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Feedback from 12/5 class:
NEED FIGURE WITH BIOLOGICAL INFO!

- WE SHOULD HAVE A FIGURE WITH A FLOW CHART!
- FIGURE WITH PHYSIOLOGY OF BLOOD PRESSURE
    - Could be our figure, or a figure we make summarizing someone else's physiological description! (NEED TO CITE SOMEONE ELSE'S PAPER HERE!)

Also - we need to move raw data table to appendix

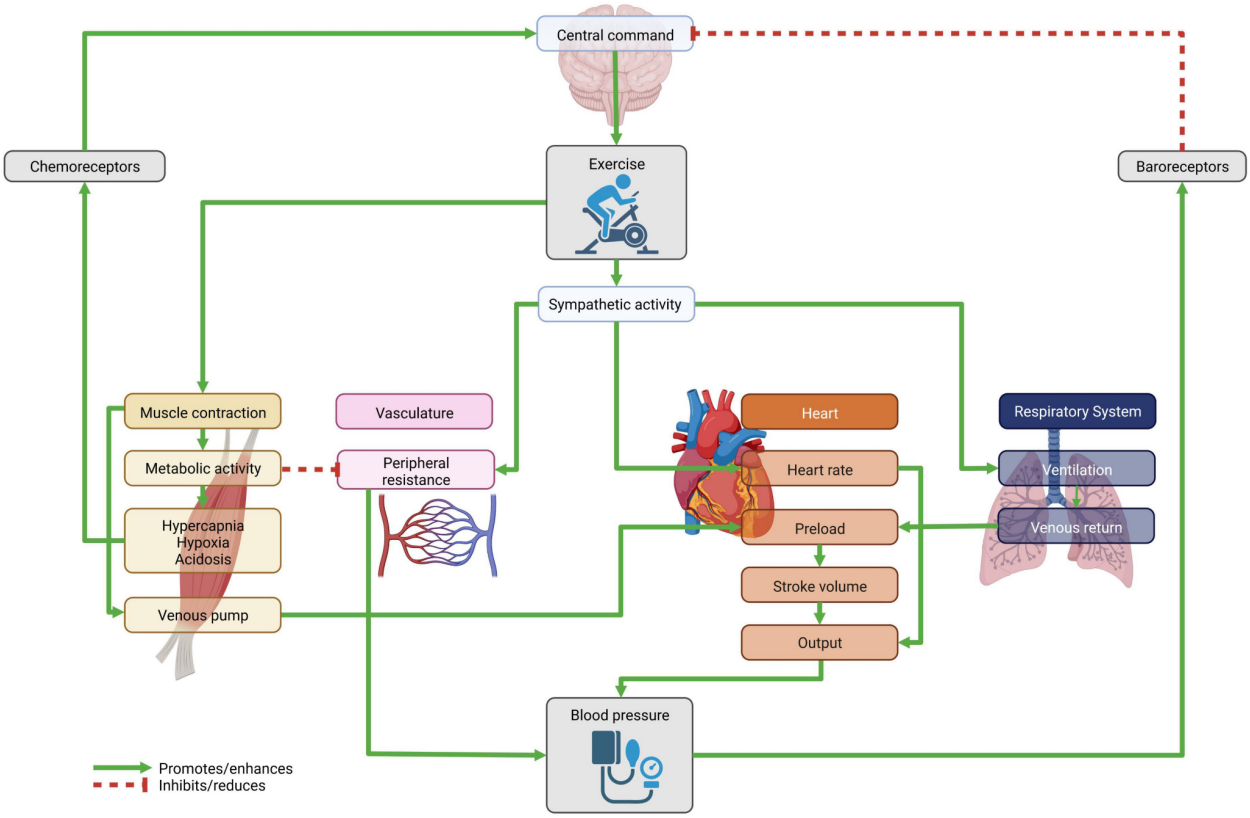
What is the Effect of the Leyburn Stairs on Blood Pressure

Introduction

Physical activity plays a crucial role in regulating various physiological processes within the human body, including cardiovascular function. One significant parameter influenced by physical activity is blood pressure, a key indicator of cardiovascular health. To understand how physical activity impacts blood pressure, it is essential to delve into the underlying biological mechanisms involved.

