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# **NASA Moonbuggy Competition: Rider's Workout Reference Guide**

By

**Susan Leslie Duron**

**An Honors Capstone**

**submitted in partial fulfillment of the requirements**

**for the Honors Diploma**

to

**The Honors College**

of

**The University of Alabama in Huntsville**

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## **Abstract**

The annual NASA Moonbuggy Competition, recently renamed to the Human Exploration Rover Challenge, allows teams from around the world to design and compete with rovers with the goal of overcoming an obstacle course and completing tasks in the fastest time possible. The University of Alabama in Huntsville partakes in this competition and offers students the opportunity to compete in it through senior design class. To improve upon the performance of future riders, it is important for them to have a reference guide to be able to train efficiently. This reference guide contains a nutritional section, training guide, and documentation of past riders' training experience. The nutritional section covers the ratio of the different food groups one should consume before, after and, in certain circumstances, during the training session. Next, the training guide breaks down the different components of working out and provides anatomical diagrams as well exercise suggestions for each of the 5 major muscle groups. Finally, the rider testimonials were then included so that these experiences could serve as a source of inspiration and advice for future riders to craft their training schedule.

## **Disclaimer**

The contents of this paper are intended to provide useful information to the general public. All materials, including texts, graphics and images are for informational purposes only and are not a substitute for medical diagnosis, advice, or treatment for specific medical conditions. All readers should seek expert medical care and consult their own physicians before commencing in any exercise program or for any general or specific health issues.

## **Introduction**

The University of Alabama in Huntsville has been competing in the NASA Moonbuggy Competition since its creation in 1994. There have been several winning rovers over the years of our participation. However, no matter how well engineered these machines are the power behind them lies with the riders. These riders, through rigorous training, are the cornerstone of success within this competition. In order to streamline the training process, a reference guide has been compiled in the following document which covers nutrition, the components of an efficient workout, and a compilation of testimonies from some of the past riders.

## **Nutritional Section**

### **Overview**

Nutrition is an important part of training as it provides the necessary nutrients to both fuel exercise and aid in recovery afterwards. The time food is eaten prior to workout and quality of food eaten greatly impacts how efficient the training will be, therefore it is broken down into three timing categories: Pre-Workout Nutrition, Post-Workout Nutrition and food consumed during exercise [24]. The NSCA recommends eating a meal composed of carbohydrates, proteins, and fats 1-2 hours before training and 1-2 hours after working out while making sure to stay hydrated. Timing is important because eating prior to working out floods the bloodstream with nutrients to fuel the workout while eating after working out provides the body with the necessary nutrients to rebuild and grow muscle tissue. Food consumed during exercise is only important if the training session lasts longer than 2 hours or under certain circumstances. Another important factor to consider is the role of glycogen within training. Glycogen is the storage system of glucose which is the body's main energy source and is mainly supplied through carbohydrates.

## **Glycogen**

When food is consumed, it is converted to glucose molecules which are the body's main source of energy. When there is not a need for energy, insulin triggers a process which connects the glucose molecules together in chains of 8 to 12 which form glycogen. These are then stored in the muscles and liver. About 1%-2% of the weight of muscles is made up of glycogen whereas the weight of the liver is made up of approximately 6% of glycogen. The glycogen stored in the muscles are used as short-term fuel for fast bursts of energy whereas the glycogen stored in the liver are distributed throughout the body but mainly to the brain and spinal cord. The quality of food eaten and activity level influence how the body stockpiles and uses glycogen. For example, a low carb and ketogenic diet paired with strenuous exercise depletes glycogen levels and causes the body to burn fat for energy. This translates into preparing for workouts by being cognizant of the body's glycogen stores and actively working to keep them at a high enough level such that the training is more efficient [26].

## **Pre-workout**

In the 1-2 hours prior to training, food should be eaten such that it will sustain energy, boost performance, hydrate, preserve muscle mass and provide for a speedy recovery [24]. Eating a variety of carbohydrates, proteins and fats will help provide for these constraints. Carbohydrates are an important composite of the pre-workout meal because they are converted to glucose which provides a large amount of immediate energy for the muscles to burn. This helps to preserve the stores of glycogen in the muscle and liver. Furthermore, carbohydrates aid in recovery and help restore glycogen levels. Essentially, carbohydrates help to maximize the body's utilization of glycogen [25]. Consuming proteins prior to exercise helps to maintain or increase muscle size and floods your blood stream with amino acids just when the body requires

them. Amino acids act as the substrate of protein synthesis and the modulator of pathway growth for intracellular signal transduction [27]. Fats provide necessary vitamins and minerals for function, however, do not contribute much to training. Adequate hydration also sustains and enhances performance [25].

The general suggestion of carbohydrates, proteins, vegetables, and fats recommended for pre-workout and post-workout meals are 2 cupped handfuls of carbohydrate dense foods, 2 palms of protein dense foods, 2 fists of fruits or vegetables, and 2 thumbs of fat dense foods for men and 1 cupped handfuls of carbohydrate dense foods, 1 palms of protein dense foods, 1 fist of fruits or vegetables, and 2 thumbs of fat dense foods for women [24]. This is a general suggestion, though, and should be noted as such.

Nutrition in practice is a fluid procedure since there will be times in which the 1–2-hour nutritional goal is not met. In this case, if the timing is within the hour of training, try and eat a smaller meal which is easy to digest and packed with proteins and carbohydrates.

