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Research Article

Standing and Dynamic Sitting: Effects on University Classroom Performance – A Pilot Study

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ABSTRACT

Background: There are health risks associated with prolonged periods of sitting. A concern with interventions to reduce sitting is performance may suffer.

Purpose: This pilot study investigated the effect of alternative posture on classroom performance.

Methods: University students (*N*=20) listened to three 50-minute lectures followed by three quizzes pertaining to the lectures, performed cognitive tasks, and rated their discomfort, ease, enjoyment, focus, and future use after each condition. For the main results, one-way repeated measures ANOVA were used to examine for differences across classic sitting, dynamic sitting, and standing conditions.

Results: Classroom performance, cognitive performance, enjoyment, and focus do not suffer by changing students' anatomical position from classic sitting. However, standing posture may cause more discomfort and difficulty for some students.

Conclusion: At this early stage of inquiry there is no evidence to recommend against providing dynamic sitting and standing options in university classrooms to allow students to receive health benefits as they learn.

Keywords: University student; Sedentary behaviour; Standing; Dynamic sitting; Classroom performance

INTRODUCTION

Sedentary behavior is any waking behavior characterized by an energy expenditure ≤1.5 Metabolic Equivalents (METs), while in a sitting, reclining, or lying posture [1]. Increased sedentary behavior, independent of Moderate-to-Vigorous Physical Activity (MVPA), is a risk factor for many health problems including but not limited to: diabetes, cardiovascular disease, cancer, and depression [2-5]. Ekelund et al. found that individuals need to accumulate 60-75 minutes of daily MVPA to eliminate the risk of all-cause mortality, as long as daily sitting time does not exceed 8 hours per day [6]. Unfortunately, the average Canadian adult is sedentary for approximately 9.5 hours of their waking day [7]. These trends are not only apparent in Canada but are happening worldwide [8].

Both behavioral and environmental interventions to reduce sedentary time have received a substantial amount of research attention over the past 10 years. Examples of behavioral components of interventions to reduce sedentary behavior include text-based messages [9,10], telephone calls [11], email reminders [12], and providing feedback to the amount of time spent sedentary and active [13,14]. Examples of environmental changes are the use of a standing desk, dynamic sitting chair (i.e. sit in a more active way: chairs without back support, unstable chairs, exercise balls, etc.), and other environmental workplace designs that promote less sedentary behavior [15]. Dynamic sitting chairs, such as the stability ball desk [16], sit-stand workstations [17], active treadmill workstations [18], cycling workstations [14] and active elliptical workstations [19] have been shown to improve body composition (e.g., fat percentage) [14] and cardiometabolic profiles (e.g., total cholesterol) [17] as well as increase energy expenditure [16,18,19]. Butler, et al. investigated the effects of standing in the college classroom on cardiometabolic risk factors [20]. Researchers found significant changes in cardiometabolic health after only 3 weeks.

University students spend more than 11 hours per day being sedentary [21,22]. One area where sedentary behavior can be reduced for university students is in the classroom. At present, students are forced to sit in a static position for all their lectures, every day, for their whole university degree. This accumulates to large sums of forced sedentary behavior. Standing and dynamic sitting postures are a way to reduce university classroom sedentary

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behavior. Active breaks during class could be used to aid in breaking up sedentary time during class [23]; however, environmental manipulations such as standing and dynamic sitting options are likely less disruptive and eliminate sedentary behavior during their use. Some university classes require students to be sedentary for 50 minutes before moving to a different classroom for their next lecture. Further, many students have multiple lectures that require them to stay in the same classroom. Although there are no specific adult guidelines for sedentary behavior at this time, 50 minutes of continuous sedentary behavior is much longer than the current beneficial break time of 2-4 minute every 20 minutes of sitting [24]. Additionally, research shows that sitting less than 3 hours per day could result in a 2-year gain in life expectancy [25] and sitting less than 4 hours per day reduces all-cause mortality [26]. Furthermore, studies have shown that those who led a sedentary lifestyle in university remain sedentary 10 years later [27].