The cardiovascular system is a complex network comprising the heart, blood vessels, and blood. The heart pumps blood throughout the body, delivering oxygen and nutrients to tissues and organs. Blood pressure, the force exerted by circulating blood against the walls of blood vessels, is tightly regulated to maintain optimal tissue perfusion. This regulation involves intricate interactions between the nervous system, hormonal pathways, and local vascular responses.

During physical activity, the body undergoes a series of physiological adaptations to meet the increased demand for oxygen and nutrients. Skeletal muscles require more blood to deliver oxygen and remove metabolic waste, necessitating an enhanced cardiac output. The heart responds by increasing its rate and stroke volume, resulting in a higher volume of blood being pumped per unit of time. Additionally, the sympathetic nervous system is activated, leading to the release of epinephrine and norepinephrine. These hormones play a pivotal role in elevating heart rate, further increasing cardiac activity.



The blood vessels also adapt to the heightened metabolic demands during physical activity. Peripheral blood vessels, particularly those supplying skeletal muscles, undergo vasodilation to facilitate increased blood flow. The combined effects of increased cardiac output and selective vasodilation contribute to an elevation in blood pressure during physical activity.

Moreover, the long-term impact of regular physical activity on blood pressure involves structural adaptations within the cardiovascular system. Chronic exercise has been associated with increased arterial compliance, and a reduction in peripheral resistance, both of which contribute to the maintenance of lower resting blood pressure over time. In light of these physiological adaptations, it becomes evident that physical activity serves as a potent modulator of blood pressure. Even though the underlying mechanism of increased cardiovascular output is identical in males and females, this output varies greatly in magnitude. Gender-related physiological differences result in cardiovascular adaptations to physical activity.

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

Studies show that females show lower vascular resistance in general which is reflected during physical activity. Women generally have a lower cardiac volume in comparison to males. To project the effect of physical activity on an acute scale, we used the Leyburn Stair Exercise as a treatment condition. This study aims to present how blood pressure changes as a result of physical activity and the change difference in men and women respectively. Our biological hypothesis can be stated as "Does the Leyburn stair exercise lead to a statistically significant increase in blood pressure in men and women?"

Methods

Experimental Design:

Our experiment examined the change in Mean Arterial Blood Pressure (MAP) in college aged men and women. Our sample was limited to those enrolled in BIOL-201. This constraint was due to Washington and Lee University's requirement to submit project plans to their "Institutional Review Board for Research with Human Subjects" which would have set our team behind schedule. The BIOL-201 class is composed of 3 college-aged men and 6 college-aged women, which were used as the two experimental groups.

Due to the expected large increase in blood pressure from our treatment, 17 mmHg, (Sharman, J. E., et al, table 2) our limited sample size should still be able to produce statistically significant results. Our power analysis was conducted with type I error (α) set to 0.01 and type II

error (β) set to 0.2, expected effect size $d = \frac{103-86}{4\sqrt{3}}$. We found $n = \frac{(Z_\alpha - Z_\beta)}{d} = 1.67 \approx 2$. Thus, our limited sample size should still be able to produce statistically significant results. One limitation for our power analysis is that we only have the expected increase in MAP due to exercise for men.

Gender was considered a blocking variable, and our treatment was walking down 8 flights of stairs, to the bottom of Leyburn Library, and then jogging back up those stairs to the main floor. Using this experimental design to collect data, we can explore the relationship between gender, and exercise-related blood pressure increases.

What Was Measured:

Systolic and Diastolic blood pressure of each subject was measured using the Amazon Basics Lovia Digital Blood Pressure Monitor (model #B02). These were converted to Mean Arterial Blood Pressure (MAP) by the formula MAP = Diastolic - (⅓)(Systolic-Diastolic). MAP was used to aggregate the systolic and diastolic measurements given by our blood pressure system, and look at the change in blood pressure wholistically. Furthermore, previous literature, which we relied on for our power analysis, used MAP in their comparison of blood pressure pre and post exercise.