### **During exercise**

Eating while exercising is only important in certain situations such as the exercising session lasting more than two hours, if another exercising session takes place again within 8 hours, if the goal is to gain maximum muscle or if the exercising session is taking place in the heat [24]. The type of food consumed during exercise are generally of a liquid consistency or will not sit heavily in the stomach. If the exercising session lasts 2 hours or less water should suffice. This is especially the case if nutrition is received before and after the session.

The nutritional goal during exercise is to: stay hydrated, provide immediate fuel, boost performance, preserve muscle and improve recovery. Consuming proteins during exercise helps



prevent muscle breakdown. While consuming carbohydrates during exercise provides an immediate fuel source. Fats are not recommended to consume while working out since they are difficult to digest.

### **Post-workout**

After your training session, the muscles exercised will have used up their glycogen stores and some will have undergone damage [25]. As a recovery response, the body tries to replenish glycogen stores and to repair the muscle proteins. To aid in recovery, one should eat within the hour. The ratio noted in the pre-workout section will satisfy the same nutritional needs as the post-workout meal. Eating carbohydrates and protein after working out helps to decrease muscle protein breakdown, increase muscle protein synthesis, restores glycogen stores and enhances recovery. Consuming protein provides amino acids which repair proteins and build new muscle tissue. Carbohydrates restore glycogen stores. Also, when carbohydrates and proteins are consumed at the same time, insulin production is stimulated which aids in the production of glycogen. Fat slows down the absorption of your post-workout meal, however it does not reduce the benefits you receive from it.

Delaying your post workout meal by two hours after workout may lead to as much as 50% lower rates of glycogen production if the rider has not eaten a pre-workout meal. The still depleted glycogen stores will cause the rider to feel more tired and will slow recovery [25]. If working out without having had a pre-workout meal or are in a fasted state while training, then it is important to eat as soon as possible to aid in recovery.

## **Training Guide**

The goal of the training guide is to provide future Moonbuggy riders with a reference to create their own workout sessions to train with. The following section breaks down the steps of how to train and provides references for anatomical depictions of the five different muscle groups along with suggested exercises as a starting point to build a workout routine.

### **Overview**

The components of an exercise training session consist of the warming up, conditioning, cool-down and stretching [1]. A warm-up consists of a minimum of 5-10 minutes of light to moderate intensity cardiorespiratory and muscular endurance activities. Conditioning consists of aerobic, resistance and/or sports activities of the length determined by the goals of the workout session. The cool-down then lasts 5-10 minutes and consists of light to moderate intensity cardiorespiratory and muscular endurance activities. Then at least 10 minutes of stretching exercises should be implemented both before and after training. These steps should be implemented each session in order to maximize the rider's training.

### **Stretches**

Stretching is an important part of exercise as it prepares your muscles for rigorous conditioning. There are 2 main types of stretching consisting of the static stretch and dynamic stretch. Static stretching is slow and constant lasting 15-30 seconds. This form of stretching increases flexibility and decreases the likelihood of muscle injury. Some suggested static stretches are shown below in Table 1. Dynamic stretching is a functionality based stretching exercise that harnesses sport-generic and sport-specific movements to prepare the body for an activity. Some suggested dynamic stretches are shown below in Table 2. This form of stretching

promotes dynamic flexibility and replicates movement patterns required for the sport activities [2].

Table 1: Static Stretches [2]

Legs	Arms	Chest	Back	Abdominals	Other (Neck)
Side Quadriceps Stretch	Behind Neck stretch (Chicken wing)	Straight arms behind back	Spinal Twist (Pretzel)	Side bend with straight arms	Look Right and Left
Sitting Toe Touch	Straight arms behind back	Seated lean back	Semi-Leg Straddle	Side bend with straight arm	Neck Circles
Flamingos	Seated Lean-back	Behind the back elbow grip [19]	Cross Arm in front of Chest	Side bend with bent arm	Look down and look up
Butterfly	Arms straight above head	Clasp hands behind head and pull elbows backwards [19]	Arms straight above head	Cobra Pose [22]	-
Spread eagle toe touch	Fingers up and down stretch [20]	Extended child's pose [19]	Knee to chest stretch [21]	Twisting crocodile stretch [22]	-

Table 2: Dynamic Stretches [2]

1	Arm Swings	Stand straight and raise your arms until they are perpendicular with the floor. While walking, proceed to swing both your arms to the right such that your right arm is straight out and your left arm is crossed over your chest. Repeat the motion in the opposite direction and continue until the determined end point. - Muscles Affected: Latissimus dorsi, teres major, deltoids, and pectorals
2	Inchworm	Stand up straight with your feet placed shoulder-width apart. While slightly bending your knees, bend forward at the waist and place hands shoulder width apart on the floor. Shift your weight to your arms and move your hands alternately forward as if taking short steps until the body is in a pushup position. Walk your legs to your hands and repeat the motion until reaching the determined distance. - Muscles Affected: Gluteals, hamstrings, erector spinae, gastrocnemius, soleus, and anterior tibialis

