

STANDING CLASSROOM EFFECTIVENESS VARIES BY PHYSICAL ACTIVITY LEVEL AND GENERAL HEALTH

MALLORY MARSHALL¹, LYDIA A. THURSTON², NICHOLAS WASHMUTH^{2*}, JABRIL COOPER DIAMOND³, ROBERT W. HENSARLING¹, MOIRA JACKSON⁴

¹Department of Kinesiology, Samford University, 800 Lakeshore Drive, Birmingham, AL 35229, UNITED STATES.

²Department of Physical Therapy, Samford University, 800 Lakeshore Drive, Birmingham, AL 35229, UNITED STATES.

³Department of Cardiopulmonary Sciences, Samford University, 800 Lakeshore Drive, Birmingham, AL 35229, UNITED STATES.

⁴Department of Anatomy and Cell Biology, University of Florida, Gainesville, FL 32611, UNITED STATES.

Email: nwashmut@samford.edu

How to cite this article: Marshall, M., Thurston, L.A., Washmuth, N., Diamond, J.C., Hensarling, R.W., & Jackson, M. (December, 2019). Standing classroom effectiveness varies by physical activity level and general health. Journal of Physical Education Research, Volume 6, Issue IV, 01-07.

Received: October 02, 2019

Accepted: December 19, 2019

ABSTRACT

There is a current trend in standing classrooms, mostly based on the notion that increasing standing time could counteract the negative effects of sedentary sitting time while potentially improving learning in a classroom. Although there is interest in standing desks in college classrooms, the impact of standing desks on academic performance among college students is largely unexplored. In addition, the literature is limited in its consideration of individual student characteristics that might alter the impact of standing while learning, such as level of physical activity or health. The purpose of this study was to determine the effect of sitting versus standing during a presentation of new academic material on quiz scores. In addition, the role of other factors that might interact with the effects of standing (i.e. physical activity, health status) were examined. 231 students were randomly assigned to either stand or sit during a 60-minute lecture, and then immediately completed a post-intervention quiz and also took a survey of characteristics related to physical activity (PA) and health. Participants who sat during the lecture scored higher on multiple choice questions than those who stood ($p = 0.024$). Those who reported no moderate PA performed more poorly on multiple choice questions than those who reported moderate PA (mean score 9.67 ± 4.62 versus 11.4 ± 2.67). Students who reported no vigorous PA and stood also performed worse on the quiz (interaction p -value = 0.05). Overall, students who stood performed worse than sitters. The findings suggest that standing while learning may negatively impact academic performance, especially in sedentary persons.

Keywords: Academic performance, randomized controlled trial, sitting, college students, learning.

1. INTRODUCTION

There is current interest in standing classrooms, mostly based on the notion that increasing standing time could counteract the negative effects of sedentary sitting time while potentially improving learning in a classroom. The use of standing desks may enable students to increase energy expenditure throughout the day, as inactivity for prolonged periods has been shown to be detrimental to health (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008) and prolonged sitting is associated with elevated risk of cervical and lumbar pain (Szczygiel, Zielonka, Metel, & Golec, 2017). Sitting has been associated with common chronic diseases including cardiovascular disease, type II diabetes and some types of cancer (Bellettiere, Winkler, Chastin, Kerr, Owen, Dunstan, & Healy, 2017; Thorp, Kingwell, Sethi, Hammond, Owen, & Dunstan, 2014; Voss, Duncombe, Dean, de Souza, & Harris, 2017; Biswas, Oh, Faulkner, Bajaj, Silver, Mitchell, & Alter, 2015). In addition, sedentary lifestyle is also associated with decreased cognitive performance (Voss et al., 2017). The impact of prolonged sitting is particularly relevant to students who sit in classrooms and office workers who sit in front of computers for many hours per day. Standing desks are considered a potential solution for counteracting the detrimental effects of prolonged sitting.