A concern with these alternative posture options is that performance will be reduced. However, reviews concluded that sit-stand and active workstations in office workers do not cause a decrease in performance [18,28-31]. Additionally, recent systematic reviews on the effects of standing desks within the primary/elementary school classroom found increased energy expenditure, reduced sedentary behavior, and no detrimental effect on classroom behavior and learning [32-34]. Researchers stress the importance of assessing these interventions with secondary/ high school and college/ university students, as reducing sedentary behavior is needed throughout the life span [33].

Tasks university students have to perform specifically in the classroom (i.e., listen, record, and recall lecture material) are sufficiently different from those of office workers. University classes are typically large, quicker paced, and in most cases have restricted teacher contact time. Classroom performance, therefore, is likely held at a premium for university students and many may choose not to use standing and dynamic sitting postures if there is doubt that their performance will suffer. A recent study found that college students significantly reduced their sedentary behaviour when provided sit-stand desks [35]. They also reported high favourability for the sit-stand desks and improvements in self-reported student engagement and affective outcomes while using the sit-stand desks [35]. Pertinent to the present study, they further reported no change in academic performance after using a sit-stand desk. However, experimental evidence is warranted to show that performance in the university classroom is not compromised by the introduction of standing and dynamic sitting postures to reduce sedentary behavior.

To our knowledge, only one published study has objectively examined the effects of alternative postures on objective classroom performance of university students. In that study, Smith and Prapavessis had students (*N*=40) perform three 3-minute classroom simulations including a typing and memory task under classic sitting, dynamic sitting, and standing posture conditions [34]. Results showed no significant difference in the typing, memory, or perception between the classic sitting, dynamic sitting, and standing postures. A limitation with this work is that the classroom performance tasks were performed for only 3 minutes under each condition. Consequently, they could only speculate that the findings would hold over a longer typical university class time of 50 minutes.

Hence, the purpose of this pilot study was to investigate the effect of classic sitting, dynamic sitting, and standing posture during a longer, ecologically valid class time of 50 minutes. Pilot studies are valuable in acquiring essential information about the methods and procedures (e.g. assessing processes such as recruitment, treatment, and follow-up as well as effect size estimates) before beginning a large adequately powered randomized control trial [36,37]. The primary outcome was classroom performance (retention of actual lecture material). Secondary outcomes were cognitive performance (attention, perceptual performance, executive memory performance, and working memory performance) and self-reported measures of discomfort, ease, enjoyment, focus, and likelihood of future use. The main hypothesis was that no significant difference would be found among the 3 postures (i.e., sitting, dynamic sitting, and standing) with respect to classroom performance. Secondary hypotheses were that no significant differences would be found among the 3 postures for any of the cognitive performance and self-reported measures. In addition, we expected to show a negative correlation between the rating of discomfort and the likelihood of alternative use.

METHODS

Participants

Participants were students from the University of Western Ontario and their demographic characteristics can be found in Table 1. Students older than 18 years of age and fluent in English were eligible to participate. Participants with musculoskeletal deficits were ineligible to participate. Participants were recruited by responding to advertisement forms. Eligible participants were enrolled into the study on a first come, first serve basis. Participants and researchers were not blinded. There were no dropouts and all participants complied with the intervention (i.e. used the assigned posture during the whole assessment). All participants were recruited, and data were collected over a 1-month period. Participants provided informed written consent to participate in the intervention and were compensated $30 for 3 hours of their time (3x1 hour). The Western University Health Science Research Ethics Board approved the research intervention.

Design, intervention, and outcome measures

The intervention followed a within subject counterbalanced design. This design was chosen to reduce errors associated with individual differences and increase statistical power [38]. Each participant used a classic sitting, dynamic sitting, and standing condition in a random order. The classic sitting condition is an adjustable computer chair, the dynamic sitting condition resembles a bosu ball on wheels that comes in three sizes (small, medium, and large), and the standing condition has an adjustable keyboard and computer monitor without a chair that can move to any height (Figure 1). The conditions were selected as both standing and dynamic sitting have more feasible and cost-effective potential to be implemented in a university classroom than other alternative workstations, such as sit-stand, treadmill, and cycling desks.