3	Lunge Walk	<p>Stand up straight with your feet parallel and placed shoulder-width apart. Take a big step forward with your left leg, planting your left foot flat on the floor while pointing straight ahead. Slightly flex your right knee and lower it until it is about 2 inches above the floor. Push yourself forward while balancing on your left foot and repeat the motion with your right foot.</p> <ul style="list-style-type: none"> <li>- Muscles Affected: gluteus maxims, hamstrings, iliopsoas, and quadriceps</li> </ul>
4	Lunge with overhead side reach	<p>Stand up straight with your feet parallel and placed shoulder-width apart. Using the steps of dynamic stretch 3, lunge forward and reach up high with your right arm and bend the torso laterally toward your left leg. Return your torso to an upright position and lunge forward again repeating the same motion with the opposite arm.</p> <ul style="list-style-type: none"> <li>- Muscles Affected: gluteus maximus, hamstrings, iliopsoas, latissimus dorsi, internal and external oblique, and rectus femoris.</li> </ul>
5	Walking Knee Lift	<p>Stand up straight with your feet parallel and placed shoulder-width apart. Step forward with your left leg and lift your left knee up grabbing your knee with both hands and pulling it towards your chest. Release and lower your leg then take a step forward and repeat the process.</p> <ul style="list-style-type: none"> <li>- Muscles Affected: Gluteus maximus, hamstrings</li> </ul>
6	Forward Lunge with elbow to instep	<p>Reference dynamic stretch 3 and lunge forward. Following that lean forward, bringing your left arm forward and touching your left elbow to the instep of your left foot with right hand on floor for balance. Return your torso to the upright position and lunge forward with your opposite foot repeating the process with your opposite arm.</p> <ul style="list-style-type: none"> <li>- Muscles Affected: biceps femoris, erector spinae, gastrocnemius, gluteus maximus, hamstrings, iliopsoas, latissimus dorsi, internal and external oblique, quadriceps, rectus femoris, and soleus.</li> </ul>
7	Heel-to-Toe Walk	<p>Stand up straight with your feet parallel and placed shoulder-width apart. Take a small step forward with your right leg and place the heel of your right foot on the ground first and keep your foot pointed upwards. Shift your weight from your heel to your toes and rise up on them before taking a step forward and repeating the process with your other leg.</p> <ul style="list-style-type: none"> <li>- Muscles Affected: gastrocnemius, soleus, anterior tibialis</li> </ul>
8	Inverted Hamstring Stretch	<p>Stand up straight with your feet placed shoulder-width apart. Take a small step forward with your left leg, bend at the waist, and reach forward with your left arm and simultaneously lift your right leg while trying to keep your hips square. Lean forward until you feel the stretch then return to an upright position and step forward to repeat the process.</p> <ul style="list-style-type: none"> <li>- Muscles Affected: gluteus maximus, hamstrings, hip abductors, hip adductors, and erector spinae.</li> </ul>

9	Straight Leg March	Stand up straight with your feet parallel and placed shoulder-width apart. Rise up onto the toes of your left leg and simultaneously raise your right leg upwards in a high kick while keeping your leg straight. Once you move your right leg as high as possible pull it downwards to starting position, take a step forward and repeat the process with your other leg. - Muscles Affected: gluteus maximus, hamstrings, iliopsoas, and rectus femoris.
10	Spiderman Crawl	Get into push up position and lift and rotate your left leg forward such that it is just outside of your left elbow. Walk your hands across your body to the right and repeat the process with your other leg. - Muscles Affected: biceps femoris, erector spinae, gastrocnemius, gluteus maximus, hamstrings, iliopsoas, quadriceps, rectus femoris, and soleus.