In contrast to prolonged sitting, physical activity (PA) has been shown to have a positive effect on health, without negatively impacting academic achievement and classroom engagement (Dornhecker, Blake, Benden, Zhao, & Wendel, 2015; Blake, Benden, & Wendel, 2012). Physical education has been shown to improve attention, behavior, and academic achievement among elementary school children (Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Carlson, Fulton, Lee, Maynard, Brown, Kohl, & Dietz, 2008; Mohammad, 2017). Studies with standing interventions over longer periods of time and with larger sample sizes have shown some significant differences in health. For instance, Wendel, Benden, Zhao, and Jeffrey, (2016) demonstrated a decrease in BMI with a 2-year intervention of standing-biased desk among a sample of 380 third and fourth grade students. Given the evidence on the benefits of PA, and the detrimental effects

of prolonged sitting, standing classrooms could be beneficial to learning, memory, and health. Research on the impact of standing desks among college students has been equivocal, with few identified adverse effects and limited evidence of meaningful benefits. It is still unknown whether standing during class constitutes enough PA to positively affect cognitive performance (Sherry, Pearson, & Clemes 2016; Mohammad, 2017). The evidence is mixed in terms of health benefits, with a trend toward supporting a negligible increase in energy expenditure when standing compared to sitting while learning (Sherry et al., 2016; Shrestha, Kukkonen-Harjula, Verbeek, Ijaz, Hermans, & Pedisic, 2016; Benden, Blake, Wendel, & Huber, 2011; Contardo-Ayala, Salmon, Timperio, Sudholz, Ridgers, Sethi, & Dunstan, 2016).

In a recent study, 95% of college students reported that they would prefer the option to stand in class, while 82.7% reported they currently sit during their entire class time. Most of the college instructors in the study (86.6%) reported being in favor of introducing standing desks into college classrooms to improve physical health, attention, focus, and restlessness (Benzo, Gremaud, Jerome, & Carr, 2016). Although there is interest in standing desks in college classrooms, the impact of standing desks on academic performance among college students is largely unexplored. In addition, the literature is limited in its consideration of individual student characteristics that might alter the impact of standing while learning, such as level of physical activity or health. Therefore, the purpose of this study was to examine the effect of standing during an academic task on learning. In addition, the role of other factors that might interact with the effects of standing (i.e. PA, health status) were examined.

2. METHODS AND MATERIALS

2.1 Participants and Procedures

Students in three sections of a college undergraduate introduction to fitness and health course participated in the study. A total of 231 participants completed the post-intervention quiz and survey. A paper format was used for the quiz and 2017 Qualtrics® Software (Qualtrics LLC; Seattle, WA) was utilized for the post-intervention survey of student characteristics. The surveys consisted of questions about demographics, PA, and general health. PA questions were derived from the International Physical Activity Questionnaire (IPAQ) to determine participants who reported no moderate versus some moderate PA, as well as those who reported no vigorous versus some vigorous PA (Craig et al., 2003). Only students who completed both surveys and the quiz were included in the analysis. The general health question used asked respondents to rate their general health as excellent, very good, good, fair, or poor. Students were randomized to either sitting or standing for a 1-hour lecture on the topic of Injury Prevention and Personal Safety; three lectures on the same material were given by the same instructor. Students were informed this activity was part of their class that day.

The standing stations consisted of aerobics risers and a step that elevated 16 inches on top of the typical classroom desks. Following the presentation, students completed a 20-question post-intervention paper-based quiz on their retention and application of material discussed in the lecture. Students were not aware they would be assessed at the end of class on the covered material until the quiz was given. Of the 20 questions, 16 were multiple choice and four required listing responses (1 point per answer, for a total of 16 listing points). Students entered assigned identification numbers into the electronic surveys to anonymously connect the paper quiz to the surveys. This research complied with the American Psychological Association Code of Ethics and was approved by the Institutional Review Board at Samford University. Informed consent was obtained from each participant.

2.2 Data Analysis

Descriptive characteristics of the sample are reported as means \pm standard deviations for height, weight, and body mass index (BMI) and as frequencies for sex and age. Analysis of variance (ANOVA) was conducted to evaluate differences between sitters and standers for each descriptive characteristic. ANOVA was also utilized to assess differences between groups for assessment scores. 2 by 2 factorial ANOVA was used to calculate *p*-values for main effects for three variables (shown in Table 3) and interaction with group (sit or stand). For all analyses, alpha level was set to 0.05.

For analyses for any moderate PA, any vigorous PA, and overall health, each participant was placed into one of two dichotomous groups. Students were classified as participating in some moderate PA if they reported any time weekly engaged in moderate PA and were classified as participating in no moderate PA if they reported zero minutes per week of moderate intensity PA. The same process was used to determine any vs. no vigorous PA. General health was considered 'good' if the participant indicated that

their general health was either very good or excellent on a 5-point Likert scale question, and was considered 'poor' if any other answer was indicated.

3. RESULTS

A total of 231 participants had complete data and were included in the analyses.

