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Effects of Using Standing Versus Sitting Workstations on the Well-Being at Work of Software Professionals

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Abstract

Although people admittedly are one of the most valuable assets of many software companies, relatively little academic research has been done from the well-being at work aspect of software professionals. This intervention study aims to address this gap in prior research by examining the potential effects of using standing instead of sitting workstations on the well-being at work of software professionals in terms of physical activity, mental alertness, and stress. The two measurements before and after the intervention were conducted in June and September 2015 for 29 employees of a local site of a large Finnish software company by using questionnaires and the Firstbeat Lifestyle Assessment service. The findings of the study suggest that using standing instead of sitting workstations results in only modest promotions of physical activity, does not to have an effect on mental alertness, and actually tilts the stress–recovery balance more towards stress, as least at the early phases of usage.

Keywords: Software Professionals, Standing Workstations, Sitting Workstations, Well-Being at Work, Physical Activity, Mental Alertness, Stress

1 Introduction

According to an old saying, people are the most valuable asset of a company. Although this traditional wisdom has lately begun to lose its validity due to more and more widespread usage of machines to substitute for human work, it still remains as true as ever especially in the software industry, where humans are still responsible for most of the creative engineering work related to various software products and services. Against this background, it is surprising how little academic research has actually been done from the well-being at work aspect of software as well as other information systems (IS) and information technology (IT) professionals. One particular aspect that has been entirely omitted are the effects of work posture on well-being at work. In this study, we aim to address this gap in prior research by examining what kinds of effects the usage of new types of workstation alternatives that substitute sitting for standing have on the well-being at work of software professionals. This topic can be considered an important one because although the potential dangers of prolonged sedentary behaviour and the potential benefits of using standing versus sitting workstations have previously been studied from a general perspective, the software profession possesses some special characteristics that set it apart from many other sedentary occupations and merit more context-specific examinations. For one, the software profession is a very mentally demanding occupation that requires high levels of mental alertness from its practitioners, typically throughout the working day when they are, for example, attempting to create solutions for complex computational problems or finding errors in thousands or even millions of lines of code. Perhaps partly because of this, software professionals have also been found to face very high levels of occupational stress and work exhaustion (e.g., Advani et al., 2005; Chilton, Hardgrave & Armstrong, 2005; Rajeswari & Anantharaman, 2005; Singh, Suar & Leiter, 2012; Amin et al., 2013). Therefore, it is interesting to study what kinds of benefits the usage of standing versus sitting workstations can provide in this specific context, not only in terms of promoting the physical activity, but also in terms of potentially promoting the mental alertness and reducing the stress levels of software professionals.

This paper consists of six sections. After this introductory section, we briefly discuss prior research on the topic in Section 2. Sections 3 and 4 present the methodology and results of the study. The results are discussed in more detail in Section 5, which also uses them to draw implications for both theory and practice. Finally, Section 6 considers the limitations of the study and potential paths of future research.

2 Prior Research

As it was already mentioned in the introduction, the well-being at work aspect of IS and IT professionals in general, as well as software professionals in particular, has received relatively little attention in academic research. For example, in the more general IS and IT context, most prior studies have concentrated only on the quite limited "ill-being" themes of occupational stress, work exhaustion, and "burnout" (e.g., Ivancevich, Napier & Wetherbe, 1983, 1985; Weiss, 1983; Li & Shani, 1991; King & Sethi, 1997; Sethi, Barrier & King, 1999; Moore, 2000; Thong & Yap, 2000; Sethi, King & Quick, 2004; Pawlowski, Kaganer & Carter, 2007), which have typically been the most commonly studied themes also in the more specific software context (e.g., Sonnentag et al., 1994; Advani et al., 2005; Chilton, Hardgrave & Armstrong, 2005; Rajeswari & Anantharaman, 2005; Singh, Suar & Leiter, 2012; Amin et al., 2013). In contrast, few studies have adopted a more holistic view of the topic, with the most prominent exceptions being the studies concentrating on themes like quality of work life (Igbaria, Parasuraman & Badawy, 1994; Rethinam & Maimunah, 2007; Korunka, Hoonakker & Carayon, 2008) and work–life balance (Hyman et al., 2003; Scholarios & Marks, 2004). However, no prior studies have concentrated on sedentary behaviour and workstation alternatives aspects in the context of software professionals.

