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RESEARCH ARTICLE

THE INFLUENCE OF HEIGHT-ADJUSTABLE STANDING DESKS ON COMPUTER-RELATED MUSCULOSKELETAL COMPLAINTS AND STUDENT PERSPECTIVE IN PHYSICAL THERAPIST EDUCATION PROGRAM STUDENTS

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ABSTRACT

Purpose: This study aims to investigate the effects of standing desks use on musculoskeletal complaints and student perspective within the classroom in a physical therapist education program students.

Method: Twenty two students (10 male, 12 female) aged27.9 years (± 6.4) participated the study. The participants completed an online questionnaire consisting of demographic questions. An online version of the Boston University Computer and Health Survey was used to assess participants' musculoskeletal complaints before and after standing desk use. The Likeness and Willingness Survey was used to assess students' perspective after standing desk use.

Results: Eighty-two percent of the participants described pain during and after working on a computer before the trimester started, while 90% of them reported pain after the trimester semester ended. The most common areas of pain/discomfort areas were the neck and low back. 72% of the participants stated that they extremely and moderately liked the standing desk. Seventy-two percent of the participants stated that the standing desk helped them to stay alert and focused during the classes.

Conclusion: Although there were no statistical comparisons regarding musculoskeletal discomfort before and after standing desk use, musculoskeletal complaints were evident among physical therapist education students after computer use in a static position. Regarding the student perspective there was an overall agreement that standing desks are beneficial for alertness, focus, concentration and fatigue.

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INTRODUCTION

The current trend in the literature and the healthcare field as a whole has been preventative medicine. With prolonged sitting being common in various school settings and the workforce, there has been an aim to minimize sitting time without incurring any discomfort, negative health changes or a decrease in work or study efficiency. Studies regarding standing desks are ongoing, aiming to combat the negative effects of prolonged sitting time. Typical physical therapy students have to sit for prolonged periods of time for class. Within a weekend based program these periods of sitting can be increased up to three times as long. The goal of this study is to identify the effects of utilizing standing desks within a weekend based physical therapy education program on musculoskeletal complaints and student perspectives.

Review of Literature

Prolonged sitting has been shown to have a detrimental impact on an individual's health. Excessive sitting time is a risk factor for cardiovascular disease mortality and morbidity independent of physical activity level (Graves *et al*., 2015). Various authors (Moffet *et al*., 2002; Hanvold *et al*., 2014; Hanvold *et al*., 2010; Prins *et al*., 2008; Brink, 2013; Bubric, 2016) have also noted that prolonged sitting has also been correlated with altered postures which leads to various musculoskeletal complaints. Prins *et al*. (2008) and Brink *et al*. (2013) emphasizes the upper quarter as a common region of musculoskeletal discomfort in children and adolescents. With limited evidence in the college setting, Bubric and Hedge (Bubric, 2016) investigated 186 college students and the prevalence of musculoskeletal discomfort associated with laptop use. Fifty-three percent of participants reported experiencing musculoskeletal discomfort during laptop use, and most commonly when at a desk. Studies by Grunseit *et al*. (2013) Thorp *et al*. (2014) Buckley *et al*. (2015) have all demonstrated increased standing time in sedentary workers with the use of standing desks. The literature is in favor of standing desks for a variety of reasons such as stress regulation (Gilson *et al*., 2017), positive neurocognitive benefits (Mehta *et al*., 2015), decrease sitting time (Grunseit *et al*., 2013; Thorp *et al*., 2014; Buckley *et al*., 2015), limiting misbehaviors (Erwin *et al*., 2017), reduce musculoskeletal

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complaints (Karakolis, 2014; Karakolis *et al*., 2016), and improving the learning experience. There is a general consensus that there is a gap in the literature with many studies of low quality evidence, especially in regards to the health benefits (Karol, 2015). Minges *et al*. (2016) performed a systematic review regarding the effects of standing desks in elementary school children and concluded that the initial evidence is in favor of implementing standing desks into the classroom. Karol and Robertson (Karol, 2015) performed a systematic review for the use of standing desks in the workplace which resulted in the need for large scale RCTs and ergonomic training to truly understand the benefits of standing desk workstations. Most of the studies in the literature were about the negative effects of the prolonged sitting and laptop use in the school setting. The literature on the effects of standing desks in the school setting is based on children and adolescents. No studies investigating the use of standing desks and its individual effects in the female and male college students. This study aims to investigate the use of standing desks at the collegiate level particularly within a physical therapist education program in order to investigate the effects of standing desks on musculoskeletal complaints as well as student perspective within the classroom.