## Warm-Up

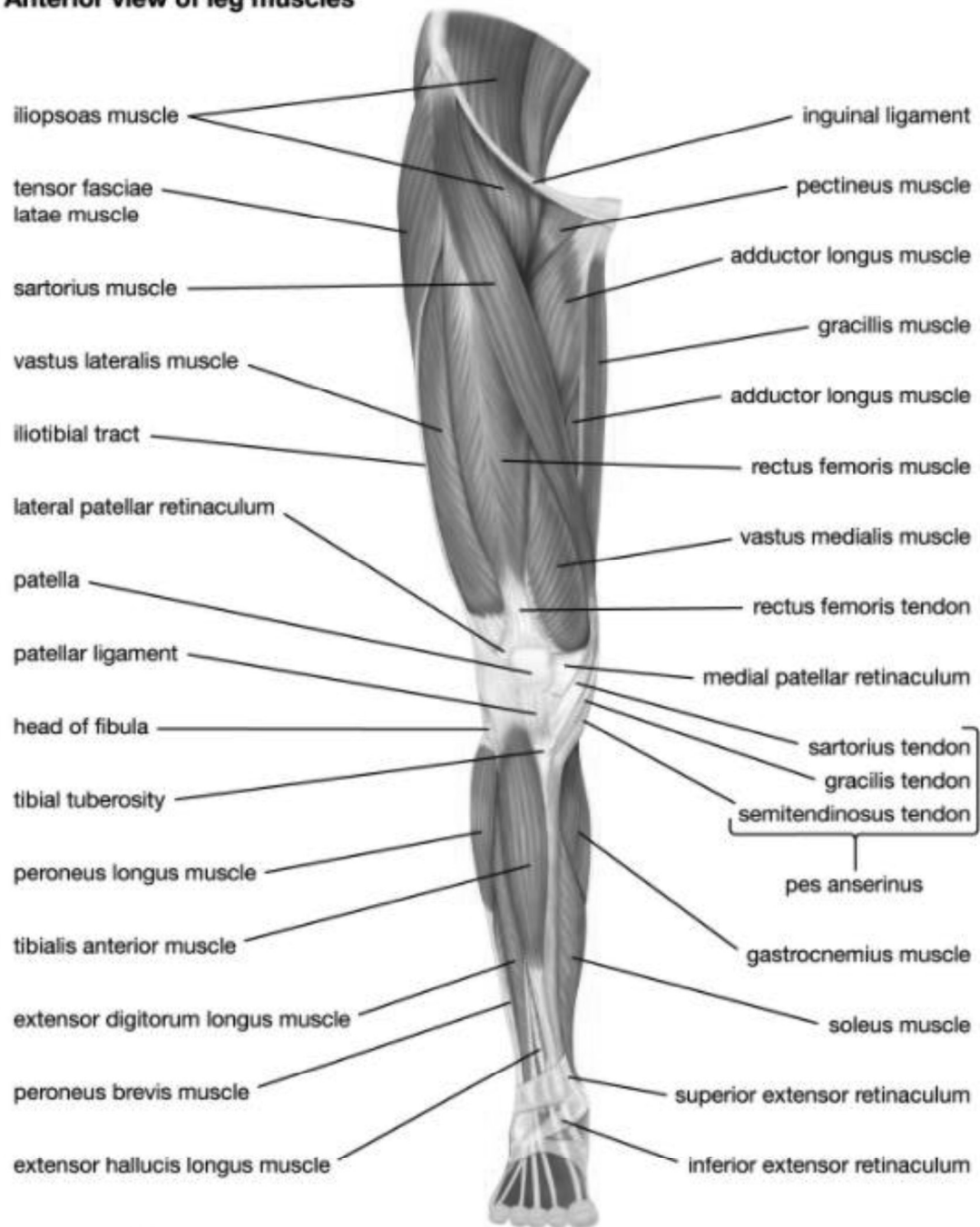
The components of warming up consist of a general warm up period and a specific warm up period. The general warm up period contains 5 minutes of slow aerobic activity like jogging or cycling. The result of warming up should increase your heart rate, blood flow, respiration rate, perspiration rate and decrease viscosity of joint fluids. Following that, the specific warm up period incorporates movements similar to the conditioning exercise that is about to take place. The whole warm-up should gradually provide sufficient intensity to increase muscle and core temperatures without causing fatigue or reducing energy stores. The suggested length of the warmup should last between 10 and 20 minutes [2].

## Conditioning

The ACSM's Guidelines for Exercise Testing and Prescription book recommends setting up your conditioning schedule is to follow the FITT acronym which is an evidence-based recommendation. The "F" stands for frequency and specifically notes that each muscle group should be trained 2-3 days a week [1]. The five major muscle groups are legs, arms, chest, back

and abdominals. The “I” stands for intensity in which one should go from moderate to vigorous intensity in order to improve strength. The first “T” stands for time which is the time allotted for exercise and should be in 10-minute increments for the training to be most efficient. The second “T” stands for type which could be resistance exercises, multi-joint exercises, and single-joint exercises. The number of repetitions vary from 8-12 in order to improve power to 15-25 in order to increase muscular endurance. Aerobic exercise is also recommended to pair with conditioning and is an exercise in which large muscles move continuously for a period of time and heartrate reaches a certain target. From there, it is recommended to complete 2-4 sets of each exercise you choose to condition. See Tables 3-7 to reference some suggested conditioning exercises and Table 8 to reference some aerobics exercises [1].

## Anterior view of leg muscles



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Figure 1: Anterior view of Leg Muscles