Participants selected one of three dynamic sitting bosu balls (Figure 1, top-left) and adjusted the chairs (Figure 1, bottom-left) and keyboard height (Figure 1, right) to their own comfort. For each posture, the keyboard and computer monitor were the same (Figure 1, right). There was no acclimation period to any of the conditions or tasks. Each posture was maintained for 1 hour (i.e. participants

Figure 1: Classic sitting (bottom left), dynamic sitting (top left), and standing (right) conditions.

were not permitted to change postures during the task). Between each condition, participants were given a 10-minute break; a typical break time interval between 50-minute university classes.

Primary outcome

During each hour, participants listened to 1 of 3 approximately 50-minute online lectures from a University of Western Ontario Professor. The lectures were from the "Classes Without Quizzes" YouTube channel [39-41]. The order of the lectures was randomized. No participants had heard the lecture prior the intervention. While listening to the lecture, students were encouraged to take typed (N=14) or written (N=4) notes as if they were in class. Some participants (N=2) expressed that they typically did not take notes during class, thus they were permitted to solely listen to the lecture. Participants were not assessed on their notes and were not permitted to use their notes during the quiz. Following the lecture, participants were given a 5-minute quiz on the lecture consisting of 5 Multiple Choice (MC) and 5 Fill in the Blank (FB) questions. Classroom performance, the primary outcome, was assessed by correct response to post lecture questions. Quiz questions can be accessed by contacting the primary investigator.

Secondary outcomes

At baseline and following each of the lectures and associated quizzes, secondary outcomes were obtained. Specifically, the speed and accuracy of 4 online cognitive tasks were used to assess attention ("Go/No-go task"), perceptual performance ("Fast Counting task"), executive memory performance ("Eriksen Flanker test") and working memory performance ("N-back" with N=2). These same cognitive tests have been used in research on alternative workstations in office workers [42].

Further secondary outcomes were obtained through self-reported measures. A purpose-built questionnaire was given following each condition to assess discomfort, ease, enjoyment, and focus of participants. All questions used a Likert Scale. The discomfort scale was anchored at 0 by the descriptor "no discomfort" and at 5 by the descriptor "very severe discomfort". The ease scale was anchored at 1 by the descriptor "very difficult" and at 5 by the descriptor "very easy". The enjoyment scale was anchored at 1 by the descriptor "very unenjoyable" and at 5 by the descriptor "very enjoyable". The focus scale was anchored at 1 by the descriptor "very unfocused" and at 5 by the descriptor "very focused". Additionally, a final questionnaire was given at the end of the study to assess the likelihood of students using an alternative posture (i.e., intention), given that it was available, in class. This final questionnaire was anchored at 1 by the descriptor "very unlikely" and at 5 by the descriptor "very likely". Similar Likert scales have been used in within the sedentary behavior literature to assess these types of self-reported perceptions in office workers [43,44]. Questionnaires can be accessed by contacting the primary investigator.

Statistics

Statistics were completed using SPSS (Statistical Package for the Social Science) software 2016 version 24. There was no a priori power calculation due to the pilot study design and novelty of the research question. To check the fidelity of the manipulation, one-way repeated measures ANOVA were used to examine for classroom performance differences between the three quizzes. For the main results, one-way repeated measures ANOVA were used to examine for classroom performance, cognitive performance, and self-reported perception differences across classic sitting, dynamic sitting, and standing conditions. In addition, one-way repeated measures ANOVA were also used to examine any time (order) effect. Pearson R was used to compute the correlation between discomfort rating and likelihood of use.

When appropriate, a Post Hoc Tukey test was conducted. All ANOVAs were accompanied by partial eta square values (η^2_p) to show effect sizes and the level of significance was set at .05. For all statistics tests, any extreme outliers were removed (*Q1-3*IQR* or *Q1+3*IQR*). One extreme outlier was removed for the one-way repeated measures ANOVA by lecture manipulation check. In total, four extreme outliers were removed for the one-way repeated measures ANOVA examining classroom performance (0), cognitive performance (3), and self-reported perception differences (1) by posture (Table 2). In sum, nine extreme outliers were removed for the one-way repeated measures ANOVA examining classroom performance (1), cognitive performance (8), and self-reported perception differences (0) by time (Table 3). There was no missing data to report.