Subjects

Twenty two participants (10 male, 12 female) completed the study. Subjects' characteristics included a mean age of 27.9 years (± 6.4), a mean height of 5.4 (± 0.2) feet, and a mean weight of 152.3 pounds (± 28.3). All potential participants were recruited using aconvenience sampling method. The students were invited to participate the study via an email and were selected from three cohorts in the doctor of physical therapist education program based on their willingness to participate in the study. The researchers obtained approval from College Institutional Review Board prior to the commencement of the study (IRB # 2017-0419-01). Candidates were required to sign an informed consent form prior to data collection. Inclusion criteria included male and female doctor of physical therapy education students between the ages of 21and 49 years old. The students were excluded from the study if they declined to participate in the study.

METHODS

The students completed an online questionnaire consisting of demographic questions such as age, weight, height, gender, ethnicity, activity level, daily use of laptop. The students' musculoskeletal complaints were assessed using the Boston University Computer and Health Survey (http://people.bu.edu/kjacobs/healthycomputing/) before the summer trimester started as a pre-test assessment. Two surveys, the Boston University Computer and Health Survey and the Likeness and Willingness Survey, were distributed to 22 students after the summer trimester ended as a post-test assessment to measure musculoskeletal complaints and student perspective.

The Boston University Computer and Health Survey

(http://people.bu.edu/kjacobs/healthycomputing/. Accessed January 2, 2018.): Aims to evaluate the association between laptop use and musculoskeletal pain in university students (Katz *et al*., 2000). The questionnaire, which is a self-administered questionnaire and completed in roughly 30 minutes aims to measure:

- The proportion of time spent using a laptop and desktop computer;
- The location of computer use;
- The presence, severity and location of pain; activities associated with pain (laptop use, desktop computer use, or during other school related activities).

It consists of 3 sections; Section A provides information from participants' laptop specifications such as weight of laptop and display screen width, types of laptop carriers used, location and positions of laptop usage and ergonomic awareness of users. Section B asks questions on participant's experience of pain/discomfort from using their laptop. Responses of participants were categorized by a 7-point Likert scale depending on the number of areas of the body experiencing pain/discomfort. Zero represents participants with no pain/discomfort, 7 represents groups with pain/discomfort in all the areas of the body assessed. Section C is to assess the severity of symptoms observed.

The Likeness and Willingness Survey: The survey was created in order to assess the students' perspectives regarding the use of standing desks during their classes. The students' feelings were recorded via a 9-point Likert scale (1 represents extremely dislike, 9 represents extremely like). Additionally their personal feelings towards the use of the standing desks were recorded via categorical questions for qualitative analysis.

Intervention: Twenty adjustable standing desks (Murcott Merchandising, Glen Cove, NY, https://murcott.com) with dimensions of 30"-45.25"H x 39.375"W x 23.625" were used for data collection. Four or five standings desks were placed in each classroom for the students. The standing desks were distributed throughout three classrooms and there were sufficient tables for subjects to stand whenever or for as long as they wished. The students were able to use a standing desk when they chose to use during their classes. There were no time limit or guidelines for their standing desk usage. However, the students were advised to adjust its height for their comfort. The frequency of standing desk usage was asked during the post-test survey.

RESULTS

Twelve female and 10 male students completed the study and an average age of the sample size was 27.9 (SD: 6.4) years. See Table 1 for the participants' characteristics. Thirteen subjects (59%) reported that their average daily computer usage was 3-5 hours. More than 50% of the participants reported that they mostly use laptops on a desk in their rooms. Interestingly, 41% of participants stated that they use the computer on their beds. Sixty-eight percent of the participants needed short breaks during computer usage (Table 2). Eighty-two percent of the participants described pain during and after working on a computer before the trimester started, while 90% of them reported pain after the trimester ended. The most common pain/discomfort areas were the neck and low back before the trimester started, and the hand, neck and low back after trimester ended. Duration of pain and discomfort during the daytime, and pain/numbness/tingling symptoms in the last two weeks were similar pre and post trimester (Table 3). No participants reported severe or very severe pain/discomfort, numbness, weakness, and tingling in hands, wrists, shoulder, neck and low back.

