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BIOL-201

The Leyburn Stairs' Effect on Blood Pressure

Introduction

Sitting is the new smoking. College-aged students across the nation are forced to sit for hours on end each day (Moulin, 2017.) Hypertension rates have been rising across the nation since 2013 (CDC, 2020). Students can combat a sedentary lifestyle by taking the stairs. Our study investigates the short-term impact of taking the stairs on blood pressure - a key indicator of cardiovascular health. Blood pressure[1] (BP) is tightly regulated to maintain optimal tissue perfusion by the mechanisms shown in Figure 1.

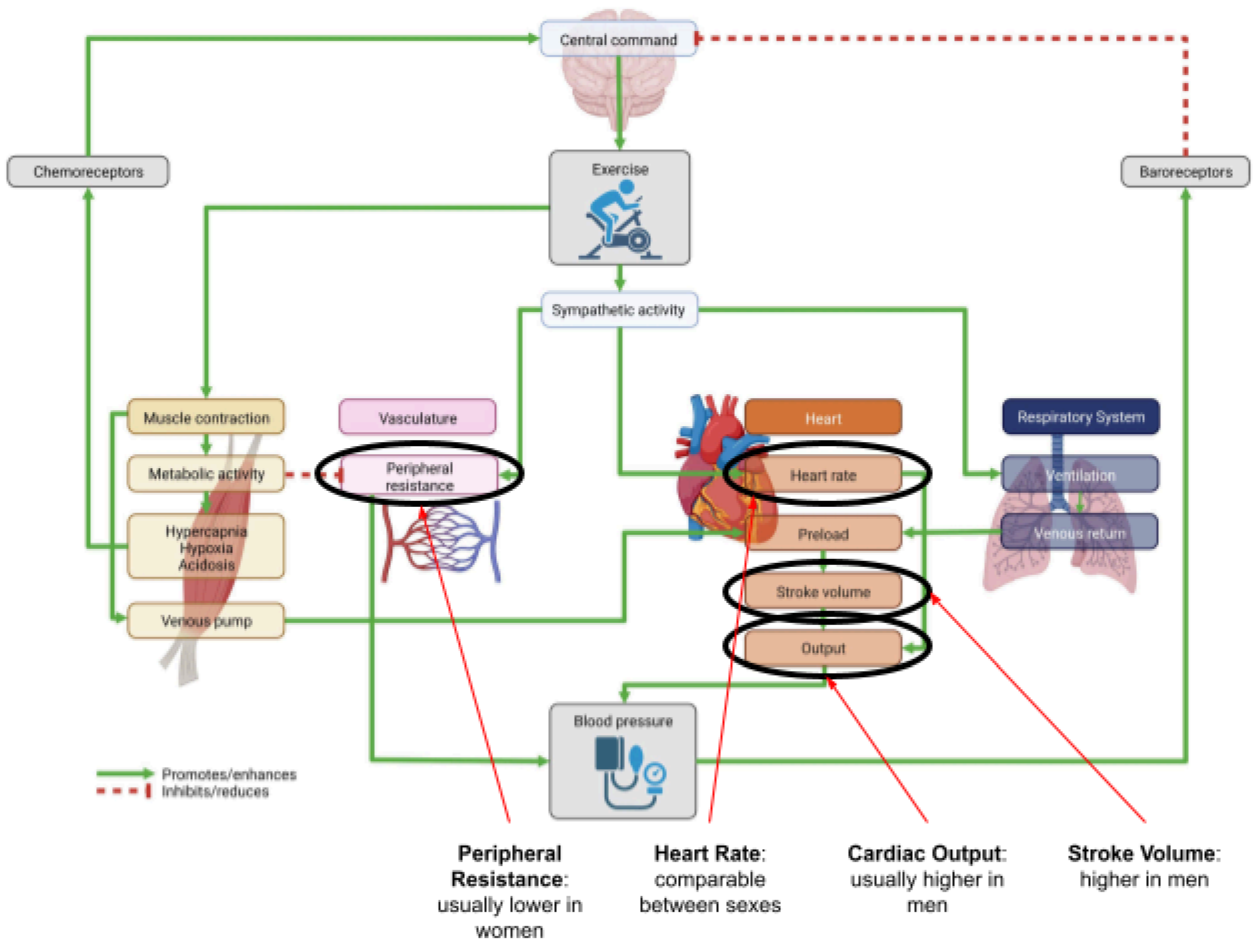

Figure 1: Adapted from Alvarez-Pitti et al., 2022, and from Bassareo and Crisafulli et al., 2020. Exercise increases BP. During physical activity, skeletal muscles require more blood to deliver oxygen and remove metabolic waste, necessitating an enhanced cardiac output. Thus, the heart increases its rate and stroke volume, resulting in more blood being pumped per unit of time. Sex differences in BP-related cardiac