Table 1: Participant demographics.

Characteristics	Percent (%)	Mean	SD
Age (years)		21.85	2.81
BMI (kg/m^2)		23	3.38
Gender			
Male	50%		
Female	50%		
Ethnicity			
Caucasian	55%		
Asian	20%		
Other	25%		
Faculty			
Health Science	35%		
Science	35%		
Engineering/Business	30%		
Degree			
Undergraduate	65%		
Graduate	35%		

Note. BMI: Body Mass Index; kg: Kilogram; m: Meter; SD: Standard Deviation

RESULTS

Research data can be accessed by contacting the primary investigator.

Manipulation (fidelity) check

Manipulation checks confirmed that there was no significant classroom performance differences between the 3 lectures ($F(2,56)=1.85$, $p=0.17$, $\eta^2_p=0.06$).

Primary outcome

Classroom performance: Descriptive data can be found in Tables 2 and 3. There was no significant difference in the classroom performance between the classic sitting, dynamic sitting, and standing conditions ($F(2,57)=0.23$, $p=0.80$, $\eta^2_p=0.08$). There was no significant decline/improvement in classroom performance over time from the first, second, and third lecture ($F(2,56)=1.89$, $p=0.16$, $\eta^2_p=0.06$).

Secondary outcomes

Cognitive performance: Descriptive data can be found in Tables 2 and 3. For the Go/No-Go task, there was no significant difference in the speed ($F(2,57)=0.04$, $p=0.96$, $\eta^2_p=0.01$) between the classic sitting, dynamic sitting, and standing conditions. There was a significant difference in the accuracy ($F(2,54)=3.93$, $p=0.03$, $\eta^2_p=0.13$) between the classic sitting, dynamic sitting, and standing conditions. A post hoc analysis [Tukey] demonstrated a significant

Table 2: Classroom performance, cognitive performance, and self-reported measures with classic sitting, dynamic sitting, and standing.

Outcome	Classic Sitting	Dynamic Sitting	Standing
Classroom Performance[a]	69 (16)	71 (14)	72 (15)
Cognitive Performance[b]			
Go/No-Go	420 (60)/96 (5)	415 (70)/98 (4)	421 (81)/100 (0)
Fast Counting	997 (165)/71 (18)	1007 (159)/72 (17)	1018 (184)/74 (17)
Eriksen Flanker	473 (52)/98 (3)	482 (61)/98 (3)	477 (45)/98 (3)
N-Back	677 (243)/83 (20)	710 (190)/79 (21)	653 (203)/81 (22)
Self-Reported Measures[c]			
Discomfort	0.75 (1.07)	1.05 (1.28)	1.85 (1.39)
Ease	4.74 (0.56)	4.15 (0.93)	3.60 (1.14)
Enjoyment	3.75 (1.07)	3.50 (1.32)	3.20 (1.28)
Focus	3.65 (1.09)	3.50 (0.89)	3.20 (1.15)
Future Use		3.90 (1.21)	2.75 (1.59)

Note. Mean (Standard Deviation).
[a]Classroom performance=Percent of questions answered correct.
[b]Cognitive performance=Speed in millisecond/accuracy as a percent.
[c]Self-reported measures=Rating on 5 point Likert Scale.

Table 3: Classroom performance, cognitive performance, and self-reported measures with the 1st, 2nd, and 3rd hour.

Outcome	1st Hour	2nd Hour	3rd Hour
Classroom Performance[a]	76 (14)	71 (14)	67 (12)
Cognitive Performance[b]			
Go/No-Go	425 (85)/97 (5)	422 (57)/100 (0)	409 (66)/97 (5)
Fast Counting	1084 (167)/64 (18)	989 (143)/75 (14)	949 (166)/77 (17)
Eriksen Flanker	490 (43)/100 (0)	468 (53)/98 (3)	475 (60)/96 (3)
N-Back	753 (222)/75 (26)	662 (212)/86 (12)	624 (175)/86 (15)
Self-Reported Measures[c]			
Discomfor	1.25 (1.25)	1.35 (1.23)	1.05 (1.50)
Ease	4.25 (1.02)	3.90 (1.17)	4.20 (0.95)
Enjoyment	3.55 (1.23)	3.45 (1.36)	3.45 (1.15)
Focus	3.90 (0.97)	3.25 (1.02)	3.20 (1.06)
Note. Mean (Standard Deviation)			

