The Effect of Dynamic Workstations on the Performance of Various Computer and Office-Based Tasks

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Abstract. The effect of different workstations, conventional and dynamic, on different types of performance measures for several different office and computer based task was investigated in this research paper. The two dynamic workstations assessed were the Lifespan Treadmill Desk and the RightAngle LifeBalance Station, and the two conventional workstations assessed were a seated and a standing workstation. Through a randomized repeated measures design, the effect of these different workstations was assessed for a series of tasks consisting of a reading, typing, telephone, mouse dexterity task and a battery of computer-based cognitive tasks. Hypothesized was that the use of these dynamic workstations would have different effects on the performance measures for the different types of tasks.

Keywords: task performance, computer work, dynamic workstations, reaction time, accuracy.

1 Introduction

The importance and contribution of general physical activity to the maintenance of good health, both physically and cognitively, has become more prominent with the increased research into the negative consequences of physical inactivity [1]. Numerous lifestyle and work aspects can contribute to physical inactivity which can result in an increase in the risk of developing chronic diseases such as cardiovascular disorders and type II diabetes [1]. Additionally numerous negative effects have been associated with prolonged sitting and sedentary work, such as an increased risk of low back pain [2] and musculoskeletal disorders [3]. The negative effects of this inactivity cannot be compensated by only increasing activity levels during leisure time [4] and require alternative means of including more physical activity in daily life. A potential means of counteracting physical inactivity is that of dynamic workstations [5].

As dynamic workstations are recent additions to the commercial market, there is only limited research-based information available on the implications or effects that

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these stations have on work performance. The spectrum of tasks where this has been investigated is limited [6-7]. As these workstations are being introduced as feasible alternatives to current workstations, the influences on performance needs to be comprehensively considered. This research paper aimed at investigating the effect on performance for various office and computer based tasks for two different dynamic workstations currently available on the commercial market. As a result of the different tasks requiring different skills and resources from the worker, it was hypothesized that the performance of different tasks would be differently affected as a result of these workstations.

2 Method

Using a randomized repeated measures design, the performance of five different basic computer and office tasks was assessed for six different workstation conditions in a laboratory under realistic VDU office settings. The six different workstation conditions consisted of two conventional workstations and two different dynamic workstations, with each dynamic workstation tested at two different intensities. The conventional workstations included seated and standing workstations, and the dynamic workstations included a treadmill station, the Treadmill Desk TR1200-DT5 by LifeSpan, and a semi-recumbent elliptical machine station, the LifeBalance Station by RightAngle. The walking workstation was assessed at a speed of 0.6km/h (WS1) and 2.5 km/h (WS2), and the semi-recumbent elliptical machine station was assessed at 40 RPM at an intensity level of 4 which resulted in 9 Watts resistance (LBS1) and an intensity level of 12 which resulted in 17 Watts resistance (LBS2). Each participant performed a randomized order of a set of standardized tasks at each station. Furthermore the order in which the workstations were assessed was randomized and each participant was required to complete a habituation phase for both the workstations and the tasks.

2.1 Tasks

The series of tasks selected for this research were aimed at simulating basic office tasks and included five different tasks, namely a typing task, a reading task, a telephone task, a mouse dexterity task and a battery of computer-based cognitive tasks. The content selected for the typing, reading and telephone tasks were set so that the difficulty level was approximately standardized and no content was repeated between the workstations for one participant. Each of these tasks had a set duration of five minutes. The reading task had on average every 100 words a character rotation, and the number of correctly identified errors and number of characters read were used as performance criteria. For the typing task, the participants were required to copy a text from a window in the top half of the computer screen to a word document situated in the bottom half of the screen and the task was assessed for both speed and accuracy. The telephone task was aimed at assessing the effect that the dynamic

workstations would have on speech quality and participants were required to repeat a spoken text through a telephone. Performance was assessed by the number of words spoken and the number of errors made in the repetition. The subjective quality of the spoken text was rated with the MOS scale [8]. The mouse dexterity test, based on Fitts Law [9], consisted of two different tasks, namely one with a randomized stimulus ("Random Circles") and the second one with a predefined response pattern ("Multi-direction"). The battery of cognitive tasks consisted of a Go/No go association task [10], a subitizing task [11], an Eriksen Flanker Test [12], and a memory task. For the mouse dexterity task and each of the cognitive tasks, accuracy scores and reaction times were recorded.