Blood pressure was taken in accordance with the user's manual for the Lovia Blood Pressure system. The BP cuff was used on bare skin, with the artery mark about an inch above the elbow pit, with subjects sitting up straight without legs crossed. Subjects were also given a roughly 3 minute resting period before initial blood pressure was taken. According to this study, 3 minutes is enough time to wait before measuring Blood Pressure. Subjects were also given the following instructions to read, and told not to talk while BP was being measured.

> "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."

The Leyburn Stairwell consists of 8 flights of 12 stairs each (96 steps in total.) Each step is 7 inches tall. To properly complete the exercise, subjects went all the way down and then up

these stairs. Upon returning from the Leyburn Stair Exercise, subjects were immediately sat down and had their blood pressure taken again. This time, they were not instructed to relax, and did not get any relaxation period. Subjects were still instructed to sit up straight and make sure their legs were uncrossed.

What was compared, and how:

Differences in MAP before and after the Leyburn Stair Exercise were compared via a T-test, and confidence interval, analysis split between males and females.

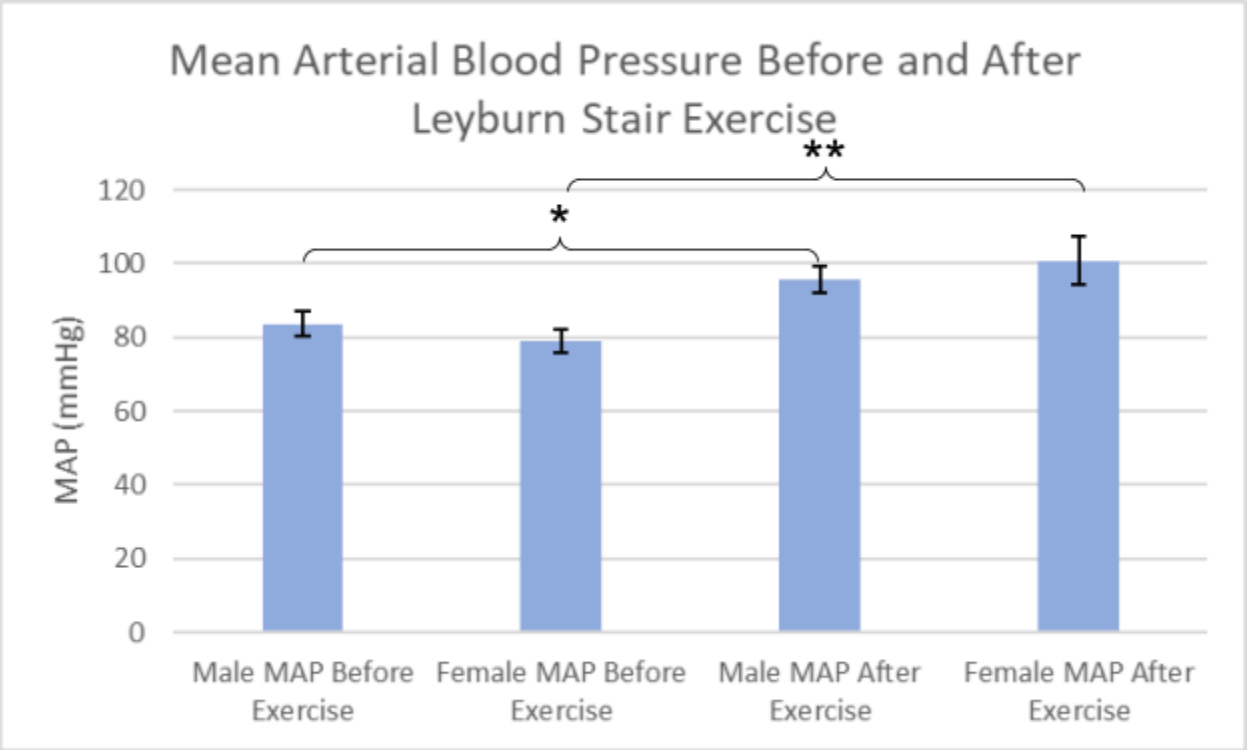
Results

CAPTION: Table of all data collected

First we will look for differences in MAP before and after the Leyburn stair exercise in both men and women.