[1] The force exerted by circulating blood against the walls of blood vessels

measures are portrayed at the bottom of the figure. Appendix E contains the sources for each gender difference, along with a review table from Bassareo and Crisafulli et al. The parameters that are especially important in gender differences in BP are peripheral resistance, heart rate, cardiac output, and stroke volume, as they all contribute to exercise-related BP increases.

Blood vessels, which supply oxygen to skeletal muscles, vasodilate to facilitate increased blood flow. The combined effects of this vasodilation and increased cardiac output contribute to an elevation in blood pressure during physical activity (Nystoriak et al., 2018). Consistent exercise has been associated with increased arterial compliance[2], and a reduction in vascular resistance[3], both of which contribute to lower resting blood pressure over time.

An important distinction to consider when examining the effects of exercise on BP is the known physiological difference between genders. Studies show that females generally show lower vascular resistance (Li et al, 1995), cardiac output (Fu and Levine, 2005), and resting blood pressure (Maranon and Reckelhoff, 1979) than males (Figure 1). These differences are due in part to the higher level of androgens in males than in females (Maranon and Reckelhoff, 1979).

To project the acute effect of physical activity, we used the Leyburn Stair Exercise (LSE) as a treatment condition for men and women. This study aims to present how blood pressure changes as a result of physical activity and differs among men and women respectively. The goal of our study is to examine if the LSE leads to significant increases in BP, and if so, how this increase differs between genders.

Methods

Our experiment examined the change in Systolic (SBP), Diastolic (DBP), and Mean Arterial Blood Pressure (MAP) in college-aged individuals, grouped by gender. Our sample was limited to those enrolled in BIOL-201, a class composed of 3 men and 6 women. This number of subjects was proved to be sufficient by our power analysis (see technical report).

Each subject completed the LSE, which consisted of jogging down and back up the Leyburn stairwell (8 flights of 12, 7-inch tall, stairs. 96 steps in total). The SBP and DBP of each subject were measured using a home BP monitor[4] before and after the LSE. MAP was also calculated (see technical report).

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[2] Ability of the arterial wall to increase in volume to adapt to changes in internal and external pressure.
[3] Force exerted by blood vessels on circulating blood
[4] AmazonBasics Lovia Digital Blood Pressure Monitor model #502

Figure 2: Adapted from Cleveland Clinic

Blood pressure was taken following the monitor's user manual[5]. The BP cuff was used on bare skin, with the artery mark an inch above the elbow pit. The subjects sat up straight without crossing their legs. Subjects were given a 3-minute resting period before initial BP was measured. 3 minutes is sufficient time to wait before measuring BP (Brady et al., 2021). Subjects were also given directions to read (see Appendix B) and instructed not to talk while BP was measured. After completing the LSE, the subjects' blood pressure was measured again by the same process but without a resting period.

[5] https://images-na.ssl-images-amazon.com/images/I/911kKv3naKL.pdf

Results

Following LSE, each subjects' SBP and MAP universally increased, and DBP followed a positive trend (Figure 3). MAP increased in both genders (Figure 4).