2.2 Participants

Twelve volunteers, all who have VDU workstations and predominantly perform computer-based tasks as the main component of their work, agreed to participate in this study. The participant group consisted of 6 males (mean age: 39.2 SD: 10.1), with a mean height of 1,76m (± 7.3) and a mean weight of 85kg (± 11.1), and 6 females (mean age: 38.2 SD: 13.5), with a mean height of 1,66m (± 7.7) and a mean weight of 65kg (± 12.5). Participants with any health problems, acute or chronic, were excluded.

2.3 Analysis

The results have been preliminarily analysed using descriptive statistics. The mean and standard deviation were calculated over all participants for each of the six workstation conditions. A comprehensive inferential statistical analysis is still outstanding and will be completed at a later point. Consequently the results in this paper are only described and no explicit conclusions can be drawn.

3 Results

3.1 Reading Task

Reading was assessed by means of speed (the number of characters read) and accuracy (the number of correctly identified characters). Figure 1 depicts these results. The most characters read were at the workstation WS2 (7070 characters) and the least number of characters were read at workstation WS1 (6556 Characters). The most identified errors occurred at the workstation LBS2, followed by the conventional seated workstation with a 0.1% difference. The workstation WS1 had the worst score with the least percent of errors identified. For both workstations LBS1 and LBS2, similar sores and variations were obtained despite the differences in intensity levels.

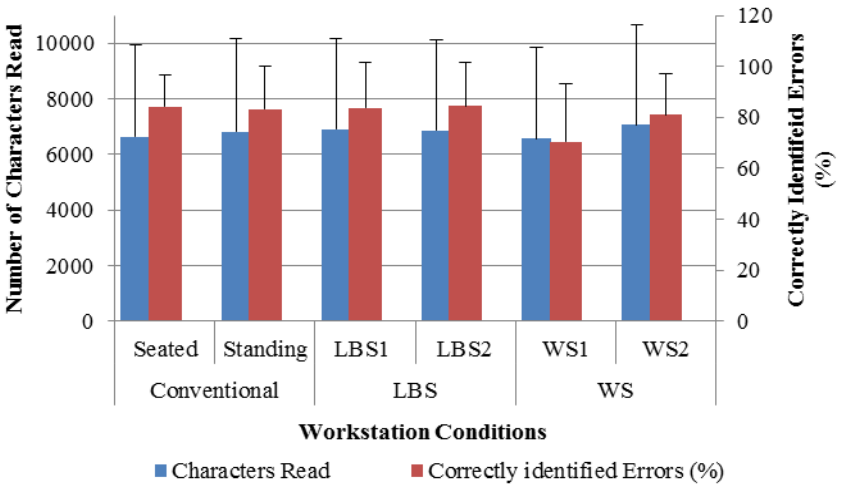

Fig. 1. The mean number of characters read and the percent of errors correctly identified for the reading task for each of the workstation conditions (Standard Deviation)

3.2 Typing Task

The performance results, in the form of characters typed, as seen in Figure 2, was best for the conventional standing workstation (908.2 characters) and worst for the workstation WS2 (815.8 characters). The mean characters typed at the seated and LBS 2 workstations only differed minimally (a difference of 1.3 characters type). With regards to accuracy, the best mean performance was for the conventional standing workstation (10.8 errors), followed by the conventional seated workstation (12.2 errors). The most errors were recorded for the workstation WS2 (18.8 errors).

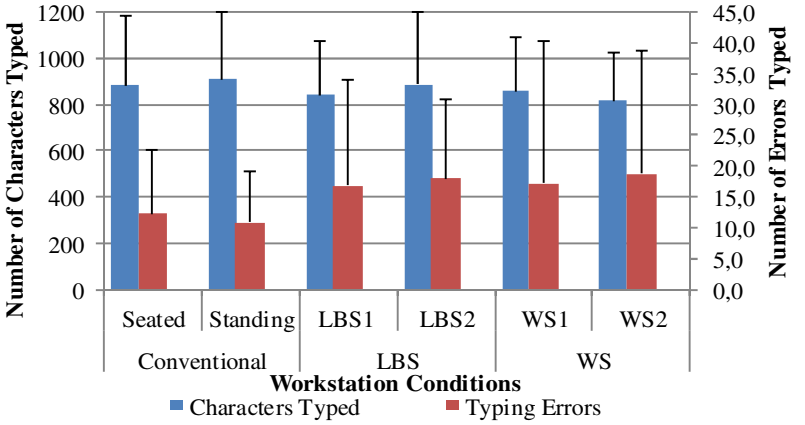

Fig. 2. The mean number of characters and errors typed for the typing task for each of the workstation conditions (Standard Deviation)

3.3 Telephone Task

From the results in Table 1, it is visible that with regards to the mean performance results, the workstation conditions did not strongly differ from one another. The mean percent of errors spoken for all the workstations did not show large differences, with all mean values being approximately 6% despite large standard deviations. The smallest mean percent of errors was obtained for the LBS2 workstation (6.0%) and the largest was for the LBS1 workstation (6.77%).

