parameters at the baseline timepoint, digital video procedures were used to compare participants' gait while walking on the treadmill without completing the typing task and then again while completing the typing task. Specifically, three different measures of gait parameters were assessed: knee angle, knee height, and stride length. The data obtained from the video procedures are presented in Table 4. Again, a series of paired samples t-tests were used to compare participants' scores on the three gait parameters across the two treadmill walking conditions. As the last column shows, significant differences were found on two of the three parameters. That is, participants showed significant decreases in knee height and in stride length when they completed the typing task while walking. In contrast, no significant differences in knee angle were found. Thus, walking while typing elicited a slightly different gait pattern than what was found at the participants’ baseline gait measurement.

In summary, then, the results of these analyses showed that study participants' typing performance did decrease significantly from the sitting to the walking condition. In addition, when participants engaged in the typing task while walking, significant changes in their gait occurred characterized by maintaining knee angle but shortening stride length and reducing knee height.
Study Purpose #2

The second purpose of this study was to compare the effectiveness of two different practice conditions on changes in participants' typing performance and gait parameters from baseline to post-test. To compare practice conditions on typing performance, a 2 X 2 (Practice Condition by Time) mixed model ANOVA with repeated measures on the second factor was conducted. The independent variables for this analysis were Practice Condition (massed versus distributed) and Time (baseline and post-practice). The dependent variable was the single score representing adjusted words per minute (typing speed as adjusted for errors). The descriptive data for this statistical design are presented in Table 5.

The results of the 2 X 2 mixed model ANOVA revealed a non-significant main effect for Practice Condition (p < .35). However a significant main effect was found for Time (Wilks' lambda = .38, F (1,15) = 25.00, p < .00, eta-squared = .63) and a significant Practice Condition by Time interaction effect was also found (Wilks' lambda = .65, F (1, 15) = 8.21, p < .01, eta-squared = .35). The significant Time main effect cannot be interpreted because the significant interaction effect shows that the changes that occurred over time differed in some way for the two practice groups.

As a follow-up to the significant two-way interaction effect, paired samples t-tests were conducted for the two practice groups separately. These results indicated that the massed practice group (A) did not show significant improvement in typing performance from baseline to post-test, t (7) = -2.285, p < .06, but it was close to significance. In contrast, the distributed practice group (B) did show significant improvement in typing performance from baseline to post-test, t (8) = -4.66, p < .00. These results show that the distributed practice condition resulted in better typing performance as compared to baseline walking while typing, while the massed practice condition did not have such results.

To compare the effects of the two different practice strategies on changes from baseline to post-test on participants' gait parameters, a series of three 2 X 2 (Practice Condition by Time) mixed model ANOVAs with repeated measures on the second factor were conducted. For these analyses, the two independent variables were Practice Condition (massed versus distributed) and Time (baseline versus post-test), and the three dependent variables were knee angle, knee height, and stride length. The descriptive data for these 2 X 2 ANOVAs are provided in Table 6.
The results of the 2 X 2 (Practice Condition by Time) ANOVA for knee angle revealed no significant main effects for Practice Condition ($p < .31$) or Time ($p < .18$) and no significant interaction effect ($p < .31$). The ANOVA results for knee height revealed a non-significant main effect for Practice Condition ($p < .97$) and a non-significant Practice Condition by Time interaction effect ($p < .69$). The main effect for Time approached significance, Pillai's Trace = .22, $F (1, 14) = 3.85$, $p < .07$, eta-squared = .22. Finally, the ANOVA results for stride length revealed a non-significant main effect for Practice Condition ($p < .26$) and a non-significant interaction effect ($p < .98$). However, the main effect for Time was significant, Wilks' lambda = .78, $F (1, 15) = 4.32$, $p < .05$, eta-squared = .24. Examination of the descriptive data in Table 7 indicates that all participants (regardless of practice type) exhibited significant increases from baseline to post-test in stride length.

Discussion

The current inactivity level of the population is an issue that must be resolved (CDC, 2008a; CDC, 2008b). Since low-intensity habitual physical activity is a sufficient way to gain health benefits, encouraging the population to participate in such activities may generate positive results (Pescatello, Murphy, & Costanzo, 2000). Because the majority of the population spends most of their time at work, the workplace would be an optimal place to incorporate low-intensity physical activity (Clark, Iceland, Palumbo, Posey, & Weismantle, 2003). The active workstation could allow the user to walk while completing any work-related tasks, however two concerns have been noted: its effects on the individual’s gait mechanics and work productivity. The ability for humans to walk and perform tasks simultaneously was addressed in much of the research reviewed (Beauchet, Dubost, Herrmann, & Kressig, 2005; Dubost, Kressig, Gonthier, Herrmann, Aminian, Najafi, et al., 2006; Dubost, Annweiler, Aminian, Najafi, Herrmann, & Beauchet, 2008; Hollman, Kovash, Kubik, & Linbo, 2007; Yogev-Seligmann, Hausdorff, & Giladi, 2008), however typing while walking has not been extensively addressed before this study.