[a]Classroom performance=Percent of questions answered correct.
[b]Cognitive performance=Speed in millisecond/accuracy as a percent.
[c]Self-reported measures=Rating on 5 point Likert Scale.

difference between the classic sitting and standing postures (p=0.02), where participants performed more accurately while in the standing posture. There was no significant difference between the classic sitting and dynamic sitting (p=0.40) or dynamic sitting and standing (p=0.27) postures. There was no significant difference in speed (F(2, 57)=0.27, p=0.76, η^2_p=0.01) or accuracy (F(2, 54)=2.89, p=0.06, η^2_p=0.10) over time from the first, second, and third hour.

For the Fast Counting task, there was no significant difference in the speed (F(2,57)=0.08, p=0.93, η^2_p=0.03) or accuracy (F(2,57)=0.16, p=0.85, η^2_p=0.06) between the classic sitting, dynamic sitting, and standing conditions. There was a significant difference in speed (F(2, 57)=3.79, p=0.03, η^2_p=0.12) and accuracy (F(2, 57)=3.74, p=0.03, η^2_p=0.12) over time from the first, second, and third hour. A post hoc analysis [Tukey] demonstrated a significant difference between the first and third hour for speed (p=0.03) and accuracy (p=0.04), where participants performed faster and more accurately in the third hour. There was no significant difference in speed and accuracy respectively between the first and second hour (p=0.16 and p=0.08) and second and third hour (p=0.70 and p=0.94).

For the Eriksen Flanker task, there was no significant difference in the speed (F(2,57)=0.15, p=0.86, η^2_p=0.05) or accuracy (F(2,57)=0.27, p=0.76, η^2_p=0.09) between the classic sitting, dynamic sitting, and standing conditions. There was no significant difference in speed (F(2, 57)=0.90, p=0.41, η^2_p=0.03) over time from the first, second, and third hour. There was a significant difference in accuracy (F(2, 53)=8.57, p<0.01, η^2_p=0.24) over time from the first, second, and third hour. A post hoc analysis [Tukey] demonstrated a significant difference between the first and third hour (p<0.01), where participants performed less accurately in the third hour. There was no significant difference between the first and second hour (p=0.08) and second and third hour (p=0.11).

For the N-Back task, there was no significant difference in the speed (F(2,57)=0.38, p=0.69, η^2_p=0.13) or accuracy (F(2,57)=0.12, p=0.89, η^2_p=0.04) between the classic sitting, dynamic sitting, and standing conditions. There was no significant difference in speed (F(2, 57)=2.12, p=0.13, η^2_p=0.07) or accuracy (F(2, 56)=2.21, p=0.12, η^2_p=0.07) over time from the first, second, and third hour.

Self-reported measures: Descriptive data can be found in Tables 2 and 3. For self-reported discomfort, there was a significant difference between the classic sitting, dynamic sitting, and standing conditions (F(2,57)=4.13, p=0.02, η^2_p=0.13). A post hoc analysis [Tukey] demonstrated a significant difference between the classic sitting and standing postures (p=0.02), where participants rated the standing posture to cause more discomfort. There was no significant difference between the classic sitting and dynamic sitting (p=0.73) or dynamic sitting and standing (p=0.12) postures. There was no significant difference in the discomfort rating over time from the first, second, and third hour (F(2, 57)=0.26, p=0.77, η^2_p=0.01).

For self-reported ease, there was a significant difference between the classic sitting, dynamic sitting, and standing conditions (F(2,56)=7.50, p<0.01, η^2_p=0.21). A post hoc analysis [Tukey] demonstrated a significant difference between the classic sitting and standing posture (p<0.01), where participants rated the standing posture to be more difficult. There was no significant difference between the classic sitting and dynamic sitting (p=0.12) or dynamic sitting and standing (p=0.15) postures. There was no significant difference in the ease rating over time from the first, second, and third hour (F(2, 57)=0.65, p=0.53, η^2_p=0.02).

