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Study of the Effect of Hip Flexibility on Maximal Oxygen Consumption and Stride Lenghth During an Incremental Treadmill Test in College-Aged Individuals

Kailey Barnette
Western Washington University

Honors Senior Thesis

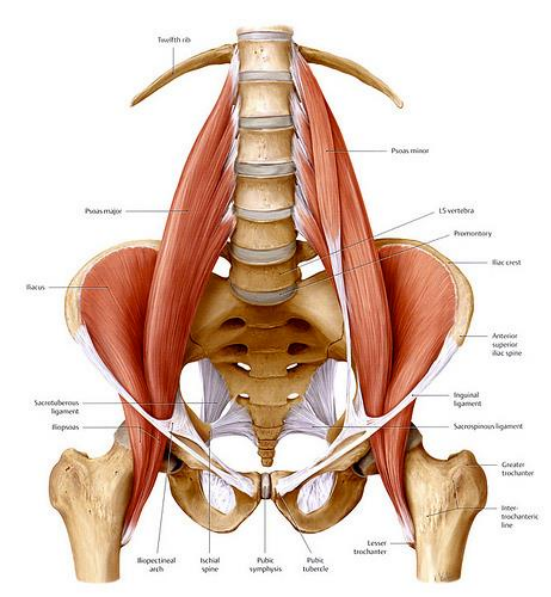
Kailey Barnette

Questions

- **Is there any effect of hip flexor flexibility on $VO_{2\ max}$ in college-aged individuals?**

- **Is there any effect of hip flexor flexibility on running stride length in college-aged individuals?**

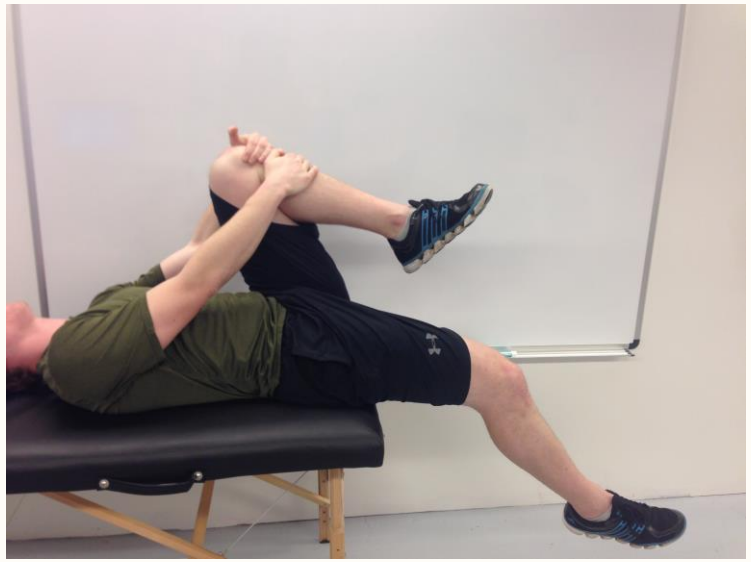
Project Overview



- 10 male and 10 female college-aged subjects
- All subjects were regular runners
- Submaximal incremental treadmill test
- Subjects ran on a pressure sensor treadmill in order to obtain stride length
- Hip flexor flexibility was measured using the Modified Thomas Test and angles were measured with a digital inclinometer
- Heart rate was obtained with a Polar Heart Rate Monitor
- Data was analyzed in Excel with T-Tests, Pearson R Correlation Tests, and graphical representations

Definitions

- $VO_{2\ max}$ (maximal oxygen consumption, maximal oxygen uptake, maximal oxygen capacity): the maximum amount of oxygen the body can use during a specified period of usually intense exercise that depends on body weight and the strength of the lungs
- Modified Thomas Test: used to obtain measures of flexibility of hip flexor muscles (quadriceps muscles and iliopsoas); client sits at the very edge of the bench, then rolls back while pulling both knees to the chest, and releases one of the legs to the table and the angle femur at the hip is measured
- Digital Inclinometer: electronic instrument used for measuring angles, slope, elevation, or depression



Study Implications

- $VO_{2\ max}$ is a universal indicator of aerobic fitness
- Insight into whether hip flexor flexibility is beneficial or detrimental to runners' running economy
- Insight into whether hip flexor stretching would be beneficial for runners
- Improvements in running warm-ups, cool-downs and/or training regimens