Up to now, numerous studies have associated sitting, or more generally sedentary behaviour, with several serious physiological, psychological, and social issues, such as weight gain and obesity, cardiovascular diseases, diabetes, depression, cancer, and ultimately premature mortality (Teychenne, Ball & Salmon, 2010; Tremblay et al., 2010; Proper et al., 2011; Thorp et al., 2011, Wilmot et al., 2012). Therefore, it seems obvious that sitting for prolonged periods of time and the resulting physical inactivity is simply not good for our health and well-being. As a way to combat these issues especially in office environments, new types of alternatives to the traditional sitting workstations have been proposed. According to a taxonomy presented by Tudor-Locke et al. (2014), these can be divided by (a) *movement* into *static* or *active* alternatives, (b) *position* into *fixed* or *adjustable* alternatives, and (c) *posture* into *seated* or *upright* alternatives. Examples of them include sitting workstations that require a worker to sit on a stability ball, standing workstations that require a worker to stand continuously, adjustable sit–stand workstations that accommodate both sitting and standing, treadmill workstations that accommodate walking or running while working, and pedal workstations that accommodate pedalling or stepping while working.

All in all, the findings of prior studies on the effects of using the aforementioned new workstation alternatives instead of the traditional sitting workstations have been quite mixed (e.g., Neuhaus et al., 2014; Torbeyns et al., 2014; Tudor-Locke et al., 2014; Cao et al., 2015; MacEwen, MacDonald & Burr, 2015), which can be explained not only by the differences in how the studies were conducted, but also by the different settings in which they were conducted. For example, some have concentrated only on laboratory settings and others on real-life office settings. In addition, in the real-life office settings, the exact case context and profession under examination is likely to significantly influence the findings, which once again emphasises the need for not only general level examinations on the topic, but also more context-specific studies concentrating on a specific line of profession, such as software profession.

3 Methodology

The research setting of this study was based on the relocation of the local site of a large Finnish software company from old to new office premises during the late summer and early autumn of 2015. In the old premises, most of the employees had been using traditional sitting workstations, whereas in the new premises all of them would have adjustable workstations, which they could use in either sitting or standing position. This offered us an ideal setting for an intervention study, in which we first measured the well-being at work of the employees before the relocation and then repeated these measurements after the relocation while asking the employees to use their adjustable workstations mainly in the standing instead of sitting position. These two measurements, which are from now on referred to as measurements A and B, were conducted in June and September 2015.

As participants for the study, we were able to recruit 30 volunteers from the total of 115 employees working at the site. The recruitment process was conducted in co-operation with one manager, who briefly told the employees about the study and also accepted the registrations. After the registration, the 30 participants were divided into an intervention group of 20 people and a control group of 10 people. The division was done partly in random but partly based on the preferences of the participants, because we did not want to force any of them into a particular group due to their voluntary participation. This is also why the group sizes and distributions in terms of gender, age, and work position ended up being not entirely balanced. The members of the intervention group sat during measurement A and stood during measurement B. In contrast, the members of the control group retained their work posture the same during both the measurements. Of them, nine sat during both the measurements, whereas the remaining one person had been working in a standing posture already in the old premises and retained this posture also in the new premises.

During the measurements, we employed three different measurement instruments to measure the potential changes in our three variables of interest: physical activity, mental alertness, and stress. All the measurements were conducted identically for both the groups. The first measurement instrument was a questionnaire, part of which the participants filled in offline by using pen and paper and part of which they filled in online by using a computer or a mobile phone. It contained several questions and rateable statements related to well-being at work, of which the relevant one for this study was a set of ten statements rated with a standard 5-point Likert scale, which concerned and were used to control the potential changes in the overall life situation of the participants between the measurements. Such control was obviously important because if there had been significant changes in the overall life situation of the participants, it would have been impossible to say whether the potential alterations in their well-being at work were actually caused by these changes rather than by the investigated intervention. However, if the overall life situation of the participants had remained unchanged, it was more likely that the investigated intervention was the prime cause for the potential alternations in their well-being at work.

