

Difference in Caloric Expenditure in Sitting Versus Standing Desks

Christopher Reiff, Kara Marlatt, Donald R. Dengel

Background: Traditional desks require students to sit; however, recently schools have provided students with nontraditional standing desks. The purpose of this study was to investigate differences in caloric expenditure of young adults while sitting at a standard classroom desk and standing at a nontraditional standing classroom desk. **Methods:** Twenty (10 male/10 female) young (22.8 ± 1.9 y), healthy participants reported to the laboratory between the hours of 7:00 AM and 2:00 PM following a 12-h fast and 48-h break in exercise. Participants were randomly assigned to perform a series of mathematical problems either sitting at a normal classroom desk or standing at a nontraditional standing desk. Inspired and expired gases were collected for 45-min for the determination of oxygen consumption (VO_2), carbon dioxide production (VCO_2), and minute ventilation (V_E) using a metabolic gas system. **Results:** There were significant increases from sitting to standing in VO_2 (0.22 ± 0.05 vs. 0.28 ± 0.05 $\text{L}\cdot\text{min}^{-1}$, $P \leq .0001$), VCO_2 (0.18 ± 0.05 vs. 0.24 ± 0.050 $\text{L}\cdot\text{min}^{-1}$, $P \leq .0001$), V_E (7.72 ± 0.67 vs. 9.41 ± 1.20 $\text{L}\cdot\text{min}^{-1}$, $P \leq .0001$), and kilocalories expended per minute (1.36 ± 0.20 kcal/min, $P \leq .0001$ vs. 1.02 ± 0.22 kcal/min, $P \leq .0001$). **Conclusions:** Results indicate a significant increase in caloric expenditure in subjects that were standing at a standing classroom desk compared with sitting at a standard classroom desk.

Keywords: oxygen consumption, carbon dioxide production, respiratory exchange ratio

In the United States, obesity currently affects more than 60% of the adult population, and the prevalence among adolescents is increasing at an alarming rate.¹ Approximately 35% of male adolescents and 26% of female adolescents meet current physical activity recommendations.² A general conception is that low levels of physical activity promote the onset of obesity.³ Of particular importance, obese individuals sit 2 hours per day longer than nonobese individuals.⁴

To some extent, schools play a role in establishing physical activity levels in young adults and adolescents. Changes in school criteria have led to a decrease in physical activity opportunities during the school day due to increased emphasis on core subjects, such as math and science.⁵ A number of schools have gone so far as to remove physical education from the curricula and reduce recess time.^{5,6}

Keeping students active during the school day is becoming increasingly difficult given the current focus on academic studies rather than physical education.⁵ A possible solution to this might be to develop methods to increase physical activity opportunities in the classroom. One method may be to use standing desks instead of sitting desks. Standing desks require that students stand during lesson time, which should result in students

expending more calories during school. The amount of increase in energy expenditure from sitting to standing is not known. The purpose of this study was to determine the changes caloric expenditure due to standing in young adults.

Materials and Methods

Participants

Twenty (10 female/10 male) healthy, young (22.8 ± 1.9 y) adults from the Minneapolis/St. Paul community volunteered to participate in this study. The Institutional Review Board (IRB) at the University of Minnesota approved the protocol and written informed consent was collected from each participant before the study. Participants were randomly assigned to either sit at a traditional classroom desk or stand at a specially designed nontraditional standing desk (AlphaBetter Adjustable Student Desk, Sunway, Inc., Centuria, WI, USA). On the following day participants were asked to come in for a second trial to be tested on the other desk. During the testing period, participants performed activities representative of classroom work, such as crossword puzzles and word-finds. All participants arrived for testing following at least a 12-h fast and 48 hours after their last bout of exercise. Upon arrival, height and weight were obtained by a wall stadiometer and standard balance scale, respectively, followed by fitting of an appropriate face mask for gas

Reiff, Marlatt, Dengel are with the School of Kinesiology, University of Minnesota, Minneapolis, MN.

collection. The volume of oxygen consumed (VO_2), carbon dioxide produced (VCO_2), and minute ventilation (V_E) were measured by a MedGraphics CPX/D metabolic cart (Medical Graphics Corporation, St Paul, MN, USA). Data were collected for 45-minutes with the first 15-minutes of each trial expunged to allow each participant to fully acclimate to the testing environment. The metabolic cart was calibrated before each testing session. All measurements were taken at the Laboratory of Integrative Human Physiology at the University of Minnesota.