Background

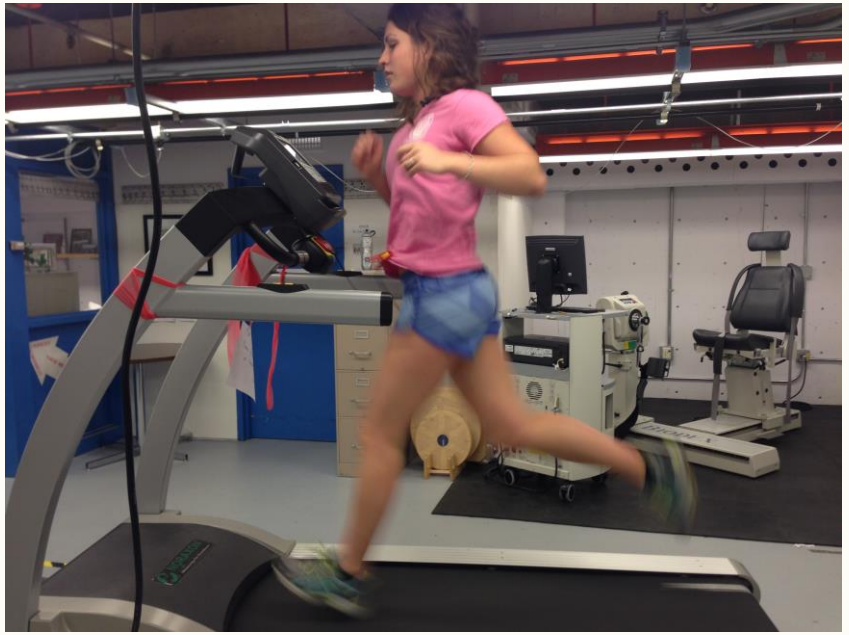
- A.M. Jones study in 2002
  - Measured running economy and sit-and-reach test performance in male international distance runners
  - Used an incremental treadmill test to test $VO_{2\ max}$
  - Found runners who performed worse on the sit-and-reach test had a higher $VO_{2\ max}$
  - Stated “it is possible that stiffer musculotendinous structures reduce the aerobic demand of submaximal running by facilitating a greater elastic energy return during the shortening phase of the stretch-shortening cycle”

Background

- Linear relationship between heart rate and $VO_{2\ max}$
  - As an individual moves from a resting state to one of exercise, the body demands more oxygen for metabolic processes to keep up with the energy demands
  - Heart rate begins to steadily increase with exercise, allowing for faster oxygen delivery to the working tissue, such as skeletal muscle, which allows for an increase in oxygen consumption ($VO_{2\ max}$)
- The National Council on Strength and Fitness equation for estimated VO_2 given heart rate was used to estimate VO_2

Methods

- Participants signed the consent form, were weighed, their heights were measured, and were attached to the Polar Heart Rate Monitor
- Participants sat in a chair for 5 minutes and their resting heart rate was measured
- Participants ran a self-paced warm-up for 5 minutes (suggested to run anywhere between 5 and 6 mph)
- Following the warm-up, the participants were taken to the treatment table and their hip flexor flexibility was measured with the Modified Thomas Test and Digital Inclinometer