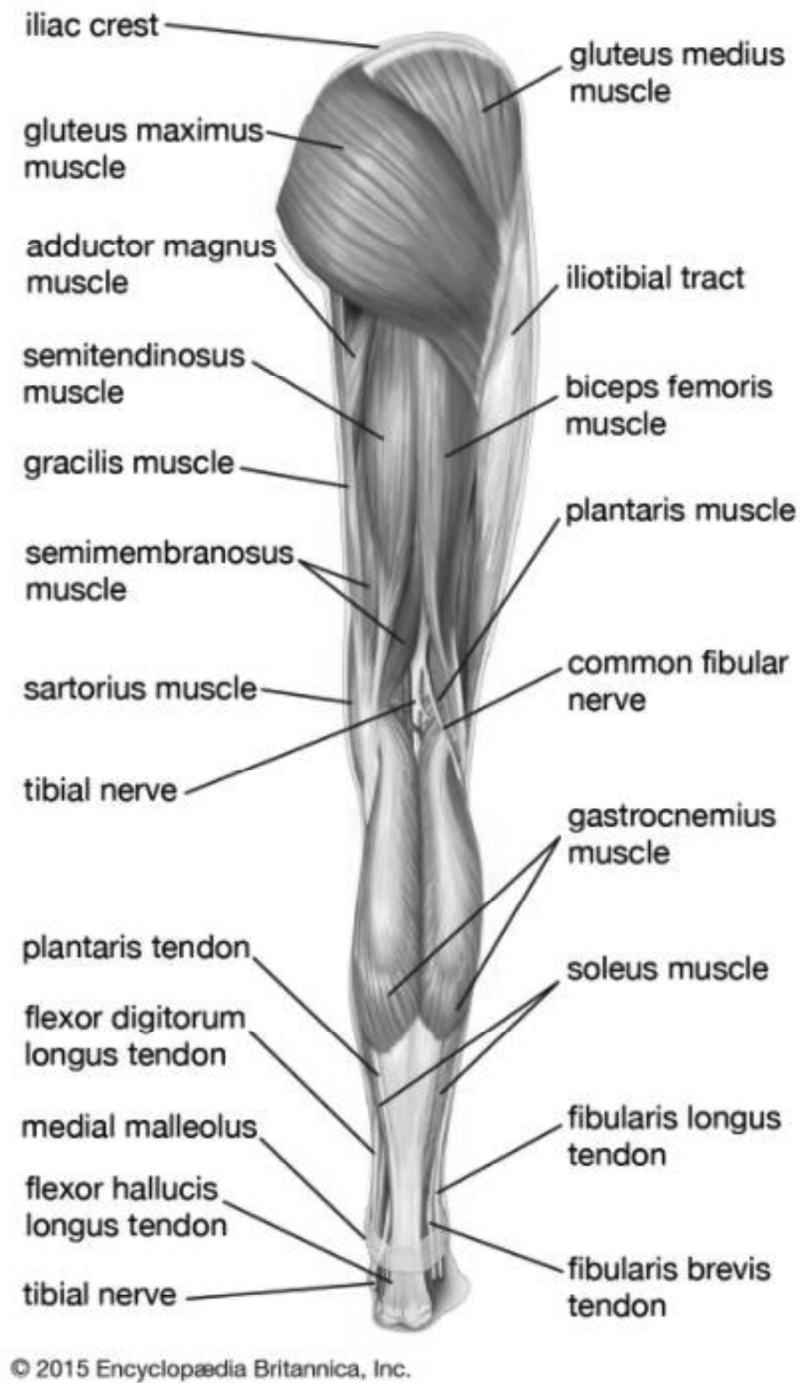
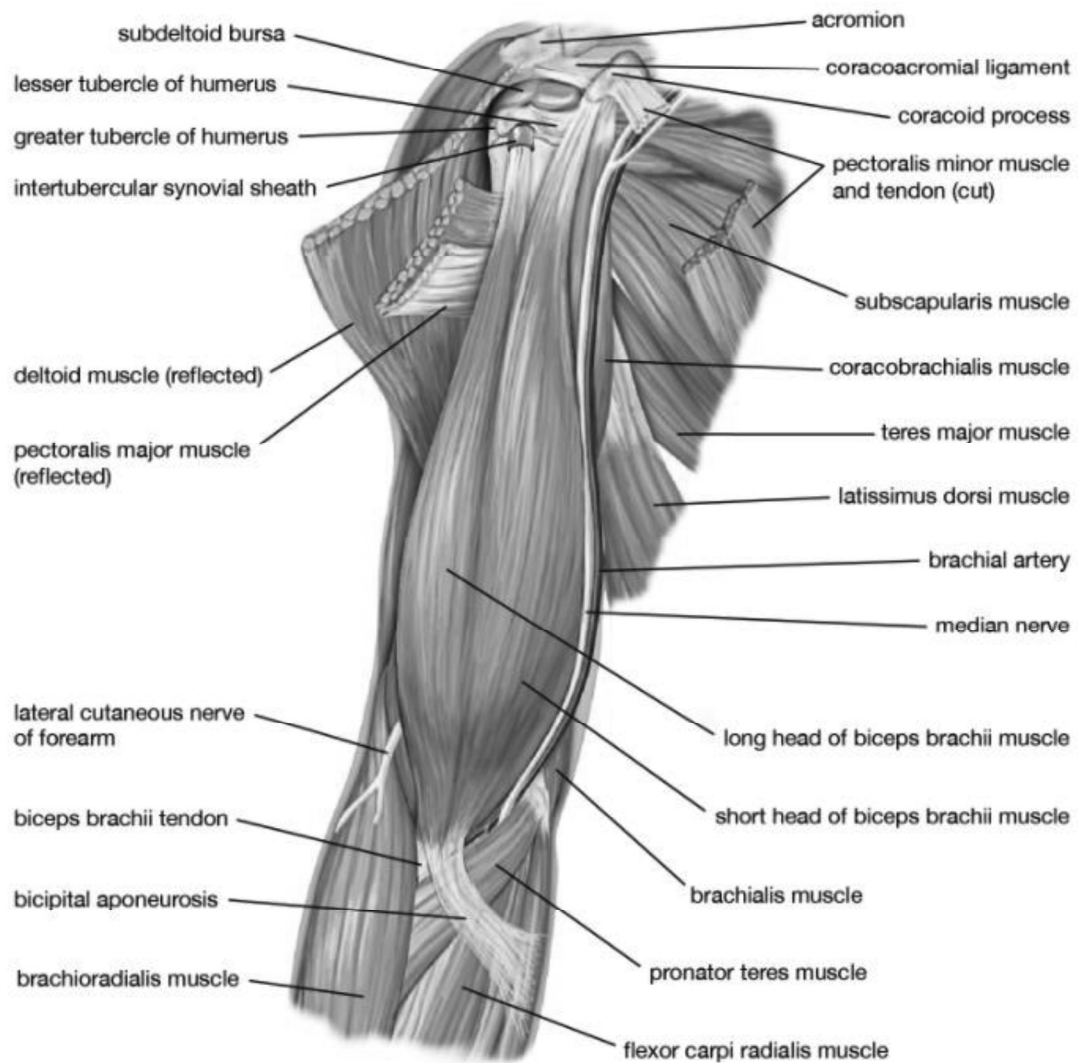