Therefore, the first issue that was addressed in the current study was to determine if typing on a computer while walking had decrements in performance on either task. It was hypothesized that typing performance would decrease during the dual task. This hypothesis was supported as the participants' typing speed, percent accuracy, and adjusted words per minute decreased significantly from the sitting to walking condition while the number of errors
significantly increased. This supports the work of John et al (2009) and extends their findings by using typists with a higher typing performance baseline.

It was also hypothesized that stride length and knee angle would decrease during the dual task, while knee height would increase, resulting in a marching-like motion. This hypothesis was not fully supported as the knee height actually decreased and knee angle did not show significant difference. However, stride length decreased showing a change in gait pattern and evidence that the stepping mechanism is not entirely automatic.

Overall the initial result of walking while typing elicited a negative effect on typing performance and changed the gait pattern of the user. This was to be expected as much of the research reviewed suggested that interference occurs when performing tasks simultaneously, specifically looking at the capacity sharing model, the bottleneck theory and the multiple resource theory (Kahneman, 1973; Broadbent, 1958; Cherry, 1953; Wickens, 1984). The results of this portion of the study coincide with the results of the older group that was tested in Hollman, Kovash, Kubik, and Linbo (2007), in that both tasks were affected by the dual task interference.

Research has suggested that practice could enhance dual task performance (Ben-Shakar and Sheffer, 2001; Pashler, Johnston, and Ruthruff, 2001; Schumacher, Seymour, Glass, Kieras, and Meyer, 2001). So the second purpose of the study was to assess whether or not the user could actually get better at typing while walking simultaneously with practice. It was hypothesized that practicing typing while walking would have a positive effect on typing performance and gait parameters, and that the distributed practice group would have better performance after practice. The findings support this hypothesis as the distributed practice condition resulted in better typing performance while the massed practice did not, similar to the results found in Shea, Lai, Black and Park (2000). With practice, the interference decreased between the two tasks that were performed simultaneously.

The typing performance results suggest that the participants were able to ‘get used to’ typing while walking by practicing the dual task, with the distributed practice group improving in typing performance more so than the massed practice group. One of the major concerns that employers might have with the active workstation is a loss in productivity. With the initial findings indicating that the typing performance was compromised while walking, this concern seemed valid. However, the results of the second part of the study demonstrate that with a few
short practice sessions, the user’s productivity is able to revert back to the original performance level.

The reasoning for the better typing performance in the distributed group appears not to be related to walking kinematics. The walking performance (knee angle and height) remained the same for both groups from pre-test to post-test. Stride length, however, increased for both groups from pre-test to post-test moving back toward their baseline stride length measurement. By looking at the change in gait parameters, it is evident that the user became more comfortable after practice. The stride length reverted back to the baseline walking stride length after practice, meaning that the ‘marching-like’ motion subsided and the ‘normal’ gait pattern came back. These results also show that the concern regarding the irregular gait pattern possibly causing risk for injury is irrelevant. The initial irregular gait pattern subsided therefore reducing any risk. These results also show that gait kinematics get better first, then typing performance. In addition, due to the nature of the massed practice protocol, the massed practice group’s lack in tying performance compared to the distributed practice group could have been related to fatigue.

Conclusion

Significant decrements in participants’ performance on all four measures of typing performance were found in this study. Thus, the task of walking while typing had a negative effect on typing performance. Participants also showed significant decreases in knee height and in stride length when they completed the typing task while walking. Thus, walking while typing elicited a slightly different gait pattern than what was found at the participants’ baseline gait measurement. With practice, both groups were able to revert back to their baseline gait measurement. However, only the distributed practice group was able to improve their typing performance contrary to the casual observations of Levine & Miller (2007) that people got better after a while in a single session. These results suggest that the active workstation would benefit many in the workplace as little compromise to productivity seems likely after prolonged use. Employers may want to look into the active workstation as a means to provide employers with health benefits while working, thus reducing need for extra time spent on physical activity during the day or money spent on exercise facilities.
From the data collected on walking mechanics during the practice sessions, it seemed as though gait was more ‘normal’ during practice versus testing, which could have been related to the possibility of additional anxiety or temporal stress elicited from the typing test. Since most work done at the computer while walking has less of a time constraint than a typing test, there might not be changes in gait what-so-ever. Future research may include examining the effect of the typing test versus a task with less temporal stress.

Other studies should also look at different work-related skills to perform while walking, as typing is not the only skill used in the workplace. Another variable to test would be changing the speed of the treadmill to find if there is an optimal walking speed for best typing performance. In addition, there may be an optimal speed per height of the user as this would change stride length and thus comfortable walking speed. Because only typing performance was a concern in this study, future studies should include a retention interval after the practice sessions to test for permanence. With practice the user might be able to learn the new skill of typing while walking, and thus have little to no compromise to productivity. Testing the long term effects of typing while walking has not yet been addressed in the literature.