The second measurement instrument was another questionnaire, which was used to measure the changes in the mental alertness of the participants based on their self-reported scores from three days at four different times of a day: at the beginning of a working day, before lunch, after lunch, and at the end of a working day. That is, this questionnaire was not filled in only once at the beginning of each measurement but continuously during the measurements. The questionnaire was pen-and-paper based and used the Karolinska sleepiness scale (KSS) as a measurement scale. KSS is a 9-point verbally anchored scale, in which the response options range from extreme alertness to extreme sleepiness (Åkerstedt & Gillberg, 1990). KSS has been successfully applied to various contexts, such as driving (e.g., Kecklund & Åkerstedt, 1993; Horne & Reyner, 1996) as well as shift work (e.g., Lowden et al., 1998; Sallinen et al., 1998), and it has been found as a highly valid scale for measuring sleepiness (Kaida et al., 2006). Thus, inversely, it can be considered a valid scale for measuring also alertness.

As the third measurement instrument, we employed the Firstbeat Lifestyle Assessment service, in which the participants were asked to wear a Firstbeat Bodyguard heart rate monitor continuously for three days (both day and night but excluding showers and other situations of extreme humidity) and to report their daily activities as well as information on their potential usage of medicines and alcohol to an online diary by using a computer or mobile phone. This collected data was then analysed by using the Firstbeat Analysis Server to produce reports on their well-being. The variables in these Firstbeat Lifestyle Assessment reports included not only basic heart rate (HR), but also various other physiological variables estimated from heart rate variability (HRV), such as respiration rate (RR), oxygen consumption (VO_2), and energy expenditure (EE). The exact estimation methods are described in more detail in the white papers published by Firstbeat (2012a, 2012c). All the four aforementioned variables (HR, RR, VO_2, and EE) were utilised in this study as measures of physical activity.

In addition, HRV and its known associations with the sympathetic and parasympathetic divisions of the autonomic nervous system (ANS) can also be used to make estimations on the physiological states of the assessed individuals, such as the balance between stress and recovery. Also this estimation method is described more detail in a white paper published by Firstbeat (2012b). In the Firstbeat Lifestyle Assessment reports, the estimations are presented as profiles exemplified in Appendix A, in which the red bars indicate a stress state and the green bars indicate a recovery state. In addition, the profiles contain light and dark blue bars. These indicate the states of more intensive physical activity, in which one's VO_2 rises to 20–30 % (light blue) or to over 30 % (dark blue) of one's maximum VO_2. However, these states were not of interest in this study. The height of the bars represents the intensity of the respective physiological state, but on a subjective scale relative to one's maximum and minimum intensity, which does not enable comparisons between individuals. Therefore, from the reported profiles, we utilised only the ratio between stress and recovery time, which we from now on refer to as stress–recovery balance.

Both measurements lasted three days, and although the data obtained from the Firstbeat Lifestyle Assessment service covered also non-work time, only the work time data based on the work times self-reported by the participants to the online diary was included in the analysis. In addition, any unusual off-workstation times, such as working at home, being on a business trip, or running personal errands during work time, were excluded from the analysed data. The analysis of the data was done with the SPSS Statistics version 22 software by using the Student's t-test for paired samples to test the statistical significance of the potential changes between the measurements. As a precaution, we also replicated these tests by using the Wilcoxon signed rank test to make sure that our small sample and the slightly non-normal distributions of data did not distort the results. The results of both the tests were practically identical in terms of statistical significance.