*assuming Mean Arterial Pressure is normally distributed in men and women both before and after exercise AND
*assuming variance of MAP is constant before and after exercise for men/women

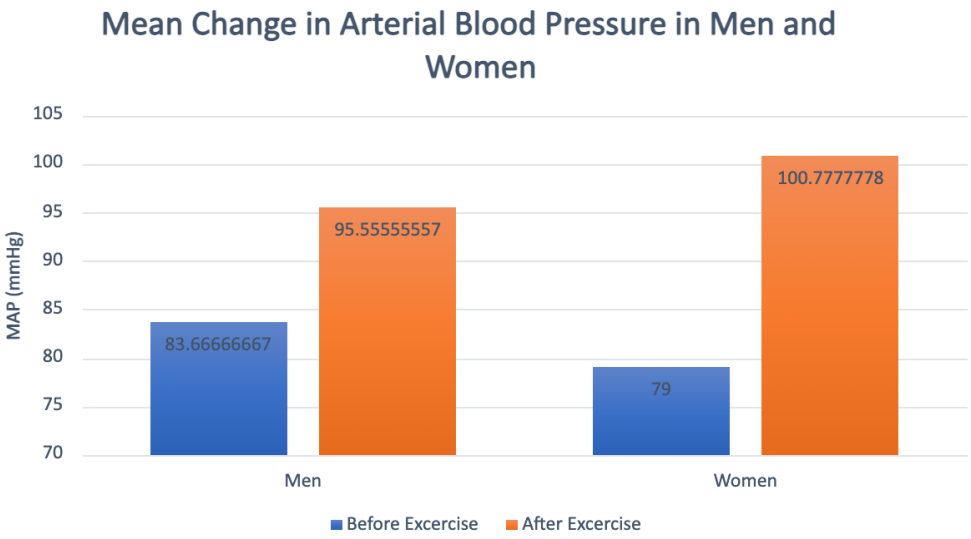
			Initial			After Exercise						
Subject		Sex	Systolic	Diastolic	MAP	Systolic	Diastolic	MAP	Change in Systolic	Change in Diastolic	Change in MAP	% MAP Increase
1 -		M	126	75	92	164	72	102.6666667	38	-3	10.66666667	11.5942029
2 -		M	112	65	80.666667	131	79	96.33333333	19	14	15.66666667	19.42148761
3 -		M	119	58	78.333333	147	58	87.66666667	28	0	9.333333333	11.91489362
4 -		F	108	66	80	135	86	102.3333333	27	20	22.33333333	27.91666666
5 -		F	98	69	78.666667	131	74	93	33	5	14.33333333	18.22033898
6 -		F	114	76	88.666667	181	95	123.6666667	67	19	35	39.47368421
7 -		F	116	66	82.666667	148	85	106	32	19	23.33333333	28.22580645
8 -		F	95	46	62.333333	112	50	70.66666667	17	4	8.333333333	13.36898396
9 -		F	115	65	81.666667	155	86	109	40	21	27.33333333	33.46938775

Ho: Before exercise and after-exercise MAP levels come from the same population in men/women.
Ha: Before-exercise and after-exercise MAP levels come from different populations in men/women.
A student t-test between Mean Arterial Pressure (MAP) for before-exercise and after-exercise groups revealed a p-value of 0.0126 for men and 0.0012 for women. Because both of these p values fall under the 0.05 threshold, we can say that the Leyburn stair exercise led to a statistically significant increase in mean MAP for both men and women.