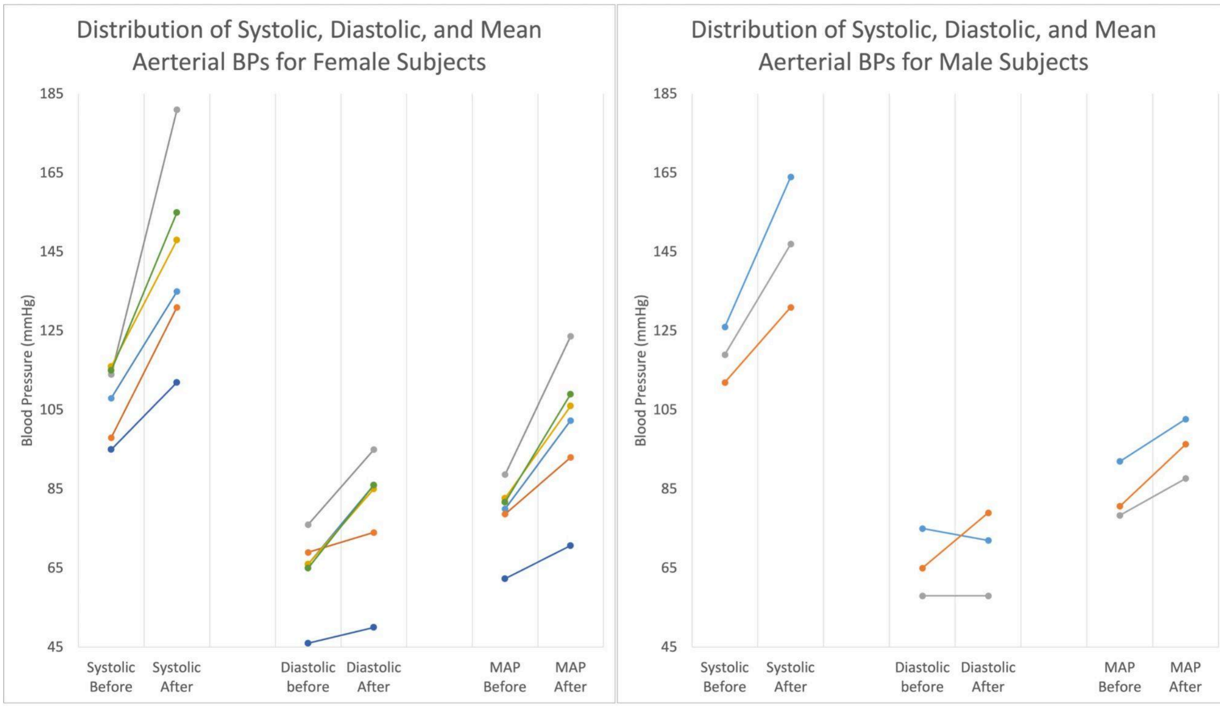

Figure 3: Distribution of blood pressure for women (left) and men (right) before and after completing the LSE. Lines connecting data points represent the change in a single subject before and after the LSE. From this figure, one can see that the LSE almost always increases BP in subjects (only 1 pressure measurement, in men's diastolic, decreases after LSE) and that the LSE always increases the spread of BP.

Our t-test (see technical report) showed that MAP increased after LSE in both men ($p = 0.0126$) and women ($p = 0.0012$) (Figure 4).