4 Results

As mentioned in the previous section, we were able recruit a total of 30 participants for our study, of whom 20 were placed in the intervention group and 10 were placed in the control group. However, between the measurements, there was one dropout in the control group, which resulted in an actual sample size of 29 participants, of whom 20 were placed in the intervention group and 9 were placed in the control group. The descriptive statistics of this sample in terms of gender, age, and work position are reported in Table 1. Here, the non-manager level positions include work titles such as software developer, software specialist, systems architect, systems designer, and documentation specialist. In contrast, the manager level positions include work titles such as project manager, group manager, development manager, product manager, and quality manager. In terms of the data from the Firstbeat Lifestyle Assessment service, the amount of analysed data was about 655.2 hours for measurement A and about 671.4 hours for measurement B, which averages to about 22.6 hours and 23.2 hours per participant, respectively.

	All		Intervention		Control	
	N	%	N	%	N	%
Gender						
Male	22	75.9	13	65.0	9	100.0
Female	7	24.1	7	35.0	0	0.0
Age						
–30 years	1	3.4	0	0.0	1	11.1
30–39 years	11	37.9	8	40.0	3	33.3
40–49 years	14	48.3	11	55.0	3	33.3
50–59 years	2	6.9	1	5.0	1	11.1
60– years	1	3.4	0	0.0	1	11.1
Position						
Non-manager	17	58.6	13	65.0	4	44.4
Manager	12	41.4	7	35.0	5	55.6

Table 1: Sample statistics (N = 29)

4.1 Life Situation

Table 2 reports the ratings given by the intervention group (N = 20) and control group (N = 9) to the ten statements on their overall life situation as well as the results of the Student's t-tests that were used to examine the statistical significance of the potential changes in these ratings between measurements A and B. The rating scale that was used ranged from 1 = strong disagreement to 5 = strong agreement. As can be seen, there were no statistically significant changes in any of the areas covered by the ten statements between the measurements, at least when examined at a group level. This suggests that if any differences in the measurement results of the intervention group are found in the next two subsections, they are more likely to be caused by the investigated intervention rather than by other factors, such as the changes in the overall life situation of the participants.

	N	A		B		Difference				
		Mean	SD	Mean	SD	Δ	SD	t	df	p
I think I am physically active enough to get health benefits	20	3.6	1.2	3.4	1.4	-0.2	0.7	-1.000	19	0.330
	9	3.1	1.6	3.3	1.6	0.2	0.7	1.000	8	0.347
I think my physical activity is intensive enough to improve my fitness	20	3.4	1.2	3.4	1.3	0.1	0.9	0.237	19	0.815
	9	3.3	1.6	3.4	1.7	0.1	0.8	0.426	8	0.681
In my opinion, my eating habits are healthy	20	4.2	0.7	4.3	0.6	0.1	0.7	0.326	19	0.748
	9	3.9	0.9	3.9	0.8	0.0	0.9	0.000	8	1.000
I feel that my alcohol consumption is not excessive	20	4.7	0.7	4.7	0.8	-0.1	0.4	-0.567	19	0.577
	9	4.4	1.0	5.0	0.0	0.6	1.0	1.644	8	0.139
I don't generally feel stressed	20	3.0	1.4	3.0	1.3	0.1	1.2	0.181	19	0.858
	9	2.3	1.3	2.1	0.8	-0.2	1.5	-0.450	8	0.665
My days include breaks that allow me to recover	20	3.9	1.1	4.0	0.9	0.2	1.0	0.645	19	0.527
	9	4.0	0.5	3.4	1.0	-0.6	1.0	-1.644	8	0.139
I usually feel rested and energetic	20	3.5	1.2	3.4	1.0	-0.1	0.6	-0.370	19	0.716
	9	3.2	1.2	3.1	0.9	-0.1	1.4	-0.244	8	0.813
I feel that I sleep enough	20	3.2	1.2	3.3	1.0	0.1	1.1	0.213	19	0.834
	9	3.0	1.3	2.8	1.1	-0.2	1.3	-0.512	8	0.622
I feel that I can influence the things that affect my health	20	4.5	0.6	4.5	0.6	0.1	0.5	0.438	19	0.666
	9	4.4	0.7	4.2	0.8	-0.2	0.8	-0.800	8	0.447
In my opinion, I feel well at the moment	20	3.9	1.0	4.2	0.5	0.3	0.9	1.552	19	0.137
	9	3.4	1.0	3.6	1.0	0.1	0.9	0.359	8	0.729