For self-reported enjoyment, there was no significant difference between the classic sitting, dynamic sitting, and standing conditions (F(2,57)=1.01, p=0.37, η^2_p=0.03). There was no significant difference in enjoyment over time from the first, second, and third hour (F(2, 57)=0.04, p=0.96, η^2_p <0.01).

For self-reported focus, there was no significant difference between the classic sitting, dynamic sitting, and standing conditions (F(2,57)=0.95, p=0.39, η^2_p=0.03). There was no significant difference in the focus rating over time from the first, second, and third hour (F(2, 57)=2.96, p=0.06, η^2_p=0.09).

Students rated that they were significantly more likely to use a dynamic sitting posture in class than a standing posture (F(1,38)=6.65, p=0.01, η^2_p=0.15).

There was a significant relationship between discomfort and likelihood of use (R=-0.65 p<0.01). This correlation was negative, such that if discomfort is increased for a posture, the likelihood of use is decreased for that posture, and vice versa.

DISCUSSION

As hypothesized, classroom performance did not suffer by changing students' anatomical position from classic sitting. These findings are in line with the classroom performance findings reported by Smith & Prapavessis, the academic self-report findings by Jerome et al. and the office worker findings reported by Sui et al. [30,34,35]. Further, as expected and as previously demonstrated in office workers there was no significant difference in the Fast Counting, Eriksen Flanker, and N-back cognitive tasks between the classic sitting, dynamic sitting, and standing conditions [42]. Zhang, Zhang, Cao, & Chen also found no significant difference between sitting and standing for college students for the stroop task, 0 and 1-back and More-odd shifting task [45]. Taken together, our findings demonstrate no perceptual performance, executive memory, and working memory performance differences among the conditions. It is encouraging that these unfamiliar postures did not reduce classroom and cognitive performance for these university students. However, participants performed the Go/No-Go test more accurately while using the standing posture. Zhang et al. found increased accuracy for the 2-back in a standing position [45]. It is possible that the standing posture may cause increased attention over the classic sitting posture. This differs from previous office worker research by Commissaris et al. and should be investigated further before clear conclusions can be made [42]. Perhaps increase exposure to these alternative postures might increase classroom and cognitive performance. To address this, more research is warranted that investigates the use of alternative postures on university classroom performance over longer periods of time.

As hypothesized, the dynamic sitting posture did not differ from the classic sitting posture in terms of self-reported enjoyment and focus. This is in agreement with previous research in office workers that found dynamic sitting to be well liked and previous work where students rated standing posture equal to classic sitting posture in terms of enjoyment [34]. However, it is interesting that participants reported using the standing posture as significantly more difficult than using the classic sitting posture, yet classroom and cognitive performance did not suffer. This self-report difference may be due to the unfamiliarity of standing during a lecture rather than a true increase in difficulty in standing. Future work should aim to acclimatize participants to the alternative postures and tasks.

A slight increase in discomfort was observed with the standing posture. This is in line with previous research where office workers rated the dynamic sitting posture more comfortable than the standing posture [16]. However, the difference was small and average discomfort was still below mild discomfort on the scale used. Additionally, some individuals experience no discomfort with the standing posture. Thus, students should be given the opportunity to make a choice to reduce their sedentary time in class with alternative postures. Since students are accustomed to being seated for all their lectures, they may simply be unfamiliar with standing for a longer period of time, thus resulting in a slight discomfort. Additionally, due to the relatively short one-time exposure to each experimental condition, it is possible that discomfort from standing may decrease or increase with repeated exposures. Perhaps with incremental increased use of the standing posture, any discomfort will disappear through adaptation. Alternatively, increased standing exposure may exacerbate discomfort. Future research should aim to shed light on this issue. Further, participants were not asked how much they typically stand during the day prior to the intervention. Perhaps individuals that stand more experienced less discomfort than those who stand less. Additionally, participants were not asked why they experienced discomfort. For some individuals the discomfort may have been due to a pre-existing condition rather than the posture itself. Whatever the cause, discomfort must be minimized in order for most individuals to regularly use the standing posture. The increase in discomfort from classic sitting to standing, but no change in discomfort from dynamic sitting to either posture may be the primary reason why students would prefer to use a dynamic sitting over a standing posture, if they were available in class. This is in agreement with previous research where office workers preferred using the dynamic sitting posture compared to the standing posture [16]. We found a significant negative correlation between discomfort and likelihood of use, in that if discomfort is increased for a condition, the likelihood of use is decreased for that condition.