Figure 2: Posterior view of Leg Muscles



Table 3: Leg Exercises

#	Exercise	Description:
1	Squats	Stand with your feet slightly greater than shoulder-width apart and your toes pointing forward. Slowly descend, bending through the hips, knees and ankles while keeping your back in a neutral position. Stop when your knees reach a 90-degree angle. [4] (See Appendix for Figure 3) <ul style="list-style-type: none"> <li>- Mods: Add dumbbells, jump squats, balance ball squat, etc.</li> <li>- Muscles Exercised: quadriceps, hamstrings, gluteals, abdominals, and calves.</li> </ul>
2	Lunges	Stand with your legs parallel and shoulder width apart. Take a step forward and shift your weight so that the heel of your foot touches the ground first and continue until your shin is vertical and your forward thigh is parallel to the floor. Switch legs & repeat. [3] Image – [12] (See Appendix for Figure 4) <ul style="list-style-type: none"> <li>- Mods: add dumbbells, jump lunges, walking lunge, reverse lunge, etc.</li> <li>- Muscles Exercised: glutes, quadriceps, and hamstrings</li> </ul>
3	Calf Raise	Stand with your feet slightly spread apart with your abdominal and back muscles tightened. Slowly rise up on your toes, pause, then return to starting position. [4] (See Appendix for Figure 5) <ul style="list-style-type: none"> <li>- Mods: Use the leg press machine for variable weight.</li> </ul> Muscles Exercised: calf muscles
4	Running	Run with a pace you are comfortable with. 1 mile suggested such that one can time it. (See Appendix for Figure 6) <ul style="list-style-type: none"> <li>- Mods: N/A</li> </ul> Muscles Exercised: glutes, hamstrings and quadriceps
5	Knee Extension	Sit on a chair with your feet dangling in a relaxed position. Slowly straighten your knee, pause then return to the starting position. Repeat. [4] (See Appendix for Figure 7) <ul style="list-style-type: none"> <li>- Mods: with exercise machine</li> <li>- Muscles Exercised: quadriceps</li> </ul>
6	Leg Press	Adjust the exercise machine such that your knees are comfortably at a 90-degree angle when your feet are on the platform. Place your feet on the platform and slowly straighten your knees. Return to starting position and repeat. [4] (See Appendix for Figure 8) <ul style="list-style-type: none"> <li>- Mods: N/A</li> <li>- Muscles Exercised: quadriceps, hamstrings, calf muscles and gluteal muscles</li> </ul>
7	Hamstring Curl	Position yourself in the hamstring curl machine. Slowly bend your knees while engaging your hamstrings. Return to starting position and repeat. [4] (See Appendix for Figure 9) <ul style="list-style-type: none"> <li>- Mods: N/A</li> <li>- Muscles Exercised: Hamstrings</li> </ul>



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Figure 10: Anterior view of Upper Arm Muscles