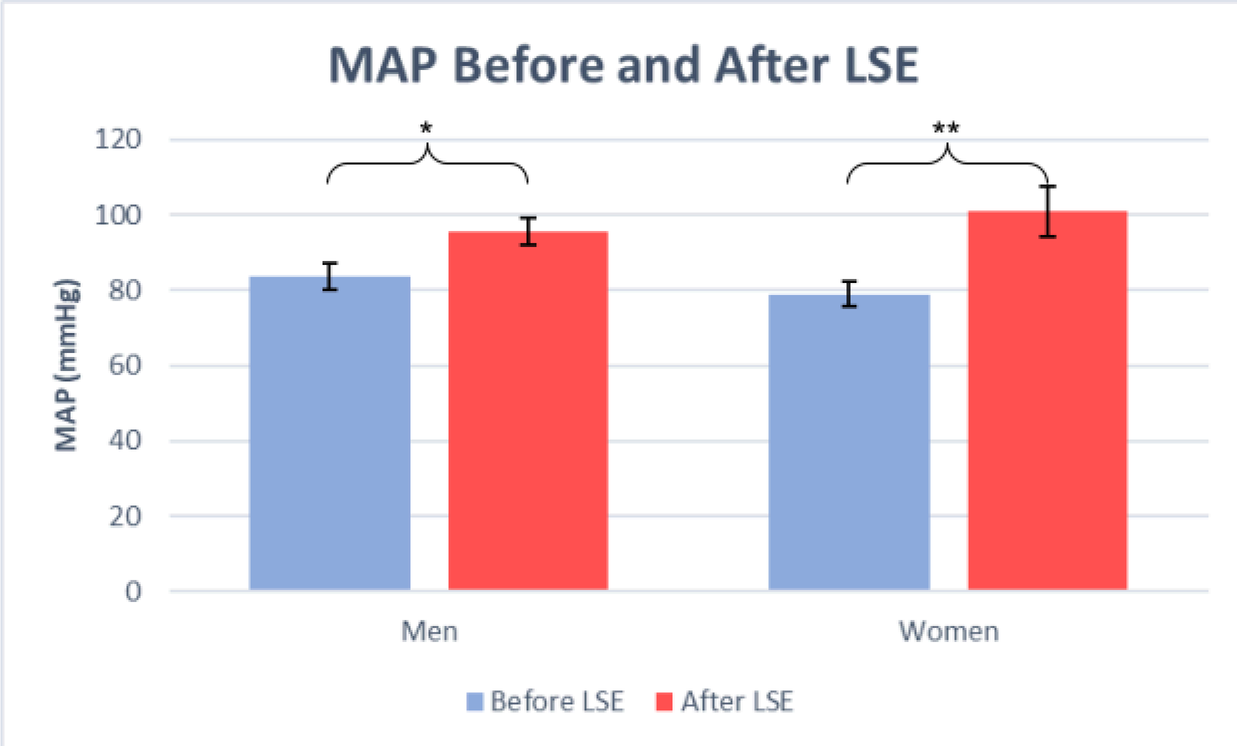

Figure 4: Average mean arterial blood pressure in men (n=3) and women (n=6) before and after the Leyburn Stair Exercise.

We also created 1-tailed, 95% confidence intervals for the increase in MAP, SBP, and DBP before and after the LSE in men and women. For men, we can be 95% confident the average increase in MAP will be between (8.80, 14.97). For women, we can be 95% confident the increase in MAP will be between (14.89, 28.67). Our CIs for SBP were (9.06, 47.60) and (19.72, 52.28) for men and women respectively, and (-14.74, 22.07) and (7.08, 22.25) for DBP.

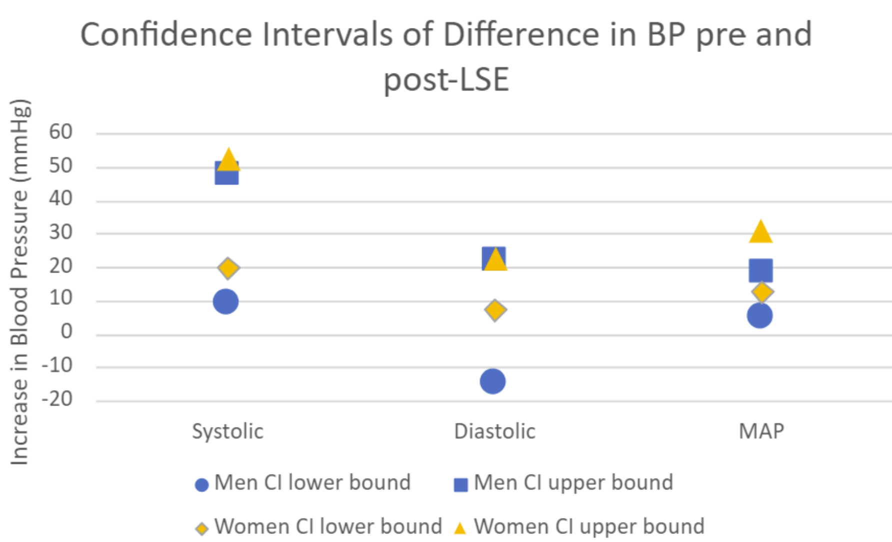

Figure 5: Confidence Intervals of change in all Systolic BP, Diastolic BP, and MAP for men and women. All confidence intervals overlap.

Finally, we performed a two-way ANOVA for repeated measures test (see technical report) (Figure 6). Our two-way ANOVA showed only the LSE treatment had a significant impact on MAP, SBP, and DBP. There were no significant effects from gender or gender-LSE interaction.