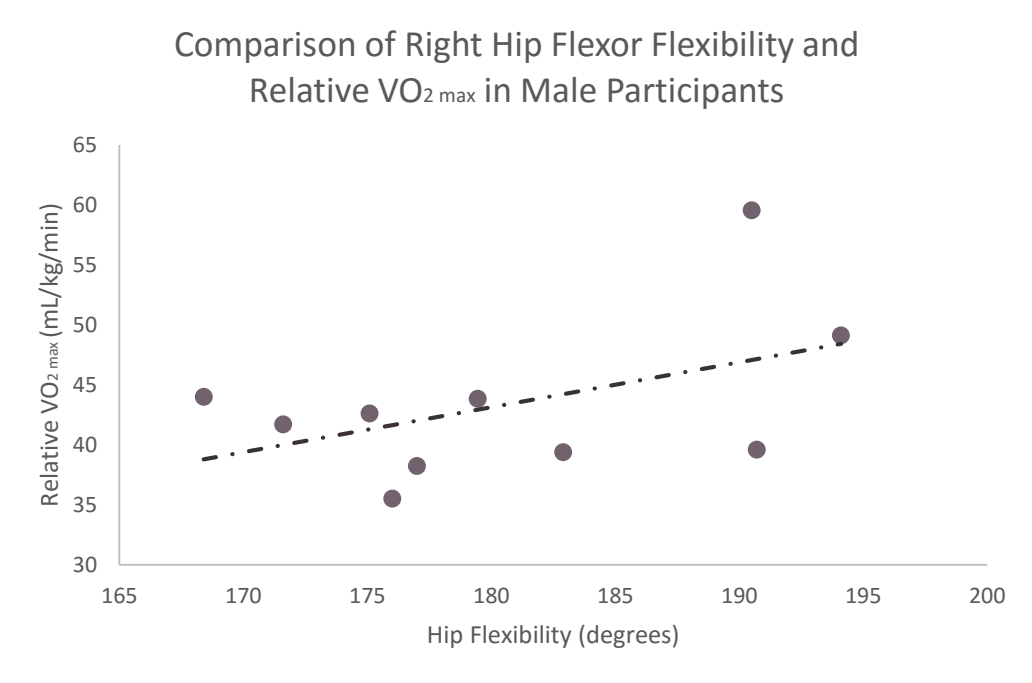
Methods

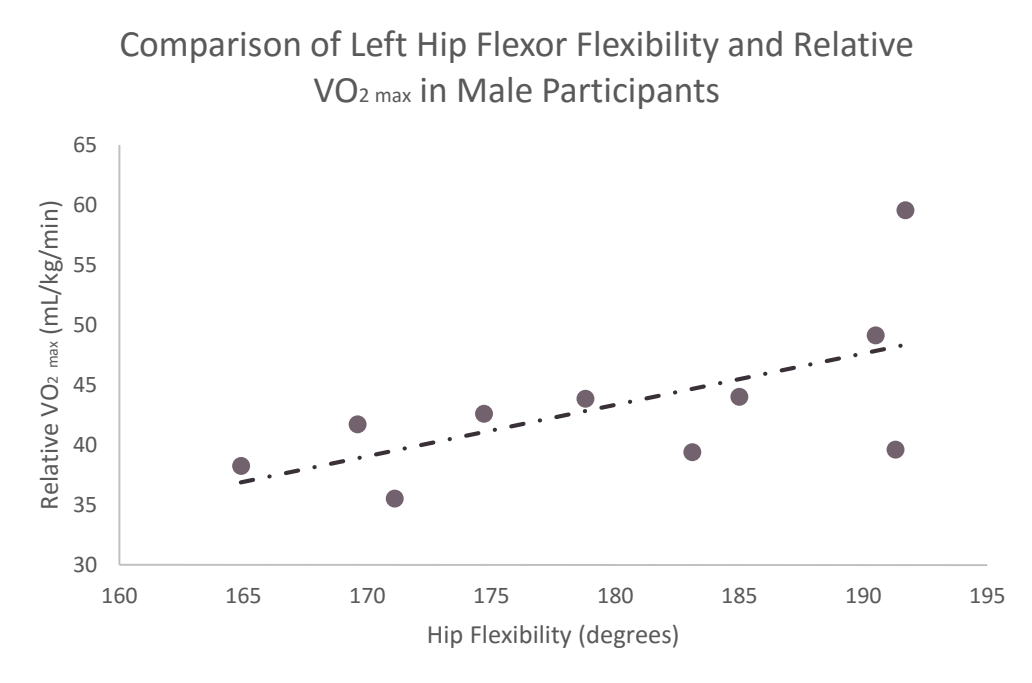
- Participants rested quietly in the chair for 2 minutes and were told the incremental running testing protocol
- Participants attached the treadmill safety clip to their shirts and began running at 4.5 mph for 3 minutes; heart rate was recording during the last 30 seconds at this speed
- After 3 minutes at 4.5 mph, the participants were instructed to increase the speed to 6.0 mph and ran for 3 minutes; heart rate was recording during the last 30
- After 3 minutes at 6.0 mph, the participants were instructed to increase the speed to 8.5 mph and ran for 3 minutes; heart rate was recording during the last 30 seconds at this speed
- Stride length was recorded at 8.5 mph

Methods

- Following completion of the test, the participants were instructed to actively cool down on the treadmill at their own pace for 5 minutes (suggested to cool down at approximately 3.5 mph)
- Each of the participants' stride lengths were normalized by dividing by their heights
- Each of the participants' maximal heart rate (correlated with $VO_{2\,max}$) was calculated by the Age-Predicted Maximal Heart Rate Formula (HR_{max}=220-Age)
- Their heart rate obtained while running at 8.5 mph was divided by their APMHR and was converted to a percentage
- Oxygen consumption (VO_2) at 8.5 mph was calculated via the predetermined formula
- $VO_{2\,max}$ was calculated given percentage of heart rate and the calculated VO_2
- Absolute Relative $VO_{2\,max}$ was calculated by normalizing VO_2 by weight