Table 1. Participants' characteristics

		Number (%)	Mean (SD)	Min	Max
Gender:	Females/Males	12/10 (54/46)			
Age (years)			27.9 (6.4)	21	49
Weight (lb)			152.3 (28.3)	115	200
Height (feet)			5.4 (.02)	5.1	6
Ethnicity	Caucasian	13(59)			
	Asian	3 (13)			
	Puerto Rican/ Filipino	3 (13)			
	Not answered	3 (13)			
Activity level	Daily	4 (18)			
	3-4 times a week	7 (32)			
	1-2 times a week	8 (36)			
	Occasionally	2 (9)			
	Never	0			
Cohort	Year 4	1			
	Year 3	9			
	Year 2	6			
	Year 1	6			

Table 2. Participants' computer usage

		Pre		Post	
		n	%	n	%
Daily computer and laptop usage	More than 10 hours	1	5	2	9
	6-10 hours	7	32	6	27
	3-5 hours	13	59	11	50
	1-2 hours	1	5	3	13
	Less than 1 hour	0	0	0	0
Computing place	Room In the Dorm Or Off-Campus	12	54	15	68
	Campus Computer Labs	1	5	2	9
	College Computer Facility	1	5	3	13
	Other	8	36	2	9
Type of computer	Laptop	19	86	19	86
	Desktop	1	5	1	5
	Both	2	9	2	9
Computing location	Desk	12	54	15	68
	Bed	9	41	10	45
	Floor	1	5	2	9
	Other	0	0	1	5
Taking a short regular breaks of a few minutes at least once an hour	Yes	15	68	13	59
	No	1	5	5	22
	Sometimes	6	27	4	18
Computer usage for work or recreation (hours per day)	0-2 hours per day	2	9	3	13
	3-4 hours per day	14	63	11	50
	5-6 hours per day	4	18	6	27
	7-8 hours per day	1	5	2	9
	More than 8 hours per day	1	5	0	0
Taking a break from computer to rest hands, wrists, shoulders or neck	Never	1	5	1	5
	Only after more than 2 hours work	2	9	4	18
	Once every 1-2 hours work	7	32	6	27
	At least once an hour	6	27	6	27
	More than once an hour	6	27	5	22
Spending more than 4 hours at the computer without getting out of chair for a break	Never	11	50	10	45
	1-2 times each semester	2	9	3	13
	1-2 times each month	7	32	2	9
	1-2 times each week	2	9	6	27
	+3 times each week	0	0	1	5

One half of the participants reported mild and moderate pain and discomfort at night while 41% reported pain and discomfort during the day before trimester started, while %46 of them reported after trimester ended (Table 4). Sixty percent of the participants stated that they had pain and discomfort during the day at least once. Most of the participants reported that they did not wake up from sleep at night because of the pain/discomfort and tingling/numbness (Table 5). The most difficult school activities were typing 10 pages (double spaced) on the computer, concentrating on work, completing handwritten assignments, performing lab work (such as manual muscle testing, goniometers) (Table 6).

Surprisingly some of the participants stated that they feel downhearted and blue some of the time and down in the dumps that nothing could cheer them up. Overall, the students reported that they are calm, peaceful and happy (Table 7). A total of 72% of the participants stated that they extremely and moderately liked the standing desk. Eighty-one percent of the participants wanted to use the standing desk in the next trimester, 91% wanted to recommend the use of the standing desk to their friends. The most popular reasons for using a standing desk was to stay alert (91%) and to increase body comfort (81%). The frequency of the standing desk use varied between 1-2 times to more than 10 times during the study.