The results from the subjective evaluation of the speech quality using the MOS scale yielded scores for all the workstations between 4 and 5. At a rating of 4 the speech quality is defined as good with the level of distortion being perceptible but not annoying. A rating of 5 defines the speech quality as excellent and the level of distortion as imperceptible. For both of the high intensities of the dynamic workstations, the worst rating on the MOS scale for the workstations was obtained.

Table 1. The mean number of words that were spoken, the percent of errors that occurred in the spoken text and the MOS scale rating for each of the workstations (Standard deviation)

	Conventional		LBS		WS	
	Seated	Standing	LBS1	LBS2	WS1	WS2
Words Spoken	450.0 (47.3)	461.7 (38.1)	451.8 (46.2)	453.7 (45.0)	456.4 (32.8)	456.2 (40.6)
Errors (%)	6.2 (4.9)	6.5 (6.5)	6.8 (5.4)	6.0 (3.4)	6.3 (4.9)	6.7 (6.2)
MOS Scale	4.8 (0.4)	4.9 (0.3)	4.7 (0.3)	4.3 (0.8)	4.8 (0.4)	4.6 (0.5)

3.4 Mouse Dexterity Task

The mean results for the reaction time and score obtained for the two mouse dexterity tasks for each workstation condition are depicted in Table 2.

Table 2. Mean reaction time (ms) and score for the two mouse dexterity tasks for each of the workstation conditions (Standard deviation)

Mouse Dexterity Task	Performance Criteria	Conventional		LBS		WS	
		Seated	Standing	LBS1	LBS2	WS1	WS2
Multi-direction	Reaction time	696.0 (114.9)	706.1 (114.4)	715.9 (139.9)	726.7 (116.9)	748.8 (125.7)	804.7 (113.9)
	Score	1240.6 (158.3)	1243.8 (75.0)	1181.5 (72.8)	1175.5 (98.4)	1165.4 (94.6)	1034.3 (88.9)
Random Circles	Reaction time	610.5 (101.9)	643.6 (112.4)	652.2 (110.8)	655.4 (103.6)	662.0 (105.2)	697.8 (114.4)
	Score	1162.9 (67.6)	1147.3 (76.3)	1140.3 (87.3)	1119.4 (64.3)	1109.0 (79.4)	1074.7 (70.9)

For both of the mouse dexterity tasks, the fastest mean reaction time was for the seated workstation, with 696.0 ms (±114.9) and 610.5 ms (±101.9) for the task "Multi-direction" and "Random Circles" respectively. The slowest mean reaction time was recorded for the workstation WS2, with 804.7 ms (±113.9) and 697.8 ms (±114.4) for the task "Multi-direction" and "Random Circles" respectively.

3.5 Cognitive Tasks

The mean results for reaction time and accurracy for each of the cognitive tasks for each workstation condition are depicted in Table 3. The mean reaction time for the Go/No-go task for each of the workstations was between 383.3 ms and 419.0 ms, with the quickest mean reaction time recorded for the standing workstation and the slowest for the workstation WS1. With regards to accurracy, the lowest score was obtained for the seated workstation and the highest was for the workstation LBS1. For the subitizing task, the mean reaction time was the slowest for the seated workstation (997.6 ms) and the quickest for the LBS2 workstation (929.8 ms). Both of the high intensity dynamic workstations obtained the highest percent of correct responses, namely 84.6% for the WS2 workstation and 82.5% for the LBS2 workstation.

Table 3. Mean reaction time (ms) and accuracy score (%) for all the cognitive tasks for each of the workstation conditions. (Standard deviation)