Table 2: Results on overall life situation (bolded are statistically significant at $p < 0.05$)

4.2 Physiological Activity and Stress

Table 3 reports the results obtained from the Firstbeat Lifestyle Assessment service for the intervention group (N = 20) and control group (N = 9) as well as the results of the Student's t-tests that were used to examine the statistical significance of the potential changes in these results between measurements A and B. Here, HR, RR, VO_2, and EE are all mean values of the measurements. As can be seen, there was a statistically significant change in the physical activity of the intervention group between the measurements in terms of HR, VO_2, and EE, with an average increase in HR of 4.2 beats per minute, in VO_2 of 0.3 ml per kg per minute, and in EE of 10.2 kcal per hour. Also RR seemed to have increased slightly, but this change was not statistically significant. In contrast, practically no change was found in the physical activity of the control group between the measurements in terms of any of the four variables.

The stress–recovery balance variable, indicating the ratio of the time spent by an individual in stress and recovery states, was scaled to vary from -1 to 1, in which -1 indicates time spent only in stress state and not at all in recovery state, 0 indicates an equal amount of time spent in both states, and 1 indicates time spent only in recovery state and not at all in stress state. As can be seen, there was a statistically significant change in the stress–recovery balance of the intervention group between the measurements, with a considerable increase in the amount of time spent in stress state. In contrast, in the control group, there seemed to be a slight increase in the amount of time spent in recovery state between the measurements, but this change in the stress–recovery balance was not statistically significant.

	N	A		B		Difference				
		Mean	SD	Mean	SD	Δ	SD	t	df	p
Heart rate (beats / min)	20	72.0	10.5	76.2	9.4	4.2	5.7	3.303	19	**0.004**
	9	70.0	7.7	69.5	7.9	-0.6	3.0	-0.550	8	0.597
Respiration rate (breaths / min)	20	13.4	1.5	13.5	1.8	0.2	0.8	0.931	19	0.364
	9	12.7	1.8	12.7	2.0	0.0	0.4	0.141	8	0.891
O_2 consumption (ml / kg / min)	20	4.1	0.7	4.4	0.8	0.3	0.5	2.804	19	**0.011**
	9	3.9	1.0	3.9	1.0	0.0	0.2	0.342	8	0.741
Energy expenditure (kcal / h)	20	92.8	35.4	98.9	35.1	6.1	10.2	2.666	19	**0.015**
	9	98.6	39.7	98.5	36.3	-0.1	5.6	-0.054	8	0.958
Stress–recovery balance (from -1 to 1)	20	-0.68	0.46	-0.90	0.17	-0.22	0.40	-2.418	19	**0.026**
	9	-0.75	0.20	-0.66	0.38	0.10	0.23	1.256	8	0.244

Table 3: Results on physical activity and stress (bolded are statistically significant at $p < 0.05$)

4.3 Mental Alertness

Table 4 reports the ratings given by the intervention group (N = 20) and control group (N = 9) on their mental alertness at four different times a day as well as the results of the Student's t-tests that were used to examine the statistical significance of potential changes in these ratings between measurements A and B. As the rating scale, we used an inverted version of KSS in order to better reflect that we were measuring alertness and not sleepiness, meaning that the rating scale ranged from 1 = extremely sleepy to 9 = extremely alert. As can be seen, there were no statistically significant changes in the mental alertness of the intervention group or the control group between the measurements, although there seemed to be, for example, a slight decrease in the mental alertness of the intervention group before lunch as well as in the mental alertness of the control group at the end of a working day. In addition, there also seemed to be a slight increase in the mental alertness of the control group both before and after lunch, of which the latter was also the change that was closest to being statistically significant.