CAPTION: Mean Arterial Blood Pressure in men (n=3) and women (n=6) before and after the Leyburn Stair Exercise.

- We calculated the percent increase in MAP for all subjects to account for differences in male and female physiology(able to assume homoscedasticity), and ran a student t-test to see whether the increase was different between the sexes
- two tailed t-test returned a p value of 0.075, which is greater than our alpha of 0.05 .
- Unable to reject null hypothesis that there is a statistically different increase in MAP between men and women.



Discussion - Zach

We used the mean arterial pressure to compare the blood pressure for each individual and group. This value is the twice diastolic blood pressure plus the systolic pressure divided by 3. We decided to use the MAP because it is a widely used, one-number, holistic measurement of blood pressure, and it tends to be more accurate than diastolic or systolic on its own. Also, using a one-number value rather than both makes our statistical analyses more precise and easier to understand. Systolic blood pressure alone tends to vary considerably, so in the formula for MAP, the systolic number is outweighed by the diastolic number, but still considered.

One source of error in our experiments that may need to be assessed, although our results were all significant, is the monitor itself. The monitor we used is a home health tool from Amazon, by no means a piece of medical-grade equipment. Therefore, we can assume that our numbers probably vary slightly, especially since we do not know if our equipment was officially validated. Also, the fact that we were measuring the blood pressures ourselves, not medical professionals, there may have been errors resulting from improper tightening of the cuff, placement on the arm, or many other variables.

One of the statistical analyses we used to decipher our data was a student t-test for MAP between before-exercise and after-exercise groups in both men and women. In this test, our null hypothesis was that there was no difference between the before and after groups. Using the t-test Excel command comparing our before-exercise and after-exercise groups for each gender, we got a p-value of 0.0126 for men and 0.0012 for women. As both of these p-values are below the alpha of 0.05, the results of the t-test tell us we can reject our null hypothesis. Therefore, there is a statistically significant increase in mean MAP for both men and women before and after running up and down the Leyburn stairs.

We also made confidence intervals in Excel for the change in MAP between before-exercise and after-exercise groups in both men and women. For men, we can say with 95% confidence that the average increase in MAP before and after the Leyburn Stair Excercise

will be between 8.80397391 and 14.9738039. For women, we can say with 95% confidence that the average increase in MAP before and after the Leyburn Stair Excercise will be between 14.8900186 and 28.6655369. From this data, we can conclude with 95% certainty that the difference in MAP will be positive, meaning it will increase, and very much so. These results were expected, given that we had significant p-values for our t-tests for both men and women.

But what does this tell us and where can these results be applied? Our exercise test was for the Leyburn stairs, stairs many college students at Washington and Lee walk consistently multiple times per week, so the results of our experiment can be reasonably applied to most students at W&L. Also, our results can be applied outside of W&L, as walking stairs and other short bursts of exercise are part of daily life for almost everybody. If the increase in blood pressure for college students on these stairs is so significant, most people likely have similar blood pressure spikes due to short periods of exercise, such as walking stairs, every day. Overall, short periods of exercise are expected to spike blood pressure, and this is a good thing. Short-term spikes are extremely beneficial for the cardiovascular system, as they make the heart stronger. Therefore, the heart does not have to work quite as hard to pump blood in the long run, meaning overall blood pressure will drop and so will the risk of heart disease. In conclusion, taking the stairs is a great form of exercise, it is cardiovascularly beneficial, and it can make a big difference in one's overall heart health.