ANOVA tables resulting from various dependent variables (dv)

dv = MAP

Effect	DFn	DFd	F	p	p<.05	ges
Gender	1	7	0.257	0.628		0.032
LSE	1	7	9.844	0.016	*	0.136
Gender:LSE	1	7	3.544	0.102		0.054

dv = Systolic BP

Effect	DFn	DFd	F	p	p<.05	ges
Gender	1	7	0.520	0.494000		0.055
LSE	1	7	35.664	0.000558	*	0.519
Gender:LSE	1	7	0.506	0.500000		0.015

dv = Diastolic BP

Effect	DFn	DFd	F	p	p<.05	ges
Gender	1	7	0.257	0.628		0.032
LSE	1	7	9.844	0.016	*	0.136
Gender:LSE	1	7	3.544	0.102		0.054

Figure 6: ANOVA tables resulting from using dependent variables MAP (left) SBP (center) and DBP (right). For each test, the LSE factor (which included "before" and "after") was the only significant factor. Gender, and the interaction between gender and the LSE both resulted in statistically insignificant outputs. There is a roughly 10% chance that gender-LSE interaction has no interaction, which makes it non-significant.

Discussion

One major limitation of our study is that our sample is not completely random, as all subjects are enrolled in BIOL-201. This may introduce bias into our sample. The small sample size in this experiment also limits the generalizability of our findings to a broader population.

The significant p-values revealed by our t-test exhibit certainty that BP will increase in a college-aged individual after completing the LSE. Our 95% confidence intervals for change in SBP and MAP also tell us that completing the LSE will significantly increase BP. Since the CIs for MAP and SBP lie completely in the positive range, we can be more than 95% confident the change in men and women will be positive. We can say the same for DBP in women, but not men.

Our confidence intervals for BP change in men and women overlap for all BP measures, suggesting there is no clear gender-based difference in increasing blood pressure. This finding is consistent with the results of our two-way ANOVA test, which indicated no significant effects on blood pressure (MAP, SBP, or DBP) from gender, or the gender-LSE interaction. The similar magnitude of BP spike across genders indicates that physiological differences between men and women did not significantly impact the BP effects of LSE.

Conclusion

MAP universally increased across genders after completing the Leyburn Stair Exercise. Gender did not play an important role in the BP spike due to the LSE.

Consistent short-term increases in BP after taking the stairs, if repeated daily, may lead to a decrease in resting BP, which is associated with improved cardiovascular health and higher cognitive functioning (Giuseppe et al., 2019). Ultimately, short-term BP spikes due to exercise are beneficial for the cardiovascular system. Therefore, we recommend college-aged people should take the stairs when they have the chance - it's an easy way to be healthier!

Appendix.

A.

			Initial			After Exercise					
Subject		Sex	Systolic	Diastolic	MAP	Systolic	Diastolic	MAP	Change in Systolic	Change in Diastolic	Change in MAP
1 -		M	126	75	92	164	72	102.6666667	38	-3	10.66666667
2 -		M	112	65	80.666667	131	79	96.33333333	19	14	15.66666667
3 -		M	119	58	78.333333	147	58	87.66666667	28	0	9.333333333
4 -		F	108	66	80	135	86	102.3333333	27	20	22.33333333
5 -		F	98	69	78.666667	131	74	93	33	5	14.33333333
6 -		F	114	76	88.666667	181	95	123.6666667	67	19	35
7 -		F	116	66	82.666667	148	85	106	32	19	23.33333333
8 -		F	95	46	62.333333	112	50	70.66666667	17	4	8.333333333
9 -		F	115	65	81.666667	155	86	109	40	21	27.33333333

B.

Instructions for the subject to read before completing the Leyburn Stair Exercise:

> "Today, we will be doing a simple test to measure your blood pressure before and after exercise.
>
> We will first measure your blood pressure now. Take a minute to relax, and breathe normally.
>
> Once your initial blood pressure has been measured, you will walk all the way to the bottom of the Leyburn stairwell, and back up to our classroom (M47.)
>
> Then, we will measure your blood pressure again."

D.