	N	A		B		Difference				
		Mean	SD	Mean	SD	Δ	SD	t	df	p
Beginning of a working day	20	6.3	1.1	6.3	1.1	0.1	1.3	0.207	19	0.838
	9	5.9	1.0	5.9	0.7	0.0	0.8	0.000	8	1.000
Before lunch	20	6.8	1.1	6.4	0.8	-0.4	1.1	-1.765	19	0.094
	9	6.2	0.7	6.5	0.9	0.3	1.0	0.815	8	0.439
After lunch	20	6.2	0.9	6.1	0.9	-0.0	1.1	-0.132	19	0.896
	9	6.0	0.8	6.3	0.9	0.4	0.5	2.169	8	0.062
End of a working day	20	5.9	1.2	6.0	1.1	0.2	1.0	0.691	19	0.498
	9	6.3	0.9	5.7	0.7	-0.6	1.1	-1.631	8	0.142

Table 4: Results on mental alertness (bolded are statistically significant at $p < 0.05$)

5 Discussion and Conclusions

In this study, we examined the potential effects of using standing instead of sitting workstations on the well-being at work of software professionals in terms of physical activity, mental alertness, and stress. The findings of the study suggest that also in the context of software professionals, the usage of standing instead of sitting workstations results in a promotion of physical activity, although a relatively modest one, with an average increase in HR of 4.2 beats per minute, in VO_2 of 0.3 ml per kg per minute, and in EE of 10.2 kcal per hour. These findings are in line with those of prior studies, which have reported increases in HR varying from 3.6 beats per minute to 13.2 beats per minute and increases in EE varying from 4.1 kcal per hour to 20.4 kcal per hour (MacEwen, MacDonald & Burr, 2015). In practice, this means that during a typical eight-hour working day, one is able consume only about 80 kcal more when using standing instead of sitting workstations, equalling approximately to one large apple. Thus, also in the context software professionals, we concur with the general position presented previously by Tudor-Locke et al. (2014) that standing workstations cannot be considered an efficient tool for short-term weight management, although they are likely to have other health benefits typically associated with the reduction in sedentary time. However, in a longer term, the changes in energy balance of even this magnitude may potentially be enough to prevent weight gain (Hill et al., 2003).

In contrast, the effects of using standing instead of sitting workstations on mental alertness of software professionals were found to be almost non-existing, suggesting that standing workstations cannot also be considered an efficient tool for promoting the work performance of software professionals by enabling them to perform better especially in tasks requiring intensive concentration. However, the findings do not suggest that standing workstations would hinder the work performance of software professionals either, meaning that their adoption is not likely to entail any significant risks from this point of view. Also these findings are in line with those of prior studies, which have, for example, presented only relatively weak evidence for the ability of using standing instead of sitting workstations to reduce fatigue (Neuhaus et al., 2014; MacEwen, MacDonald & Burr, 2015). In this respect, rather than just changing one static posture to another, a more essential issue would seem to be dynamic postural variety (e.g., Hasegawa et al., 2001), suggesting that also in the context of software professionals, more attention should be paid to the frequent changes of work posture.

Finally, in terms of stress, the usage of standing instead of sitting workstations was not found to reduce stress time and add more recovery breaks to the working days of software professionals, which have been suggested as critical, for example, in terms of supporting creativity (Elsbach & Hargadon, 2006). In contrast, the effects were found to be exactly the opposite, thus suggesting that the usage of standing workstations cannot also be considered an efficient tool for stress management in the context of software professionals. However, here, it must be noted that our measurements of stress in this study were based on ANS balance as described in the methodology, in which stress can be broadly defined as increased activation of the body caused by the domination of the sympathetic division over the parasympathetic division (Firstbeat, 2016b). Thus, the measurements cannot, for example, separate between the so-called "bad" stress with negative feelings and the so-called "good" stress with positive feelings, making interpretations more difficult. It is also difficult to compare our findings to those of prior studies because none of them seem to have measured stress in a similar manner than in this study. However, related to stress, the usage of standing instead of sitting workstations has been found to have positive effects on mental well-being and mood (Neuhaus et al., 2014; MacEwen, MacDonald & Burr, 2015), which can be seen as indications of reduced stress and, thus, would seem to conflict with our findings. However, because of the aforementioned interpretation issues, it is difficult to say whether this conflict actually exists without further examinations.