Results

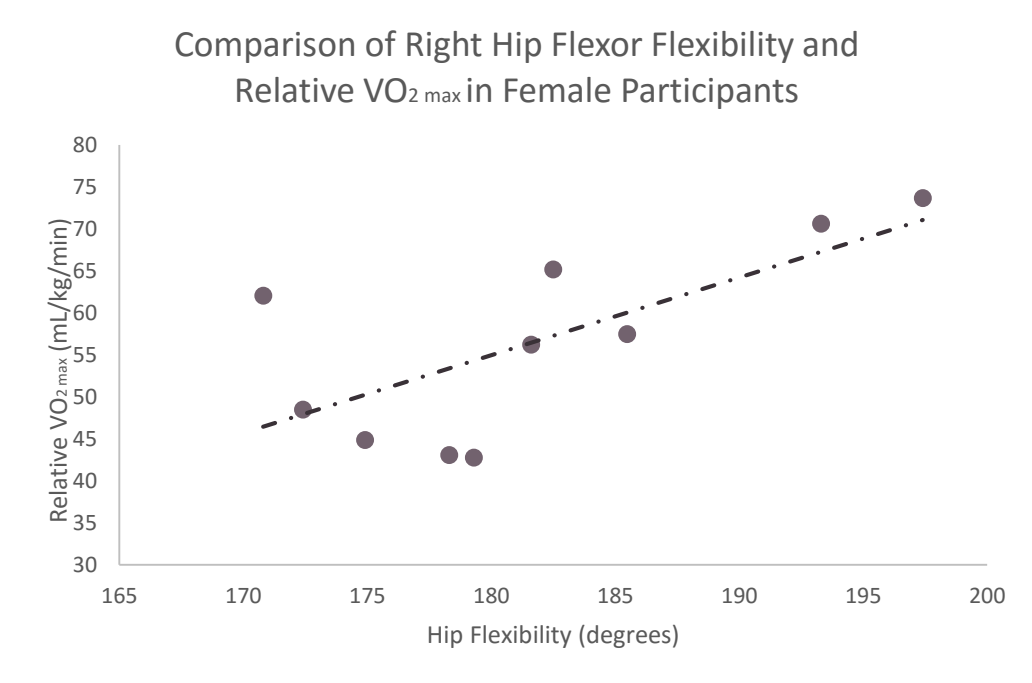




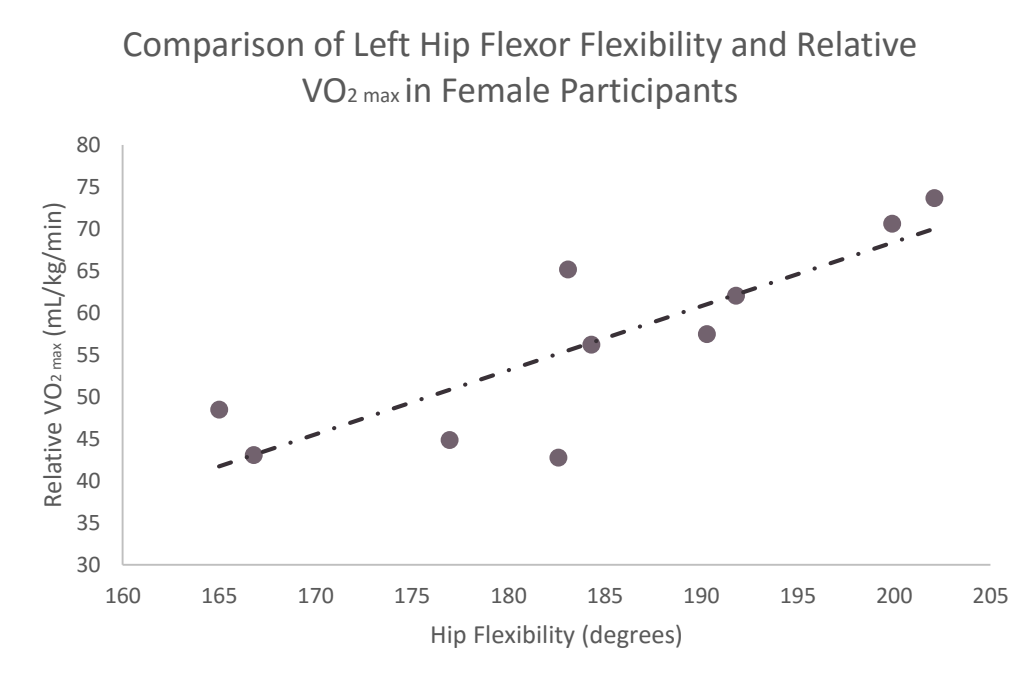
R-Value: 0.48; moderate positive relationship