Task	Performance Criteria	Conventional		LBS		WS	
		Seated	Standing	LBS1	LBS2	WS1	WS2
Go/No-Go	Reaction time	394.3 (55.1)	383.3 (79.1)	405.2 (46.3)	399.8 (56.0)	419.0 (57.3)	404.7 (40.0)
	Accurracy (%)	94.6 (5.4)	95.1 (5.6)	98.5 (2.9)	94.8 (3.1)	96.1 (4.7)	96.9 (3.0)
Subitizing Task	Reaction time	997.6 (83.5)	978.2 (124.5)	959.8 (132.6)	929.8 (96.1)	983.2 (84.2)	939.0 (100.7)
	Accurracy (%)	80.5 (8.2)	80.0 (11.5)	82.1 (9.8)	82.5 (8.7)	80.3 (11.7)	84.6 (8.7)
Eriksen Flanker	Reaction time: Congruent	494.6 (78.1)	470.9 (80.0)	497.0 (96.5)	472.3 (71.4)	487.4 (64.8)	474.6 (78.8)
	Reaction time: Incongruent	545.4 (86.8)	516.0 (84.1)	555.3 (136.8)	514.5 (63.1)	520.7 (58.5)	523.4 (92.8)
	Accurracy (%)	99.2 (1.9)	97.9 (2.5)	98.3 (2.4)	98.3 (2.4)	98.8 (2.2)	98.3 (2.4)
Working Memory	Reaction time	688.7 (107.5)	682.0 (131.0)	721.3 (102.2)	681.3 (109.8)	709.7 (108.5)	695.0 (130.5)
	Accurracy (%)	76.7 (11.2)	79.8 (16.5)	74.9 (8.1)	83.1 (9.5)	84.8 (9,4)	76.6 (11.1)

For the Erikson Flanker test, for all workstations the mean congruent reaction time was less than the mean incongruent reaction time. The quickest mean congruent reaction time was measured for the standing workstation (470.9 ms), with the slowest measured for the LBS1 workstation (497.0 ms). The quickest mean incongruent reaction time was measured for the LBS2 workstation (514.5 ms), with the slowest measured for the LBS1 workstation (555.3 ms). The highest percent of correct responses was obtained for the seated workstation (99.2%) and the lowest was for the standing workstation (97.9%). The accuracy for this task also had the smallest standard deviations for the workstations compared to the standard deviations for the accuracy of the other tasks. The quickest mean reaction time for the memory test was recorded for the LBS2 workstation (681.3 ms) and the slowest was for the LBS1 workstation (721.3 ms). The highest percent of correct responses was recorded for the WS1 workstation (84.8%), and the lowest was for the LBS1 workstation (74.9%).

Noticeable was that for all tasks, the mean reaction times were higher for the lower intensity than the higher intensity for both the LBS and the WS workstations with exception to the incongruent reaction time of the Erikson Flanker test at the WS workstations. With regards to percent of correct responses, each workstation condition except the workstation LBS2 and the standing workstation, had the highest accurracy for one of the cognitive tasks.

4 Discussion

In this research, a group of basic tasks which contribute to daily office work was assessed to determine the effect of the type of workstation they were performed at for several different performance characteristics. As the inferential statistical analysis has not yet been completed, the results can only be very briefly and generally discussed.

For reading, the workstation that yielded the least characters read and least number of correctly identified errors was the WS1 but the most characters read were for the workstation WS2 and the most identified errors was for the workstation LBS2.

The lowest mean performance results for both the typing and the mouse dexterity tasks of the workstation WS2 may be attributed to biomechanical factors. During walking, specifically at the higher speed when compared to the workstation WS1, the individual was less stable as a result of the small movements of the upper trunk produced during walking [13], and despite supporting the upper limbs on the treadmill desk, the upper limb fine motor movements were affected and consequently both speed and accuracy were impaired.

The mean performance values, for both of the mouse dexterity tasks, for the LBS workstations were not as low as for the WS stations, which may also be explained by biomechanical factors. Potentially as a result of the backrest and that the upper body may have moved less during cycling at the LBS workstations, and a more stable base may have been provided in the seated position than during walking [13].

The performance results, both objective and subjective, for the telephone task, did not show large differences between the workstations and these differences may even prove to be negligible with further statistical analysis.

Available literature provides contradicting information regarding the effect of moderate and acute exercise on basic cognitive processes [6-7]. The mean descriptive

results from the cognitive tasks appear confounding as some tasks obtained a higher performance score with regards to accuracy or reaction time at the dynamic workstations and some at the conventional workstations. This may have been as a result of the different task demands between the cognitive tasks. For all of the above described results, more comprehensive statistical analyses are required before drawing substantial conclusions.

5 Conclusion

Numerous studies have shown that physical activity not only promotes physical health but may also be associated with a long term positive effect on cognitive ability. This further highlights the need to incorporate physical activity more in everyday life. Pending further statistical analysis, this research may have practical implications by contributing to the knowledge required for providing guidelines for implementing these types of workstations into the work environment and determining the most suitable type of work to perform at these types of workstations.

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