Table 1: Demographic characteristics of sitters versus standers

	Sitters		Standers	
	Mean	SD	Mean	SD
Height (in)	65.79*	± 3.58	67.29	± 4.47
Weight (lb)	142.55*	± 25.71	151.54	± 30.1
BMI	23.13	± 3.59	23.61	± 4.48
Age (% 18-25 yrs)	120/125 (96.00%)		101/106 (95.30%)	
Sex (% male)	22/125 (17.6%)*		32/106 (30.20%)	

*indicates significantly different from stand group ($p < 0.05$)

Table 1 shows the descriptive characteristics of the sitters versus standers. The sitters weighed less, were shorter, and were less likely to be male compared to the standers.

Table 2: Average scores for multiple choice and listing portions of the assessment for the overall sample, sitters, and standers

	Overall (n=232)		Sit (n=125)		Stand (n=106)	
	Mean	SD	Mean	SD	Mean	SD
Multiple Choice (16 possible)	10.92	±2.80	11.28*	±2.61	10.50	±2.97
Listing (16 possible)	8.33	±3.63	8.62	±3.82	7.99	±3.39

*indicates significantly different from stand group ($p < 0.05$).

Table 2 shows the mean scores on the multiple choice and listing portions of the assessment. There was no interaction between groups (sit or stand) reflected in assessment scores based on sex or age ($p < 0.05$). Overall, those who sat during the lecture scored significantly higher on the multiple choice portion than those who stood ($p = 0.024$) but there was no difference in scores for the listing portion of the assessment ($p = 0.962$).

Table 3: Mean scores for multiple choice (MC) and listing exam questions (best possible score is 16 in each category) by sitters and standers and three categories: any versus no vigorous PA, any versus no moderate PA, and good versus fair/poor general health

		MC Score		Listing Score	
		Sit	Stand	Sit	Stand
Any Vig PA*	Yes	11.20	10.60	8.41	8.08
	No	12.00	9.18	9.50	8.00
Any Mod PA*‡	Yes	11.31	10.73	8.51	8.16
	No	12.25	4.50	11.38	6.50
General Health‡	Good	11.92	11.59	8.45	8.43
	Fair or Poor	8.00	12.00	8.50	3.33

*indicates a statistically significant main effect for the variable for MC score,

‡indicates a main effect for the variable for listing score,

‡indicates interaction between sit/stand and the variable for MC score, and

‡indicates interaction between sit/stand and the variable for listing score ($p < 0.05$).

Table 3 shows the results of the 2 by 2 factorial ANOVA analyses. Three dichotomous variables (any vigorous PA, any moderate PA, and general health) were analyzed for a main effect on either multiple choice or listing quiz score, as well as analyzed for interaction with sit/stand grouping. For the multiple choice analysis, there was a main effect for any moderate PA. Those who reported no moderate PA performed more poorly than those who reported moderate PA (mean score 9.67 ± 4.62 versus 11.4 ± 2.67 , $p = 0.002$); see Figure 1. In addition, there was a statistically significant interaction between sit/stand assignment and PA ($p = 0.000$), indicating that those who were reported no moderate PA and stood performed more poorly.

For the listing question analysis, there were statistically significant interactions between sit/stand and two variables: any moderate PA, and general health (see Table 3). The participants who reported no

moderate PA performed worse on listing questions while standing versus sitting (Figure 2), and those with poor health performed worse on listing questions while standing versus sitting (Figure 3).

Figure 1: Average score for multiple choice (MC) portion of quiz based upon indication of performing either no or some moderate intensity PA, by sitting or standing assignment

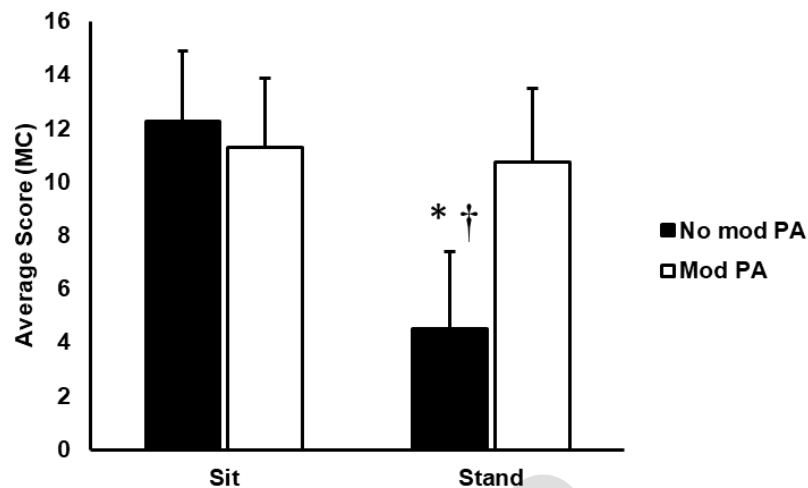


Figure 2: Average score for listing portion of quiz based upon indication of performing either no or some moderate intensity PA, by sitting or standing assignment