Table 3. Characteristics of pain/discomfort in hands, wrists, arms, shoulders or neck, during or after working on a computer (pre and post standing desk usage)

		Pre		Post	
		n	%	n	%
Pain during or after working on a computer	Yes	18	82	20	90
Pain/discomfort areas	Neck	9	41	8	36
	Low back	7	31	7	31
	Hand	5	22	9	41
	Shoulder	6	27	5	22
	Thoracic	2	9	2	9
	Elbow	2	9	2	9
	Wrist	4	18	2	9
Duration of pain/discomfort during the daytime	No never	4	18	9	41
	10 minutes or less	12	54	9	41
	10-60 minutes	4	18	4	18
	Greater than 60 minutes	-	-	-	-
	Constant throughout the day	2	9	-	-
In the past two weeks pain/discomfort, numbness, tingling or any other symptoms	No, never	12	54	14	63
	If use the computer for several hours at a time	7	31	7	31
	If use the computer for an hour or so	2	9	1	5
	If just use the computer for a few minutes	1	5	-	-
	Yes, with virtually all activities	-	-	-	-

Table 4. The severity of pain and sensational symptoms in hands, wrists, arms, shoulders, neck and low back been during a typical 24 hour period in the past two weeks

	Pre		Post	
	Never n(%)	Mild Moderate n (%)	Never n(%)	Mild Moderate n (%)
Pain/discomfort at night	11(50)	11 (50)	14(64)	10(46)
Pain/discomfort during the day	13(59)	9(41)	7(31)	15(69)
Numbness	15(68)	7(32)	16(73)	6(27)
Weakness	17(77)	5(23)	15(68)	7(32)
Tingling sensation	14(64)	8(36)	16(72)	6(28)
Numbness or tingling at night	19(86)	3(14)	17(77)	5(23)
Difficulty grasping and using small objects	19(86)	3(14)	20(95)	1(5)

Table 5. The frequency of pain/discomfort in the hands, wrists, arms, shoulder, neck, or low back in the past two weeks

	Pre			Post		
	Never n(%)	Once n(%)	2-3 times n(%)	Never n(%)	Once n(%)	2-3 times n(%)
Waking up from sleep at night	18(82)	2(9)	2(9)	15(68)	5(22)	2(9)
Pain/ discomfort during the daytime	8(35)	13(60)	1(5)	6(27)	12(54)	4(18)
Waking up from sleep at night because of hand/ numbness or tingling	18(82)	3(13)	1(5)	14(63)	5(22)	2(9)

The most popular standing desk characteristics were its height (63%) and foot rest (59%). Seventy-two percent of the participants stated that the standing desk helped them to stay alert and focused during the classes, and 63% stated that it helped for their fatigue. Fifty-nine percent of the participants stated that the standing desk increased their level of energy and helped them to concentrate in class (Table 8). Based on the open-ended questions on the survey, the students complained of standing positions and maintaining erect posture during class activities when using the standing desks.

One student stated that after standing for a prolonged period had back pain, and had to do stretching exercises in order to relieve the pain. They also stated that it would be better to alternate sitting and standing positions every two hours in order to prevent fatigue and pain. They also stated that standing desks were in the back of the class, therefore it was hard to see presentations and hear the lectures. Painful activities were being in one position for too long, computer usage more than 4 hours continuously, poor posture during sitting position, lifting objects, sleeping on one side, working on the computer on uneven surfaces.

DISCUSSION

As part of College's weekend based program, the professional courses are scheduled on a trimester system such as summer, fall, winter/spring. The physical therapist education program meets eight weekends per trimester. Each instructional weekend includes all-day Friday, Saturday, and Sunday. There are various learning\experiences (e.g. lectures, open labs, proficiency checkouts, student-driven group work, student/faculty meetings, etc.) during instructional weekends. The students are required to sit approximately 8-10 hours some weekends for classes, written exams, meetings, etc. The students use their own laptops on various desks, tables, or plinths during some classes in order to follow the class activities for prolonged periods of time. Therefore, our main goal was to investigate the influence of the standing desks on the computer related musculoskeletal complaints and student perspective in the classroom. A variety of qualitative data came from investigating various aspects of the use of standing desks within the weekend program college classroom setting. While various questions during our investigations were answered, it became apparent that there were other questions that arose that are consistent within the literature or a gap that