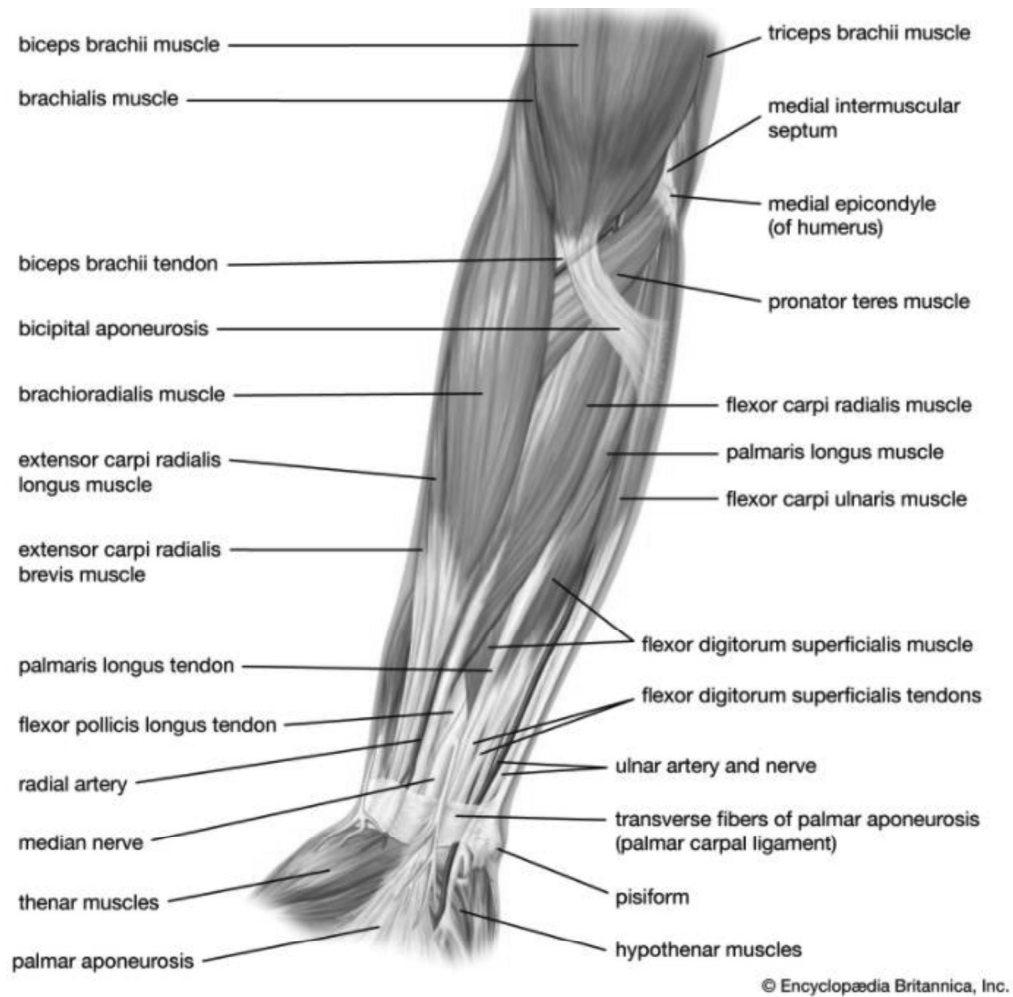


Figure 11: Anterior view of Forearm Muscles

Table 4: Arms

#	Exercise	Description:
1	Bicep Curl w/ dumbbell	Stand straight with feet about shoulder width apart and knees slightly bent. Hold the dumbbell with your palm facing upward and slowly curl the weight up by bending your elbow towards your body. [4] (See Appendix for Figure 12) - Mods: Hammer Curl, different weight dumbbells, barbells, etc. Muscles Exercised: Biceps and forearm
2	Dumbbell lateral raise	Stand straight with feet about shoulder width apart and knees slightly bent. Hold a light dumbbell in each hand by your sides with a slight bend in your elbows. Raise the weights out to shoulder height, leading with your elbows, then return slowly to the starting point and repeat. [5] Image - [13] (See Appendix for Figure 13) - Mods: Raise weights in front of you, angled outwards and into t-pose. Muscles Exercised: deltoids
3	Triceps Extension	Stand straight with feet about shoulder width apart and knees slightly bent. Grip one dumbbell in both hands and extend both arms straight above your head. Slowly bend your elbow such that the dumbbell descends towards your back and return to starting point. (See Appendix for Figure 14) - Mods: Different weights, one handed triceps extension, and laying down triceps extension. Muscles Exercised: Triceps
4	Chest Press	Lie on your back with your knees bent and a dumbbell in each hand. Hold your upper arms perpendicular to your body and hold your forearms perpendicular to the floor. Slowly press the dumbbells upward until your elbows are almost straight. Return to starting position and repeat. [4] (See Appendix for Figure 15) - Mods: Bench Press, Different weight dumbbells, etc. Muscles Exercised: shoulder muscles and triceps
5	Pushups	Position yourself on your hands and feet with your eyes facing the floor. Place your hands and feet slightly wider than shoulder-width apart and your feet comfortably apart. Slowly bend your elbows and lower your chest until your arms make a 90-degree angle with the floor. [4] (See Appendix for Figure 16) - Mods: Wall pushups, half pushups, one-armed pushups. Muscles Exercised: Pectoral muscles, shoulder muscles, and triceps
6	Incline Dumbbell Fly	Lie back on an incline bench holding two dumbbells directly over your chest with straight arms. Bend your elbows slightly, then lower your hands out to the sides until you feel a stretch across your chest. Return to start and repeat. [5] (See Appendix for Figure 17) - Mods: Fly machine, and alternate inclines. Muscles Exercised: Shoulders, pectorals, and triceps.
7	Dumbbell pullover	Lie flat on a bench, holding a dumbbell in both hands above your chest with straight arms. Lower the weight behind your head in a slow and controlled

		<p>movement, keeping your arms straight, then raise it back to the start position. [5] (See Appendix for Figure 18)</p> <p>- Mods: N/A</p> <p>Muscles Exercised: Pectorals, back, triceps, core</p>
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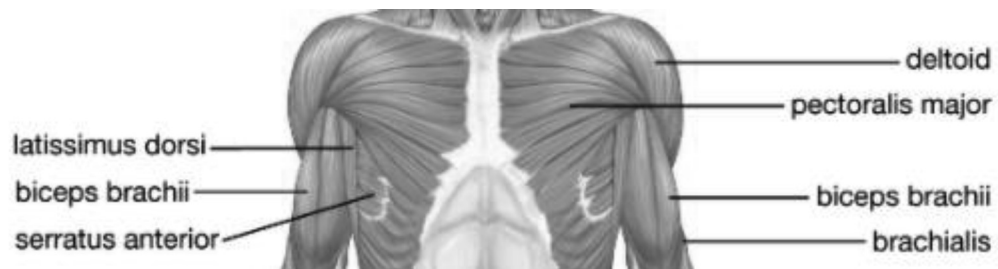