R-Value: 0.61; moderate positive relationship

Results

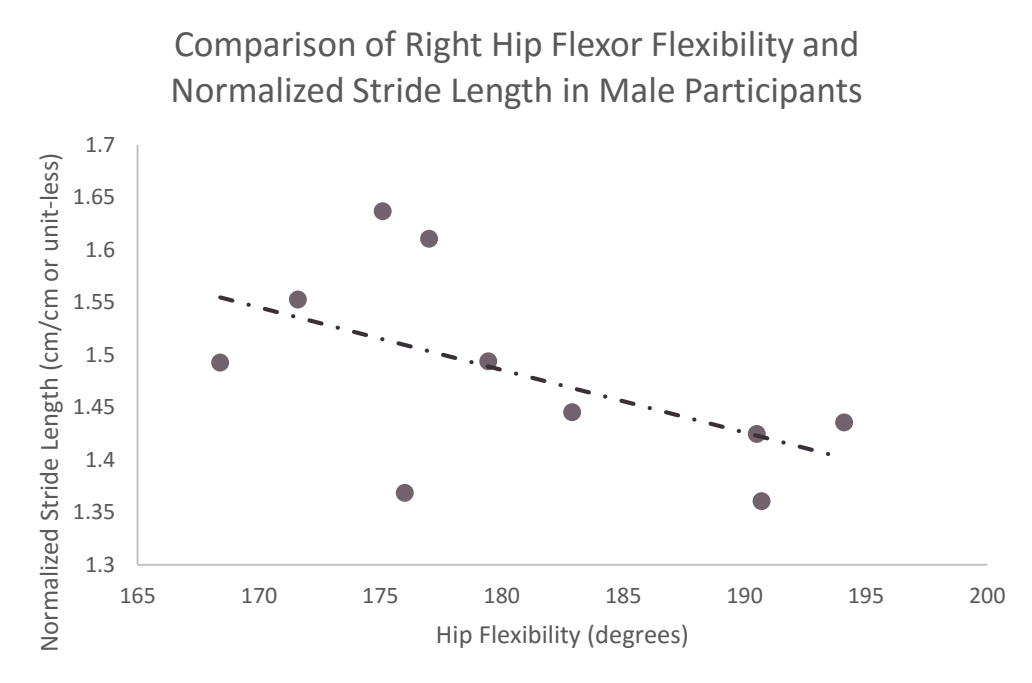


R-Value: 0.70; strong positive relationship

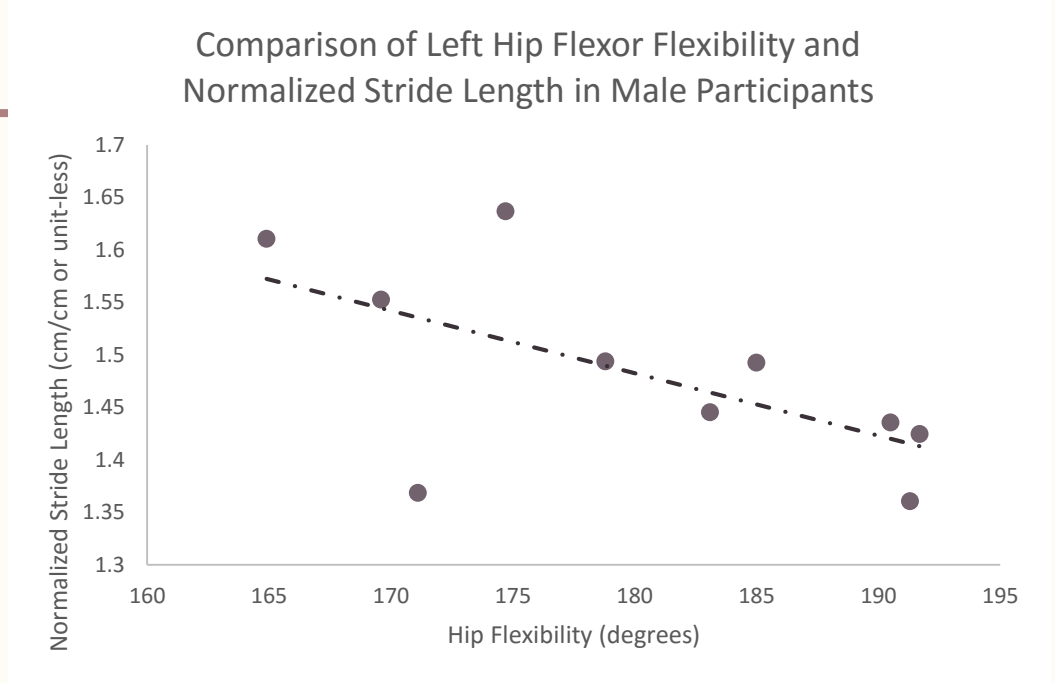


R-Value: 0.83; strong positive relationship

Results

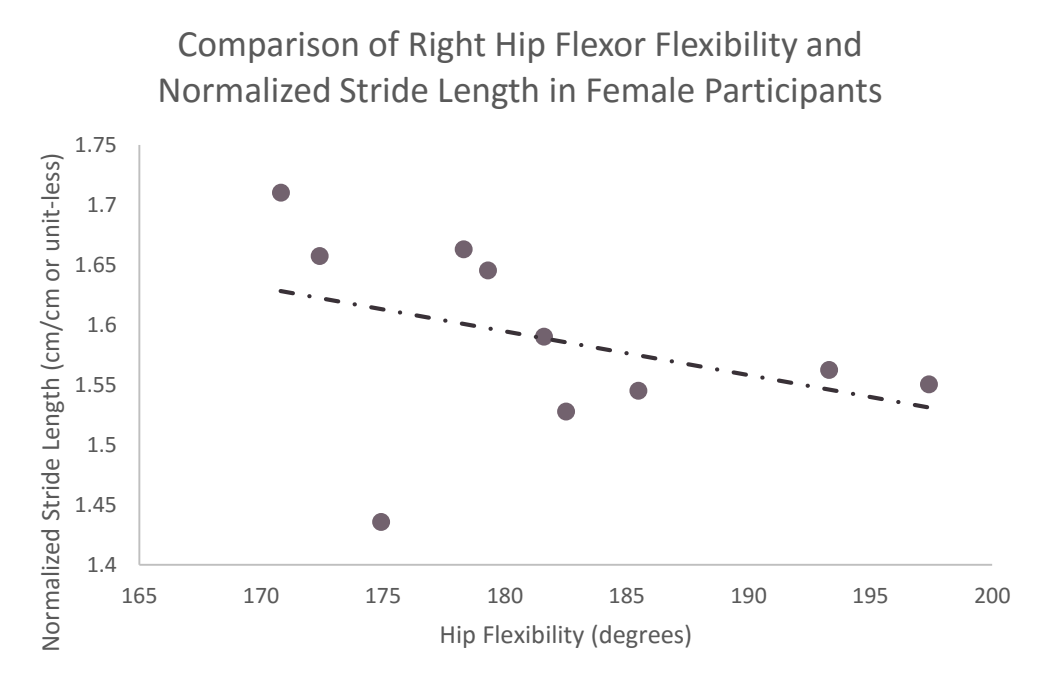


R-Value: -0.55; moderate negative relationship

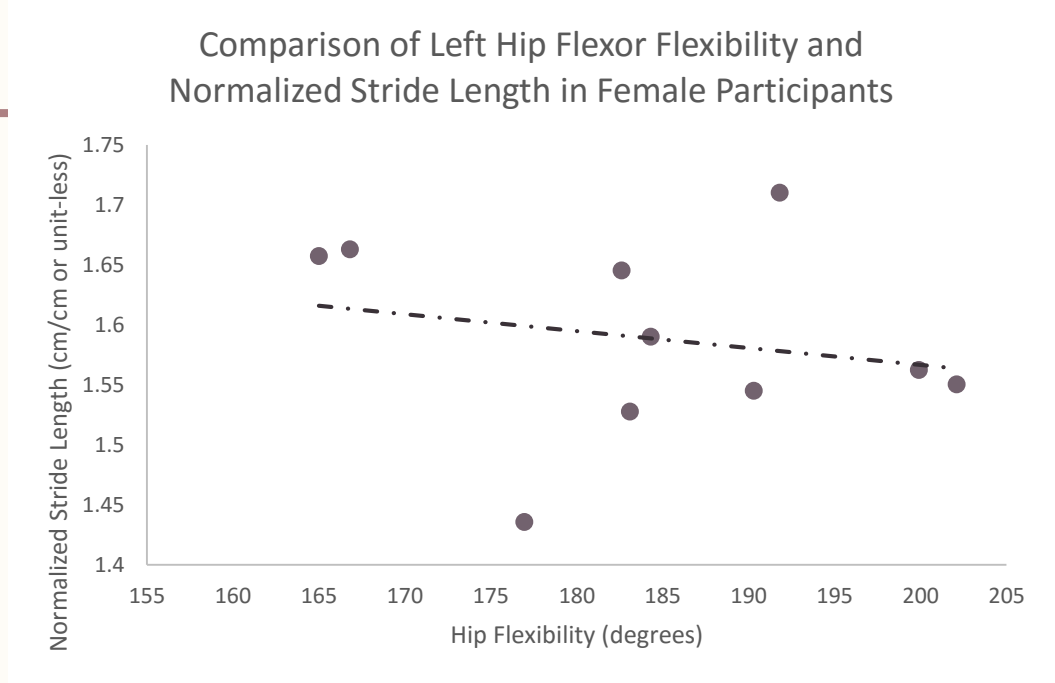


R-Value: -0.62; moderate negative relationship

Results

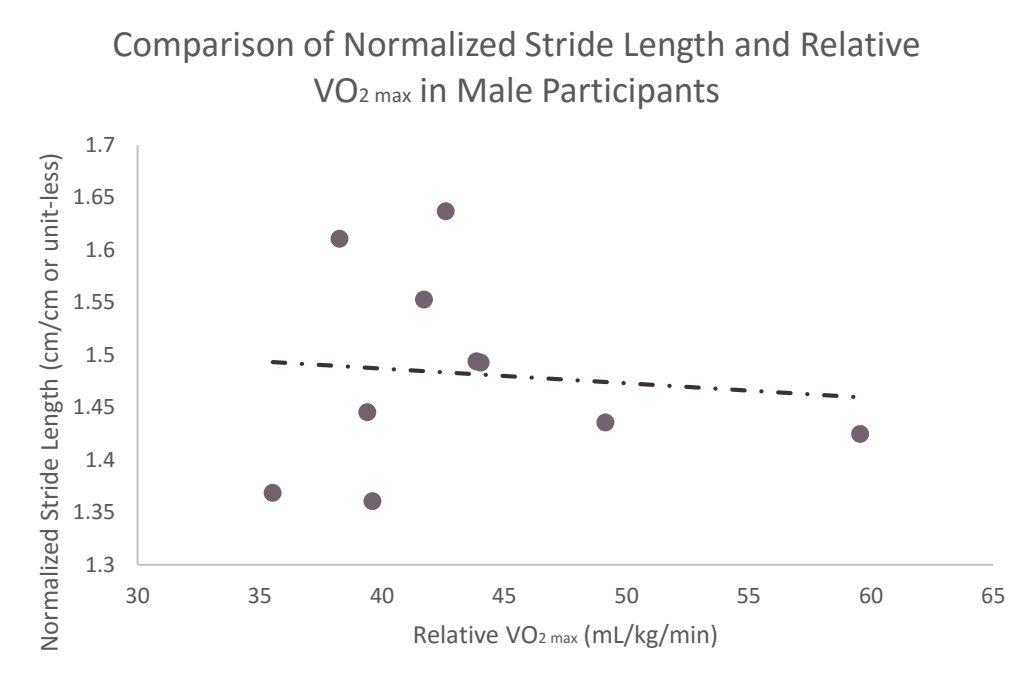


R-Value: -0.39; weak negative relationship

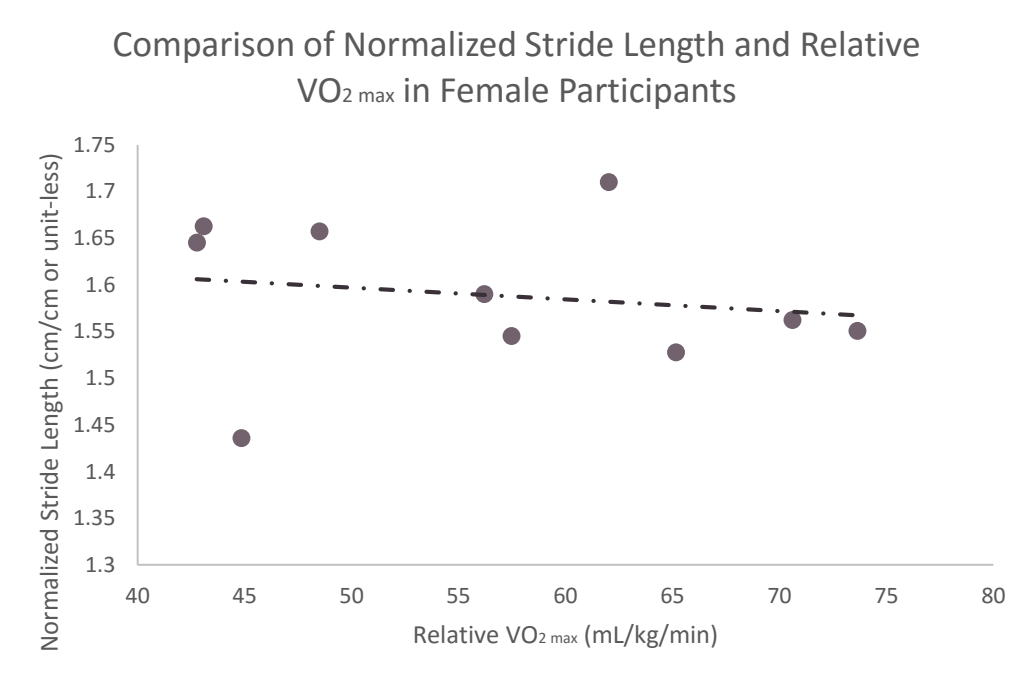


R-Value: -0.22; weak negative relationship

Results



R-Value: -0.10; weak/no relationship



R-Value: -0.18; weak/no relationship

Analysis

- T-Tests were run to analyze the statistical significance of the differences between the male and female populations
  - Men and Women's Relative $VO_{2\ max}$: 0.0060
  - Men and Women's Right Hip Flexibility: 0.794
  - Men and Women's Left Hip Flexibility: 0.410
  - Men and Women's Standardized Stride Lengths: 0.0143

Interpretations