Table 6. Activities associated with pain during school related activities

	Pre			Post		
	No Difficulty n(%)	Mild Difficulty n (%)	Moderate Difficulty n(%)	No Difficulty n(%)	Mild Difficulty n(%)	Moderate Difficulty n(%)
Typing one page (double spaced) on the computer	15(68)	7(31)	-	19(87)	3(13)	-
Typing 10 pages (double spaced) on the computer	10(45)	12(55)		11(50)	11(50)	
Completing assignment on the computer (such as typed papers) on time	15(68)	6(32)		17(77)	5(23)	
Doing assignments on the computer as well as you would like	15(68)	7(31)	-	17(77)	5(23)	
Completing handwritten assignments	13(59)	8(36)	1(5)	11(50)	10(45)	1(5)
Corresponding as often as you would like by email with friends, faculty and others	19(86)	3(13)	-	20(91)	2(9)	
Taking notes in class by hand	14(64)	7(31)		15(68)	6(27)	1(5)
Taking timed written examinations	14(64)	8(36)		15(68)	1(5)	1(5)
Doing extracurricular activities (such as sports, musical instruments, hobbies)	15(68)	6(27)	1(5)	13(59)	9(41)	-
Using the mouse (or other computer pointing devices) repeatedly	15(68)	7(32)	-	19(86)	3(13)	-
Searching through the internet/ web	19(86)	3(13)	-	21(95)	1(5)	-
Carrying your books around campus	16(72)	5(23)	1(5)	11(50)	7(32)	3(13)
Carrying a tray in the dining hall	20(90)	1(9)	-	21(95)	1(5)	
Performing lab work (such as manual muscle testing, goniometers)	14(64)	8(36)/23	-	16(73)	5(23)	1(5)
Playing video games	18(82)	4(18)	-	18(82)	3(13)	1(5)
Completing assignments and homework on time	19(86)	3(13)	-	21(95)	1(5)	-
Concentrating on your work	11(50)	10(45)	5/5	11(50)	9(41)	1(5)
Engaging in the class activities	19(86)	3(13)	-	18(81)	4(18)	

Table 7. General health status of the participants during the past two weeks

	Never n(%)	Hardly never n(%)	Only now and then n(%)	Some of the time n(%)	Most of the time n(%)
Being a nervous person	1 (5)	7 (32)	7 (32)	4 (18)	3 (13)
Feeling felt so down in the dumps that nothing could cheer you up	10 (45)	5 (23)	6 (27)	1 (5)	-
Feeling calm and peaceful	-	2 (9)	4(18)	7 (32)	9 (40)
Feeling downhearted and blue	7 (32)	5 (23)	5 (23)	5 (23)	-
Being a happy person	-	1 (5)	3 (13)	7 (32)	11 (50)

are still to be researched. Initial results showed 41% of participants use their laptops while on their beds. Even though this was not a direct concern during the study, it may correlate with an increase in musculoskeletal complaints that were recorded within the pre to posttest survey. Bubric and Hedge looked at preferred positions of lap top use in college students. In particular for females, laying on a bed was one of their preferred positions. For males, it was leaning forward on a couch over a coffee table or with their feet up on an ottoman. Both positions can alter mechanics at the cervical and lumbar spine. Gold *et al* looked at nontraditional positioning during laptop use and noted prone being the worse position for cervical, shoulder, elbow and wrist mechanics. Our study revealed the cervical and lumbar spine being the most commonly affected areas of discomfort which are shown to occur with poor postures and positioning. There may be a connection as to why musculoskeletal discomfort increased throughout the trimester that could be investigated further. Being a weekend based program requires longer periods of sustained positioning due to the increased class time.It is also expected that the time spent on a computer would increase from the beginning of the trimester compared to the end due to increasing demands from their studies and workload.

Our study, which revealed 82% of participants having pain while working on a computer before the trimester started versus 90% reporting pain at the end was similar to Hamilton *et al* in which 80.6% of female college students complained of some source of musculoskeletal discomfort from laptop computer usage. Students mentioned in the survey that prolonged standing positions and maintaining erect posture was difficult and sore on their low back requiring stretching to relieve discomfort. Students were not given guidelines as to standing desk usage, but any prolonged position would lead to altered mechanics and discomfort. Students were verbally educated that they may utilize the standing desks as little or as much as they wanted. The literature has recently investigated appropriate parameters for the standing to sitting time ratio. Thorp *et al* and Buckley *et al* had consistent results that active workstations demonstrated promise in terms of their preventative effects on both the cardiovascular and musculoskeletal systems. Even short-term use has demonstrated beneficial health effects, but that a gap in the literature is an appropriate plan for laying out parameters regarding length of time spent sitting versus standing. Karakolis and Callagh`an performed a study looking at these ideal ratios for sit to stand time, particularly regarding the