There was no significant decline/improvement in classroom performance, Go/No-Go speed and accuracy, Eriksen Flanker speed, N-back speed and accuracy, discomfort, ease, enjoyment, and focus rating over time from the first, second, and third lecture. This demonstrates that students are able to perform just as well following 1 hour of class as following 2 or 3 hours of class. There was a significant improvement in Fast Counting speed and accuracy from the first hour to the third hour. This is attributed to a learning effect with the Fast Counting task. However, any time (order) effects are counteracted by the randomized counterbalanced design. There was also a significant decline in Eriksen Flanker accuracy from the first hour to the third hour (Table 3). This may be due to slight distraction or fatigue for this task. However, similarly any time (order) effects for this test are also counteracted by the randomized counterbalanced design.

We acknowledge that there are many financial and structural challenges (i.e. visibility and access issues) for implementing alternative workstations in the university classrooms. However, in support of implementation, a recent study by Benzo et al. examined the acceptability of introducing standing desks in college classrooms [44]. The large majority of students (95%) reported they would prefer the option to stand in class. Most students (76.6%) and instructors (86.6%) reported being in favor of introducing standing desks into college classrooms. Their findings support the acceptability of introducing standing desks in college classrooms. Additionally, dynamic sitting chairs would not impact visibility and would cause less access issues than standing desk options would. Future work should investigate the acceptability of introducing dynamic sitting chairs in university classrooms.

There are a number of strengths with the present study. First, the within subject counterbalanced design allowed for high internal validity. Second, the intervention had strong external validity in that the classroom performance tasks were exactly what students usually do in a real university lecture (i.e., listen to, record, and recall lecture material). Third, the participants were all university students from a wide range of disciplines. Fourth, the cognitive performance tests selected are widely accepted in this field and have been used in previous research. Finally, the study targets an important population, university students, who spend a substantial amount of sedentary time in class and while studying.

Despite these strengths, there are several weaknesses that must be acknowledged. First, some university classes are 2 or 3 hours long. Hence, we can only speculate that our findings would hold over these longer class times. However, in the present study students were able to perform just as well following 1 hour of class as following 2 and 3 hours of class. Thus, it is expected that our finding would hold over these longer class times. Furthermore, we cannot infer that our finding would hold over multiple exposures to each experimental condition. Second, no pre-intervention sedentary behavior was asked from participants. Thus, participants may vary in their pre-intervention standing, which may have influenced the results. Third, a simulated classroom lecture and quiz was used as opposed to an actual classroom lecture and quiz. This simulated classroom performance measure needs to be validated with actual performance measures in future work. However, at this time there are no standing or dynamic sitting options in university classrooms at the University of Western Ontario for research to be conducted. Fourth, the standing posture findings reported may not necessarily apply to standing desks and/or sit-stand desks. This issue warrants further research attention. Fifth, this was the first study to address this issue in an ecological manner with university students who volunteered and were compensated. This work must be replicated with a larger sample using different research designs (i.e., randomized control trial) before findings can be universally accepted. Lastly, both physical (e.g., glucose, cholesterol, blood pressure) and mental (e.g., anxiety, depression, stress) health outcomes need to be assessed to determine if students who sit less in their educational environment receive actual benefits.

CONCLUSION

Classroom performance, cognitive performance, enjoyment, and focus do not suffer by changing students' anatomical position from classic sitting. However, standing posture may cause more discomfort and difficulty for some students. Ways to decrease and eliminate discomfort and difficulty should be further investigated before all students have access to standing options in class. Discomfort differences do not exist between dynamic sitting and classic sitting and dynamic sitting postures are more likely to be used in class than standing postures. Hence, at this early stage of inquiry there is no evidence to recommend against providing dynamic sitting and standing options in university classrooms to allow students to receive health benefits as they learn.

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