Acknowledgments

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References


Tables

Table 1: Practice Protocol

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-Test</th>
<th>Practice</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Informed Consent</td>
<td>Complete Demographic Questionnaire</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Height and Weight</td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>Practice Typing Test</td>
<td>10 min Spontaneous typing</td>
<td>Typing Test Walking</td>
</tr>
<tr>
<td></td>
<td>Typing Test Seated</td>
<td>10 min Spontaneous typing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baseline Walking</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Typing Test Walking</td>
<td>10 min Spontaneous typing</td>
<td></td>
</tr>
</tbody>
</table>

| Group B | Informed Consent             | Complete Demographic Questionnaire            |                   |
|         |                               | Height and Weight                             |                   |
|         | Practice Typing Test         | 15 min Typing Test Day 1                      | Practice Typing Test|
|         | Typing Test Seated           | 15 min Typing Test Day 2                      | Typing Test Seated |
|         | Baseline Walking             | 15 min Typing Test Day 3                      | Baseline Walking   |
|         | Typing Test Walking          |                                               | Typing Test Walking|

Table 2: Descriptive Data for Study Participants

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>42.53</td>
<td>11.41</td>
<td>24</td>
<td>59</td>
</tr>
<tr>
<td>Height (inches)</td>
<td>65.2</td>
<td>3.5</td>
<td>58.0</td>
<td>72.8</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>193.3</td>
<td>41.9</td>
<td>103.0</td>
<td>249.0</td>
</tr>
<tr>
<td>BMI (kg/m2)</td>
<td>31.9</td>
<td>6.4</td>
<td>20</td>
<td>44</td>
</tr>
<tr>
<td>Hours seated/day</td>
<td>6.8</td>
<td>1.7</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Exercise days/week</td>
<td>2.84</td>
<td>2.09</td>
<td>0</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 3: Typing Performance at Pre-Test Phase: Sitting versus Walking

<table>
<thead>
<tr>
<th></th>
<th>Sitting</th>
<th>Walking</th>
<th>Difference</th>
<th>Results of t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPM</td>
<td>67.00 (9.45)</td>
<td>56.58 (8.30)</td>
<td>-10.42</td>
<td>p &lt; .00</td>
</tr>
<tr>
<td>ACC</td>
<td>93.21 (13.36)</td>
<td>89.58 (18.44)</td>
<td>-3.63</td>
<td>p &lt; .03</td>
</tr>
<tr>
<td>ERR</td>
<td>50.00 (56.98)</td>
<td>85.17 (67.95)</td>
<td>+35.17</td>
<td>p &lt; .02</td>
</tr>
<tr>
<td>AWPM</td>
<td>61.83 (14.28)</td>
<td>50.56 (14.03)</td>
<td>-11.27</td>
<td>p &lt; .00</td>
</tr>
</tbody>
</table>
Table 4: Walk Parameters at Pre-Test Phase: No Typing versus Typing Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>No Typing</th>
<th>Typing</th>
<th>Difference</th>
<th>Results of t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee angle</td>
<td>123.55 (7.31)</td>
<td>124.44 (6.55)</td>
<td>+.89</td>
<td>p &lt; .11</td>
</tr>
<tr>
<td>Knee height</td>
<td>.50724 (.033)</td>
<td>.50483 (.034)</td>
<td>-.00241</td>
<td>p &lt; .03</td>
</tr>
<tr>
<td>Stride length</td>
<td>.38218 (.057)</td>
<td>.35579 (.051)</td>
<td>-.02639</td>
<td>p &lt; .00</td>
</tr>
</tbody>
</table>

Table 5: Effects on Typing Performance (AWPM), Practice Condition by Time

<table>
<thead>
<tr>
<th>Practice Condition</th>
<th>Baseline: Walk while typing</th>
<th>Post: Walk while typing</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massed Practice</td>
<td>48.75 (18.92)</td>
<td>51.38 (17.48)</td>
<td>+2.63</td>
</tr>
<tr>
<td>Distributed Practice</td>
<td>51.89 (9.96)</td>
<td>61.56 (10.61)</td>
<td>+9.67</td>
</tr>
</tbody>
</table>

Table 6: Changes in gait parameters from Baseline to Post-Test, Practice Condition by Time

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Massed Practice</th>
<th>Distributed Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 8</td>
<td>N = 8</td>
</tr>
<tr>
<td>Knee Angle</td>
<td>Baseline</td>
<td>123.98 (4.36)</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>123.03 (4.57)</td>
</tr>
<tr>
<td>Knee Height</td>
<td>Baseline</td>
<td>.505 (.0427)</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>.500 (.0420)</td>
</tr>
<tr>
<td>Stride Length</td>
<td>Baseline</td>
<td>.338 (.0481)</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>.352 (.0414)</td>
</tr>
</tbody>
</table>
Figures

Figure 1. The Active Workstation

Details: A Steelcase Company, 2008