Table 8. Likeness and willingness survey findings

		n	%
How would you rate your feelings about the standing desk?	Like extremely	3	13
	Like moderately	13	59
	Like slightly	3	13
	Neither like or dislike	1	5
	Dislike slightly	0	0
	Dislike moderately	1	5
	Dislike extremely	0	0
Would you use the standing desk for the next trimester?	Yes	18	81
	No	3	13
Would you recommend the standing desk to your friends?	Yes	20	91
	No	1	5
Which of the following factors (check all that apply) would influence you toward trying a standing desk?	To stay alert	20	91
	Increased body comfort	18	81
	Curiosity to try it out	13	59
	Productivity	11	50
	Low back pain	8	36
	Neck pain	7	31
	Seeing others standing while using	5	23
	Direct encouragement by others	2	9
	Other health problems	1	5
	Other	1	5
How frequent you used the standing desk?	1-2 time	4	18
	3-5 times	6	27
	5-10 times	5	22
	More than 10 times	6	27
What do you like most about the standing desk? (check all that apply)	Height	14	63
	Foot rest	13	59
	Easy to move it	8	36
	Top part	8	36
	Other	6	27
	Style	4	18
	I didn't like it	1	5
How does the standing desk benefit you? (check all that apply)	It makes me alert and focused during the classes	16	72
	It helps my fatigue	14	63
	It increases my level of energy	13	59
	It helps me to concentrate the class	13	59
	It helps for discomfort and pain	8	36
	It decreases my pain	8	36
	It doesn't benefit me at all	0	0

effects on discomfort and productivity. Their research was consistent in that the sit to stand paradigm is effective in regards to discomfort and productivity, but that the initial recommendation of 15:5 (sit: stand) time, may not be the most effective ratio. The authors concluded a more frequent postural adjustment may be needed to maximize the benefit of sit to stand workstations. In regards to future research it would be beneficial to provide appropriate guidelines to help identify an appropriate sit: stand ratio to eliminate prolonged postures and inevitable musculoskeletal complaints that arise from prolonged postures. One of the survey responses discussed having the desks in the back of the classrooms which altered their ability to see and hear. This is logistically important for future research to emphasize classroom placement. This may affect productivity or the effectiveness of standing desk use for cognitive benefits which is another avenue of research in the use of standing desks. This will be taken into consideration for future studies. Overall the student perspective was in favor regarding the use of the standing desks. Greater than 80% of participants would want to use the standing desks next trimester and > 90% would recommend their use to a friend. Initially, the reasons for wanting to try the standing desk were to stay alert, and by the end 72% were in agreement that it did help alertness in the classroom. This is consistent with a variety of literature including Finch *et al* which noted even small bouts of standing workstations (30-60 minutes) improve alertness, interest and enthusiasm. The participants in the literature performed by Graves *et al* noted standing workstations heightened their alertness and were more awake. Others in the study mentioned it was less effective for them due to being distracted when able to see more of those around them, which may be based on the setting the individual was in. In this study, 63% stated it helped with their fatigue, which has been consistent in the literature. Fifty-nine percent noted the standing desks helped with their energy level and concentration. Karakolis and Callaghan noted from a systematic review that the majority of literature noted improvement in productivity, a few with no change and one with mixed results. Because of this they concluded that standing desks do not have a negative effect on productivity. These results are consistent in that > 60% felt it helped in various areas of productivity with only one student noting their dislike. More standardized protocols in regards to time spent standing versus sitting can help in regards to use. Small sample size and lack of statistical analysis of data are the main two limitations of this study. Future research would be beneficial in regards to standardized sit to stand ratios and time frames, location or placement within the classroom of the standing desk, and academic achievement as a result of the perception of increased focus within the classroom.

Conclusion

Any musculoskeletal complaints seem to have arisen from prolonged standing use due to a lack of sit to stand guidelines and parameters, increased lap top use as the trimester progressed, and position of use outside of the classroom when working on the lap top.

Regarding the student perspective there was an overall agreement that standing desks are beneficial for alertness, focus, concentration and fatigue. More guidance on length of use may increase the effectiveness regarding the student preference perspective.

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