Statistical Analysis

All statistical analyses were accomplished using StatView for Windows (SAS Institute, Inc., Cary, NC, USA). Values for VO_2 , VCO_2 , and V_E were averaged for 30-minutes of each data collection period. Analysis by paired *t*-test was used to determine statistically significant differences in VO_2 , VCO_2 , and V_E between the 2 activities for each participant. Caloric expenditure (kcal/min) was calculated by multiplying average V_E by the caloric equivalent, which was based on the average respiratory exchange ratio.⁷ Data are reported as mean \pm SD. All statistical comparisons were made at the alpha level of 0.05.

Results

Mean height and weight were 175.9 ± 8.1 cm and 72.7 ± 13.3 kg, respectively (Table 1). There were significant increases from sitting to standing in all subjects in VO_2 (0.22 ± 0.05 vs. 0.28 ± 0.05 L·min⁻¹, $P \leq .0001$), VCO_2

(0.18 ± 0.05 vs. 0.24 ± 0.050 L·min⁻¹, $P < .0001$), and V_E (7.72 ± 0.67 vs. 9.41 ± 1.20 L·min⁻¹, $P \leq .0001$; Table 2). From these results, an increase in caloric expenditure (0.34 ± 0.14 kcal/min, $P \leq .0001$) from sitting to standing was calculated using caloric equivalents.⁷

Discussion

This research study examined the difference in caloric expenditure from sitting at a traditional classroom desk to standing at a nontraditional standing desk. The results of this study demonstrate a significant increase in caloric expenditure standing at a nontraditional standing desk. In more practical terms, a U.S. middle-school student spends, on average, 1003 hours per year in a classroom receiving structured learning.⁸ Therefore, a student would expend approximately an additional 20,461 kcal (~114 kcal/day) per year by using a standing desk. This translates to an extra weight loss of approximately 5.85 pounds each year when enrolled in a classroom utilizing a standing desk, assuming the caloric intake is held constant. It has been suggested that obesity can occur from a positive energy balance of as little as 100 kcal per day.⁹ Increasing caloric expenditure by using a standing desk could be a great way to reduce a positive energy balance.

The standing desk may also have implications for not only school-aged children, but also for others who spend a large amount of their work day sitting at a desk. Researchers found that caloric expenditure increases in the work place by incorporating a walking motion into the daily lives of desk workers.¹⁰ For this study, researchers put a walking treadmill at a speed of 1 mile per hour

Table 1 Physical Characteristics of Subjects*

	Mean	Standard deviation	Range
Age (y)	22.750	1.888	21.0–28.0
Height (cm)	175.895	8.069	152.4–188.0
Weight (kg)	72.720	13.304	58.0–116.3
Body mass index (kg/m ²)	23.480	3.704	20.0–33.8

* Data recorded at the Laboratory of Integrative Human Physiology at the University of Minnesota between the hours of 7:00 AM and 2:00 PM.

Table 2 Respiratory Values Between Sitting and Standing Desk* (mean \pm SD)

	Sitting desk	Standing desk	<i>P</i> -value
Ventilation (L·min ⁻¹)	7.71 ± 0.67	9.41 ± 1.19	≤ 0.0001
VO_2 (L·min ⁻¹)	0.22 ± 0.05	0.23 ± 0.05	≤ 0.0001
VCO_2 (L·min ⁻¹)	0.18 ± 0.05	0.23 ± 0.05	≤ 0.0001
Respiratory exchange ratio	0.81 ± 0.05	0.85 ± 0.05	0.0007
Caloric expenditure (kcal/min)	1.02 ± 0.22	1.36 ± 0.20	≤ 0.0001

* Data recorded at the Laboratory of Integrative Human Physiology at the University of Minnesota between the hours of 7:00 AM and 2:00 PM.