- Discussion of why we used MAP specifically
    - one-number, holistic measurement of blood pressure (diastolic and systolic both considered)
    - tends to be more accurate than either diastolic or systolic on its own
- What Statistical Tests and Why?
    - T-test comparing our before-exercise and after-exercise groups for each gender
        - p-value of 0.0126 for men and 0.0012 for women
        - Reject null for both - statistically significant
        - Increase in mean MAP for both men and women before and after running up and down the Leyburn stairs
    - Confidence Intervals for the change in MAP for both genders
        - MOST INTERESTING RESULTS
        - For men, we can say with 95% confidence that the average increase in MAP for before and after the Leyburn Stair Exercise will be between 8.80397391 and 14.9738039.
            - 95% CI for men: (8.80, 14.97)
        - For women, we can say with 95% confidence that the average increase in MAP for before and after the Leyburn Stair Exercise will be between 14.8900186 and 28.6655369
            - 95% CI for women (14.89, 28.67)

- Comparing the % MAP increase with a 1 tailed t-test, with alpha = .05, we found a p value of .0389. This indicates the % MAP increase is actually significantly greater in women than in men.

- From this data, we can conclude with 95% certainty that the difference in MAP will be positive, meaning it will increase, and very much so. These results were expected, given that we had significant p-values for our t-tests for both men and women

- But what does this tell us and where can these results be applied?
  - Students walk these stairs every day
  - Stairs and short bursts of energy use are part of everyday life
    - If our results were so strong, most likely experience similar blood pressure spikes throughout their day due to physical exercise
    - These short-term spikes are usually completely normal and healthy, increasing cardiac capacity and overall heart health and function.
    - However, if someone has high blood pressure already, we can recommend

Conclusion.

Ultimately, we found that blood pressure universally increased across genders after completing the Leyburn Stair Exercise, most noticeably in systolic blood pressure. However, mean arterial blood pressure increased more for women than for men after completing the exercise, leading to a . This short term increase in blood pressure, if repeated on a daily or weekly basis, may lead to a net decrease in blood pressure for the long term, which has been linked to increased cognitive functioning(Forte, Giuseppe et al.)

Appendix.

			Initial			After Exercise						
Subject		Sex	Systolic	Diastolic	MAP	Systolic	Diastolic	MAP	Change in Systolic	Change in Diastolic	Change in MAP	% MAP Increase
1 -		M	126	75	92	164	72	102.6666667	38	-3	10.66666667	11.5942029
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9 -		F	115	65	81.666667	155	86	109	40	21	27.33333333	33.46938775

Technical Report Outline:

- Power Analysis
    - Show the math, men vs women assumed similar variances/std. deviation

Power analysis conducted using type 1 error of 0.01 and standard type 2 error of 0.2, based on expected literature increase in MAP of 17 mmHg. Analysis yielded an n value of 1.67, rounded up to 2 to observe the MAP increase in subjects.

- Technical Explanation of Confidence Interval

For statistical analysis of the data, we assume that the variance of resting MAP differs slightly, but not greatly, between men and women, and that both of these populations are normally distributed. We made the same assumptions for post-exercise populations of elevated MAP blood pressures. However, we assume that the % increase in MAP will be comparable between men and women as the % increase will account for physiological differences.

Student t-tests run in excel:
Before vs After more men/women, 1 tailed (1), paired(1)
% MAP increase for men/women, 1 tailed (1), homoscedastic (2)

- Null and alternative hypotheses

- Math
  Thus we use the formula:
- Excel functions used
- Resulting CI:
- 95% CI for men MAP increase: [8.80, 14.97]
- 95% CI for women MAP increase: [14.89,28.67]
-
- 1 tailed: expected increase
- Actual formulas and math
- Excel functions and processes used
- Resulting significance level

- (in progress)Technical Explanation of ANOVA (Note, this test is yet to actually be done! It's unclear if we will add this for certain or not.)
    - Assumptions
    - Null and Alternative Hypotheses
    - Details of Exactly what ANOVA we used
        - Probably: 2 way test with repeated measures
    - Interaction chart!

- Resulting Anova table, with a description of the exact excel process to get it.

Citations & Takeaways:

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
-> lower blood pressure increases cognitive functioning in the long run, diastolic blood pressure linked to blood supply in brain

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.

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.

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

Effects of Different Rest Period Durations Prior to Blood Pressure Measurement: The Best Rest Trial
https://www.ahajournals.org/doi/full/10.1161/HYPERTENSIONAHA.121.17496