- The P-Values calculated when comparing the male and female participants show that the drastic differences between male and female $VO_{2\ max}$ and stride length scores were statistically significant
- The R-values comparing the female participants' right and left hip flexor flexibility to their relative $VO_{2\ max}$ scores demonstrate that there is a strong correlation between hip flexor flexibility and $VO_{2\ max}$

Interpretations

- Dissimilar to the study by A.M. Jones, this study did not find limited flexibility improved relative $VO_{2\ max}$
  - Otherwise, there were no significant correlations between any of the other variables
- There were statistically significant differences between the male and female participants in stride length and relative $VO_{2\ max}$
  - The average relative $VO_{2\ max}$ score for males was 43.36 mL/kg/min, while the average relative $VO_{2\ max}$ score for females was 56.43 mL/kg/min
  - The average male stride length was 1.48, while the average female stride length was 1.59

Interpretations

- The average relative $VO_{2\ max}$ for college-aged sedentary females is 33 ml/kg/min, while the average relative $VO_{2\ max}$ for college-aged sedentary males is 42 ml/kg/min (Bouchard 1998)
- The average relative $VO_{2\ max}$ for college-aged elite female athletes is around 70 ml/kg/min, while the average relative $VO_{2\ max}$ for college-aged elite male athletes is around 82 ml/kg/min (Pate et al. 1987)
- The average maximal oxygen consumption for female college-aged recreational runners is around 55-60 ml/kg/min, while the average for college-aged male recreational runners is around 67-72 ml/kg/min
- The males that participated in this study averaged much lower than the national average for the same population, while the females were right around the national average for the female population
- The significant statistical difference between the male and female $VO_{2\ max}$ scores could possibly be due to the inaccurate and disproportionate fitness level of the male participants in this study

Discussion

- Given the small population this study tested and the possible unequal fitness levels between the male and female populations, the results are inconclusive and simply present some correlation
- The strong positive correlation between the female participants' $VO_{2\ max}$ scores and both the right and left hip flexor flexibility did not support this study's hypothesis
  - This study's hypothesis was based on the relationship between men's hamstring flexibility and $VO_{2\ max}$ scores
- Further research should be done to assess any gender differences between flexibility and relative $VO_{2\ max}$

Future Research

- Study only looking at competitive female runners' hip flexor flexibility and $VO_{2\ max}$
- Study of varying levels of physical fitness (non-runner, recreational runner, and elite runner) and a comparison of $VO_{2\ max}$ and hip flexor flexibility
- Study looking at any differences between sprinters and distance runners
- Study using a metabolic cart and maximal tests

Thank you

- Thank you to Dr. San Juan for advising and overseeing this research
- Thank you to all 20 of the participants
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- Thank you to the Kinesiology Department and Honors Program for providing the opportunity and resources to conduct this study