From a theoretical point of view, this study extends the perspective of the prior studies on the well-being at work of software professionals in particular as well as IS and IT professionals in general from the traditional "ill-being" themes of occupational stress, work exhaustion, and "burnout" to the novel themes of sedentary behaviour and workstation alternatives, which have not been researched in this specific context by any prior studies of which we are aware of. At the same time, it also contributes to the more general research on these themes by illustrating that many of the findings of the prior studies on sedentary behaviour and workstation alternatives are applicable also to the specific context of software professionals. From a practical point of view, the findings of the study offer the managers of software companies insights on the potential of the new types of workstation alternatives to promote the well-being at work of software professionals, which they can use as a basis of their decisions to invest or not to invest in them in the future.

6 Limitation and Future Research

We consider this study to have five main limitations. First, we collected the data only from 29 software professionals working in one site of one Finnish software company, which obviously limits the generalisability of our findings. In addition, when dividing this sample into an intervention and control group, the division was partly based on the preferences of the participants, which resulted in less than ideally balanced group sizes and distributions in terms of gender, age, and work position and may have introduced some bias into the findings. Thus, future studies should replicate the study also in other companies both in Finland and in other countries by using larger samples consisting ideally of at least a few hundred participants. The division of the participants into an intervention and control group of approximately the same size should also be done totally at random.

Second, although we tried to control the potential effects of any external factors by using a control group and control variables in our study setting, it is difficult to reliably determine how much of the changes in the well-being at work of the participants can actually be attributed to the investigated intervention of using standing instead of sitting workstations and how much to these other factors. For example, when moving from the old to the new premises, the participants were not only provided with new workstations, but they were also subjected to several other changes, such as the change of the whole office layout towards a more open-plan theme and the relocation of the premises from 10th and 11th floors to 3rd and 4th floors. The potential effects of such external factors should by placed under even tighter scrutiny in future studies.

Third, a control variable that was completely missing in our study was the measure of the actual sitting and standing times, because although we had requested the participants to report also this data to the online diary, only a few of them complied with this request. This data would have been very valuable, because in a real-life office setting, the participants obviously did not sit or stand at their workstations all the time but had lunch, coffee, and toilet breaks, attended meetings, and so on. Thus, future studies should collect also this data, preferably in an as automated manner as possible by using activity bracelets or other corresponding technologies.

Fourth, the duration of our study was relatively short because only two measurements lasting three days were conducted, during the latter of which many participants started using standing workstations for the very first time. This obviously limits our findings only to short-term effects of using standing instead of sitting workstations and makes it difficult to say anything conclusive about the longer-term effects. Thus, future studies would benefit from more longitudinal study settings consisting of more than only two measurements and lasting ideally at least one year.

Fifth, as already mentioned in the conclusions, the study concentrated on measuring stress from a quite limited physiological aspect, meaning that future studies would also benefit from better considering its psychological and other aspects, such as individual differences in experiencing stress. In addition, the current measurements obtained from the Firstbeat Lifestyle Assessment service must be interpreted by bearing in mind that the service does not have a medical classification. However, its estimates on oxygen consumption and energy expenditure have been found as sufficiently accurate for field studies (e.g., Montgomery et al., 2009; Smolander et al., 2008; Smolander et al., 2011), and many prior studies have successfully used the service as a measurement instrument of these variables (e.g., Finni et al., 2014; Mutikainen et al., 2014) as well as stress (e.g., Salonen et al., 2013; Jaatinen et al., 2014; Föhr et al., 2015).

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Appendix A: Firstbeat Lifestyle Assessment Report

Person: HR Manager Case

Age	47	Activity Class	4.0 (Average)
Height (cm)	170	Resting heart rate	36
Weight (kg)	62	Max. heart rate	189
Body Mass Index	21.5		

Measurement:

Start time	Mon 01.10.2012 06:00
Duration	24h 0min
Heart rate (low/avg./high)	39 / 62 / 126

Additional information: Alcohol 2 units