Excel Data Table: https://wlu.box.com/s/nmfa1o46gqmsp4qybnfh1h8mrn9o77x9
Two Way ANOVA with Repeated Measurements data table:
https://wlu.box.com/s/0vf52ptxwwc6e5zu7vgkweu0vdyan2jp

E.

Parameter	Sex-related Differences
Heart Rate	No-difference between sexes
Stroke Volume	Usually higher in men
Stroke Index	Slightly higher in men or similar between sexes
Stroke Volume normalized by lean body mass	No-difference between sexes
Cardiac Output	Usually higher in men
Cardiac Index	Slightly higher in men or similar between sexes
Ejection Fraction	Slightly higher in men or similar between sexes
Arterio-venous oxygen difference	Usually higher in men
Systemic Vascular Resistance	Usually lower in women

Review from Bassareo and Crisafulli et al., 2020

Specific parameter citations:

Peripheral Vascular Resistance:

Li, Y., & Kloner, R. A. (1995). Is There a Gender Difference in Infarct Size and Arrhythmias Following Experimental Coronary Occlusion and Reperfusion?. *Journal of thrombosis and thrombolysis*, *2*(3), 221–225. https://doi.org/10.1007/BF01062713

Heart rate:

Hutchinson, P. L., Cureton, K. J., Outz, H., & Wilson, G. (1991). Relationship of cardiac size to maximal oxygen uptake and body size in men and women. *International journal of sports medicine*, *12*(4), 369–373. https://doi.org/10.1055/s-2007-1024696

Cardiac Output & Stroke Volume:

Fu, Q., & Levine, B. D. (2005). Cardiovascular response to exercise in women. *Medicine and science in sports and exercise*, *37*(8), 1433–1435. https://doi.org/10.1249/01.mss.0000174886.08219.85

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Nystoriak, M. A., & Bhatnagar, A. (2018). Cardiovascular Effects and Benefits of Exercise. Frontiers in cardiovascular medicine, 5, 135. https://doi.org/10.3389/fcvm.2018.00135

Centers for Disease Control and Prevention. (2020, April 24). Products - data briefs - number 364 - April 2020. Centers for Disease Control and Prevention. https://www.cdc.gov/nchs/products/databriefs/db364.htm#:~:text=In%20survey%20period%202017%E2%80%932018,%25%20(60%20and%20over).

Forte, Giuseppe et al. “Effects of Blood Pressure on Cognitive Performance: A Systematic Review.” Journal of Clinical Medicine vol. 9,1 34. 22 Dec. 2019, doi:10.3390/jcm9010034

Amazon Lovia Blood Pressure System User’s Manual: https://images-na.ssl-images-amazon.com/images/I/911kKv3naKL.pdf

Bassareo PP, Crisafulli A. Gender Differences in Hemodynamic Regulation and Cardiovascular Adaptations to Dynamic Exercise. Curr Cardiol Rev. 2020;16(1):65-72. doi: 10.2174/1573403X15666190321141856. PMID: 30907327; PMCID: PMC7393595.

Brady, T. M., Charleston, J., Ishigami, J., Miller, E. R., Matsushita, K., & Appel, L. J. (2021). Effects of different rest period durations prior to blood pressure measurement: The best rest trial. Hypertension, 78(5), 1511–1519. https://doi.org/10.1161/hypertensionaha.121.17496

Maranon, Rodrigo, and Jane F Reckelhoff. “Sex and gender differences in control of blood pressure.” Clinical science (London, England: 1979) vol. 125,7 (2013): 311-8. doi:10.1042/CS20130140

Moulin, Marc S., and Irwin, Jennifer D. (2017) "An Assessment of Sedentary Time Among Undergraduate Students at a Canadian University," International Journal of Exercise Science: Vol. 10: Iss. 8, Pages 1116 - 1129. Available at: https://digitalcommons.wku.edu/ijes/vol10/iss8/3

Sharman, J. E., et al. “The Effect of Exercise on Large Artery Haemodynamics in Healthy Young Men.” European Journal of Clinical Investigation, Received 6 July 2005; Accepted 11 October 2005, vol. 35, no. 12, 2005, pp. 738–44, https://doi.org/10.1111/j.1365-2362.2005.01578.x.

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