in place of a chair during work time so desk workers walked for the work day. The energy increases observed in that study (1.98 ± 0.42 kcal/min) were substantially higher than the increases calculated in our study (0.34 ± 0.14 kcal/min), which is attributable to walking being more of an energy demanding activity than standing. Researchers estimated that a weight loss of 20–30 kg per year could be attained if walking replaced sitting for 2–3 hours per day.¹⁰

Another possible implication of using the standing desk is improvements in posture. Most school-aged children have experienced some sort of back and/or neck pain from inappropriate sitting posture in the standard classroom desk.¹¹ The pain is reported to having originated from increased trunk flexion for a period of longer than 1 hour.¹¹ Implications for the standing desk are that neck and back pain could be significantly improved by altering students' posture during the school day through standing. In fact, researchers have found that students sit 97% of lesson time; using a "moving" classroom where students sit dynamically (53% school day), stand (31% school day), and walk around (10% school day), trunk flexion decreases significantly.¹² By using the "moving" classroom, more favorable postural habits in school children are observed. By standing throughout the school day, children may adapt a more appropriate sitting posture and experience less back pain as a result.

We acknowledge several limitations to this study. The trials were only 45 minutes in duration and did not take place through an entire school day nor in an actual school environment. To find precise numbers, it would be ideal to carry out gas measurements for longer periods of time while in a school environment.

Conclusion

In this paper, we describe the energy expenditure associated with young adults while sitting versus standing. With this, we incorporated likely implications to children to positively affect the adolescent obesity epidemic. We found that by using a standing desk, caloric expenditure increased significantly. Using a standing desk may be a great way to increase physical activity in children.

Acknowledgments

The University of Minnesota Undergraduate Research Opportunities Program funded this study. We thank all participants for their involvement in this study. No financial disclosures were reported by the authors of this paper.

References

- Wyatt SB, Winters KP, Dubbert PM. Overweight and obesity: prevalence, consequences, and causes of a growing public health problem. *Am J Med Sci*. 2006;331:166–174. PubMed doi:10.1097/0000441-200604000-00002
- Li S, Treuth M.S, Wang Y. How active are American adolescents and have they become less active? *Obes Rev*. 2010;11(12):847–62.
- Blair SN, Brodney S. Effects of physical inactivity and obesity on morbidity and mortality: current evidence and research issues. *Med Sci Sports Exerc*. 1999;31:646–652. PubMed doi:10.1097/00005768-199905000-00004
- Levine JA, Lanningham-Foster LM, McCrady SK, et al. Inter-individual variation in posture allocation: possible role in human obesity. *Science*. 2005;307:584–586. PubMed doi:10.1126/science.1106561
- Levine JA. Schools are obesity zones because of marketing pressures of U.S.A. 2004; Retrieved from <http://www.medicalnewstoday.com/articles/8716.php>.
- Center for Disease Control and Prevention. Guidelines for school and community programs to promote lifelong physical activity among young people. *MMWR Morbidity and Mortality Weekly*. 1997;46:1–36.
- Carpenter TM. *Calorific values of oxygen and carbon dioxide for non-protein respiratory quotients and proportions of energy from carbohydrate and fat consumed*. Washington, DC: Carnegie Institution of Washington Publication. 1993;303:104.
- National Center for Education Statistics. *Time in classroom, indicator of the month*. Washington, D.C. 1993.
- Hill JO, Wyatt HR, Reed GW, Peters JC. Obesity and the environment: where do we go from here? *Science*. 2003;299:853–855. PubMed doi:10.1126/science.1079857
- Levine JA, Miller JM. The energy expenditure of using a "walk-and-work" desk for office workers with obesity. *Br J Sports Med*. 2007;41:558–561. PubMed doi:10.1136/bjism.2006.032755
- Murphy S, Buckle P, Stubbs D. Classroom posture and self-reported back and neck pain in schoolchildren. *Appl Ergon*. 2004;35:113–120. PubMed doi:10.1016/j.apergo.2004.01.001
- Cardon G, Clerc DD, Bourdeauhuji ID, Breithecker D. Sitting habits in elementary school children: a traditional versus a "moving school". *Patient Educ Couns*. 2004;54:133–142. PubMed doi:10.1016/S0738-3991(03)00215-5