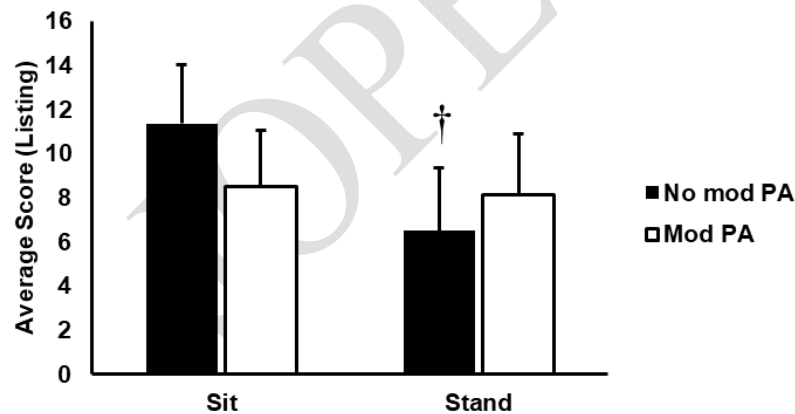
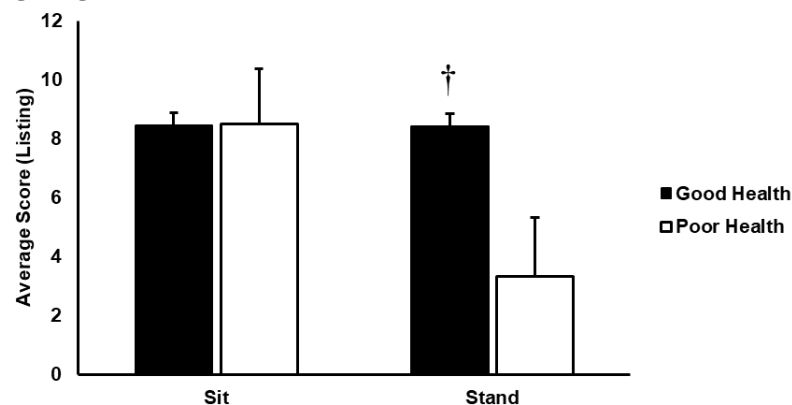


Figure 3: Average score for listing portion of quiz based upon self-reported good or poor health, by sitting or standing assignment



4. DISCUSSION

We found that students who were assigned to stand during an academic lecture performed worse on the multiple choice portion of an unannounced post-lecture quiz than students who were assigned to sit. The current study also explores whether participant characteristics (related to PA and health) interact with retention and application of material in undergraduate college students when learning while sitting versus standing. The findings of this study suggest that persons who report no moderate PA and stand while learning perform worse on multiple choice assessments than those who report moderate PA and sit while learning. In addition, those who report being in poor general health were negatively impacted by standing compared to those in good health. These data suggest that participation in any PA and overall health may predict effectiveness of standing interventions in individual learners. Despite some of the implied health benefits of standing while learning, the academic performance of some students may be negatively impacted by standing while learning and that negative impact is most notable in sedentary students and those in poor health.

There is some limited research to suggest a mechanism for these findings, particularly that inactive students perform better sitting. Longman, Stock, and Wells (2017) suggested that humans must sacrifice metabolically active tissue (i.e. muscle) to promote brain development and mental performance. They found an acute effect of this trade-off of brain and muscle when college-age participants performed maximal rowing exercise and performed a memory recall test simultaneously; performance decrements were greater in muscle performance compared to mental performance when dual tasking was required. Our findings may be related in that students who engage more muscle mass to stand are required to dual-task when learning and therefore mental performance decrements are present in those who do not regularly engage muscle mass by being physically active. More research must be done to better understand this finding and its implications for the utility of standing classrooms.

Another mechanism by which sitters may have performed better on the post-lecture quiz than standers is that physical activity, such as standing, may induce arousal and reduce boredom (Shephard, Lavalley, Volle, LaBarre, & Beaucage, 1994) which, in theory, can increase attention span and concentration. However, increased arousal may cause students to be hypersensitive to their surroundings and decrease attention paid to the lecture.

To the authors' knowledge, these findings suggesting that participation in any PA and overall health may predict effectiveness of standing classrooms on learning have not been demonstrated in any other studies. This adds to the knowledge base surrounding the benefits of moderate- to vigorous-intensity PA and the effects a sedentary lifestyle has on cardiovascular disease, health, and learning. It appears, from our findings, that only some students are not negatively impacted by standing classroom arrangements, and knowing which students are less likely to be impacted can play a role in determining the most advantageous standing classroom arrangement.

Although careful consideration was given to the study design, results of this current study should be evaluated in the context of some limitations. First, student participants represented undergraduate students at a private, suburban university. Additional research should examine effects in rural and urban universities to enhance the generalizability of our findings. Second, students sat or stood for a 1 hour lecture. It is possible that the acute nature of this intervention may not have fully captured the effects of either standing or sitting in the classroom. The one-time nature of this intervention didn't allow students to become accustomed to standing during the hour lecture. Mehta et al. studied the neurocognitive benefits and prefrontal cortex activity while using standing desks over a 27 week period. Their research found improved or no performance benefits on five neurocognitive assessments, but students took less time to complete some tasks (Mehta, Shortz, & Benden 2015). Additionally, the researchers found increases in executive function and working memory at the end of the study. As the current study was a one-time, one hour exposure, researchers are unable to determine the long term effects of standing on exam performance. Finally, as students were randomly selected for the standing and sitting groups, preference for standing was not included in the present study. Studies have shown imposed PA has a deleterious effect on affective responses and intensity (Ekkekakis & Lind 2006; Hamlyn-Williams, Freeman, & Parfitt 2014).

5. CONCLUSION

While there is evidence for deleterious effects of inactivity and sitting, our findings suggest that sitters outperformed standers, indicating that much remains to be understood on sitting versus standing in the classroom. More data is needed on the relevant mechanisms as to why sitting is hazardous to human health and why, in our study, sitters outperform standers in the classroom. These studies need to be carefully conducted in the same way that exercise physiology studies have enhanced our understanding of the

importance of moderate- to vigorous-intensity PA. Future studies should examine chronic sitting versus standing in the classroom on student learning. Our current study looked at the effect of an acute bout of sitting versus standing during a 1 hour lecture. Our findings should be compared to sitting versus standing during an entire semester. Other opportunities for future research includes experimentally manipulating the amount and type of PA student engage in, while comparing PA with the acute and chronic effects of sitting versus standing in the classroom on student learning. Another opportunity for future research would be to determine what percentage of students would stand during class if given the option. It has been shown that 95% of college students would prefer the option to standing in class¹⁶, however, data related to how many student actually stand during class and how much time they spend standing during class, when given the option, would assist in determining what standing classroom arrangements would be best utilized.

6. REFERENCES

- Bellettiere, J., Winkler, E.A.H., Chastin, S.F.M., Kerr, J., Owen, N., Dunstan, D.W. & Healy, G.N. (2017). Associations of sitting accumulation patterns with cardio-metabolic risk biomarkers in Australian adults. *PLoS One*, 12(6), e0180119.
- Benden, M.E., Blake, J.J., Wendel, M.L., & Huber, J.C. (2011). The impact of stand-biased desks in classrooms on calorie expenditure in children. *American Journal of Public Health*, 101(8), 1433-1436.
- Benzo, R.M., Gremaud, A.L., Jerome, M. & Carr, L.J. (2016). Learning to stand: the acceptability and feasibility of introducing standing desks into college classrooms. *International Journal of Environment Research and Public Health*, 13(8), 823.
- Biswas, A., Oh, P.I., Faulkner, G.E., Bajaj, R.R., Silver, M.A., Mitchell, M.S., & Alter, D.A. (2015). Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults a systematic review and meta-analysis sedentary time and disease incidence, mortality, and hospitalization. *Annals of Internal Medicine*, 162(2), 123-132.
- Blake, J.J., Benden, M. E., & Wendel, M. L. (2012). Using stand/sit workstations in classrooms: lessons learned from a pilot study in Texas. *Journal of Public Health Management and Practice*, 18(5), 412-415.
- Carlson, S.A., Fulton, J.E., Lee, S.M., Maynard, L.M., Brown, D.R., Kohl, H.W., & Dietz, W.H. (2008). Physical education and academic achievement in elementary school: data from the early childhood longitudinal study. *American Journal of Public Health*, 98(4), 721-727.
- Coe, D.P., Pivarnik, J.M., Womack, C.J., Reeves, M.J., & Malina, R.M. (2006). Effect of physical education and activity levels on academic achievement in children. *Medicine & Science in Sports & Exercise*, 38(8), 1515-1519.
- Contardo-Ayala, A.M., Salmon, J., Timperio, A., Sudholz, B., Ridgers, N.D., Sethi, P., & Dunstan, D.W. (2016). Impact of an 8-month trial using height-adjustable desks on children's classroom sitting patterns and markers of cardio-metabolic and musculoskeletal health. *International Journal of Environmental Research and Public Health*, 13(12), 1227.
- Craig, C.L., Marshall, A.L., Sjostrom, M., Bauman, A.E., Booth, M.L., Ainsworth, B.E., & Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine & Science in Sports & Exercise*, 35(8), 1381-1395.
- Dornhecker, M., Blake, J., Benden, M., Zhao, H. & Wendel, M. (2015). The effect of stand-biased desks on academic engagement: an exploratory study. *International Journal of Health Promotion and Education*, 53(5), 271-280.
- Ekkekakis, P., & Erik, L. (2006). Exercise does not feel the same when you are overweight: the impact of self-selected and imposed intensity on affect and exertion. *International Journal of Obesity*, 30(4), 652.
- Hamilton, M.T., Healy, G.N., Dunstan, D.W., Zderic, T.W., & Owen, N. (2008). Too little exercise and too much sitting: inactivity physiology and the need for new recommendations on sedentary behavior. *Current Cardiovascular Risk Reports*, 2(4), 292-298.
- Hamlyn-Williams, C.C., Freeman, P., & Parfitt, G. (2014). Acute affective responses to prescribed and self-selected exercise sessions in adolescent girls: an observational study. *BMC Sports Science, Medicine and Rehabilitation*, 6(1), 35.
- Longman, D., Stock, J.T., & Wells, J.C.K. (2017). A trade-off between cognitive and physical performance, with relative preservation of brain function. *Scientific Reports*, 7(1), 13709.
- Mehta, R.K., Shortz, A.E., & Benden, M.E. (2015). Standing up for learning: A pilot investigation on the neurocognitive benefits of stand-biased school desks. *International Journal of Environmental Research and Public Health*, 13(1), 59.

- Mohammad, A. (2017). Physical fitness variables required for pre-service teachers. *European Journal of Physical Education and Sports Science*, 3(11), 396-406.
- Shephard, R.J., Lavallee, H., Volle, M., LaBarre, R., & Beaucage, C. (1994). Academic skills and required physical education: The Trois Rivières experience. *CAHPER Research Supplement*, 1(1), 1-12.
- Sherry, A.P., Pearson, N., & Clemes, S.A. (2016). The effects of standing desks within the school classroom: A systematic review. *Preventive Medicine Reports*, 3, 338-347.
- Shrestha, N., Kukkonen-Harjula, K.T., Verbeek, J.H., Ijaz, S., Hermans, V., & Pedisic, Z. (2016). Workplace interventions for reducing sitting at work. *Cochrane Database of Systematic Review*, 20, 6.
- Szczygiel, E., Zielonka, K., Metel, S., & Golec, J. (2017). Musculo-skeletal and pulmonary effects of sitting position - a systematic review. *Annals of Agricultural and Environmental Medicine*, 24(1), 8-12.
- Thorp, A.A., Kingwell, B.A., Sethi, P., Hammond, L., Owen, N., & Dunstan, D.W. (2014). Alternating bouts of sitting and standing attenuate postprandial glucose responses. *Medicine & Science in Sports & Exercise*, 46(11), 2053-2061.
- Voss, C., Duncombe, S.L., Dean, P.H., de Souza, A.M., & Harris, K.C. (2017). Physical activity and sedentary behavior in children with congenital heart disease. *Journal of American Heart Association*, 6(3).
- Wendel, M. L., Benden, M. E., Zhao, H., & Jeffrey, C. (2016). Stand-biased versus seated classrooms and childhood obesity: a randomized experiment in Texas. *American Journal of Public Health*, 106, (10), 1849-1854.