Figure 19: View of Chest Muscles

Table 5: Chest

#	Exercise	Description:
1	Chest Press	<p>Lie on your back with your knees bent and a dumbbell in each hand. Hold your upper arms perpendicular to your body and hold your forearms perpendicular to the floor. Slowly press the dumbbells upward until your elbows are almost straight. Return to starting position and repeat. [4] (See Appendix for Figure 20)</p> <ul style="list-style-type: none"> <li>- Mods: Bench press, different weight dumbbells, barbells, etc.</li> <li>- Muscles Exercised: shoulder muscles and triceps</li> </ul>
2	Pushups	<p>Position yourself on your hands and feet with your eyes facing the floor. Place your hands and feet slightly wider than shoulder-width apart and your feet comfortably apart. Slowly bend your elbows and lower your chest until your arms make a 90-degree angle with the floor. (See Appendix for Figure 21)</p> <ul style="list-style-type: none"> <li>- Mods: Wall pushups, half pushups, one-armed pushups.</li> <li>- Muscles Exercised: Pectoral muscles, shoulder muscles, and triceps</li> </ul>
3	Squeeze press	<p>Lie back on a flat exercise bench holding two dumbbells on your chest with palms facing one another. Press dumbbells together and slowly push them to arm's length over your chest, pause and repeat. [6] (See Appendix for Figure 22)</p> <ul style="list-style-type: none"> <li>- Mods: different dumbbells</li> <li>- Muscles Exercised: Chest and triceps</li> </ul>
4	Dumbbell pullover	<p>Lie flat on a bench, holding a dumbbell in both hands above your chest with straight arms. Lower the weight behind your head in a slow and controlled movement, keeping your arms straight, then raise it back to the start position. [5] (See Appendix for Figure 23)</p> <ul style="list-style-type: none"> <li>- Mods: N/A</li> <li>- Muscles Exercised: Pectorals, back, triceps, core</li> </ul>
5	Incline Dumbbell Fly	<p>Lie back on an incline bench holding two dumbbells directly over your chest with straight arms. Bend your elbows slightly, then lower your hands out to the sides until you feel a stretch across your chest. Return to start and repeat. [5] (See Appendix for Figure 24)</p> <ul style="list-style-type: none"> <li>- Mods: Fly machine, and alternate inclines.</li> <li>- Muscles Exercised: Shoulders, Pectorals and triceps.</li> </ul>
6	Cable fly	<p>Attach stirrup handles to the high pulleys of a cable crossover machine. Take in each hand while outstretching your arms at a slight bend. Place one foot slightly forward, brace your core and pull the handles downward and across your body. Return to starting position and repeat. [6] (See Appendix for Figure 25)</p> <ul style="list-style-type: none"> <li>- Mods: N/A</li> <li>- Muscles Exercised: pectorals, deltoids and biceps</li> </ul>
7	Decline press-up	<p>Place your feet on a bench with your hands planted on the floor in front of you. Lower your body down until your chest almost reaches the floor. Press your body back up to the starting position while activating your pectorals, pause and repeat. [6] (See Appendix for Figure 26)</p>

		<ul style="list-style-type: none"> <li>- Mods: N/A</li> <li>- Muscles Exercised: Pectorals, abdominals, biceps and triceps</li> </ul>
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### Muscles of the abdominal wall

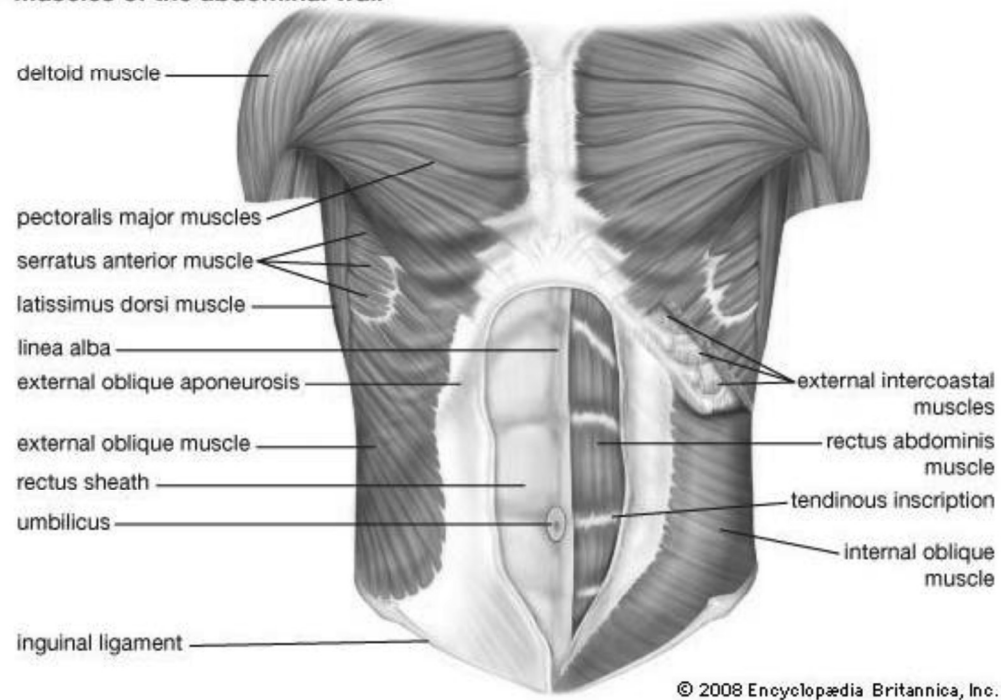


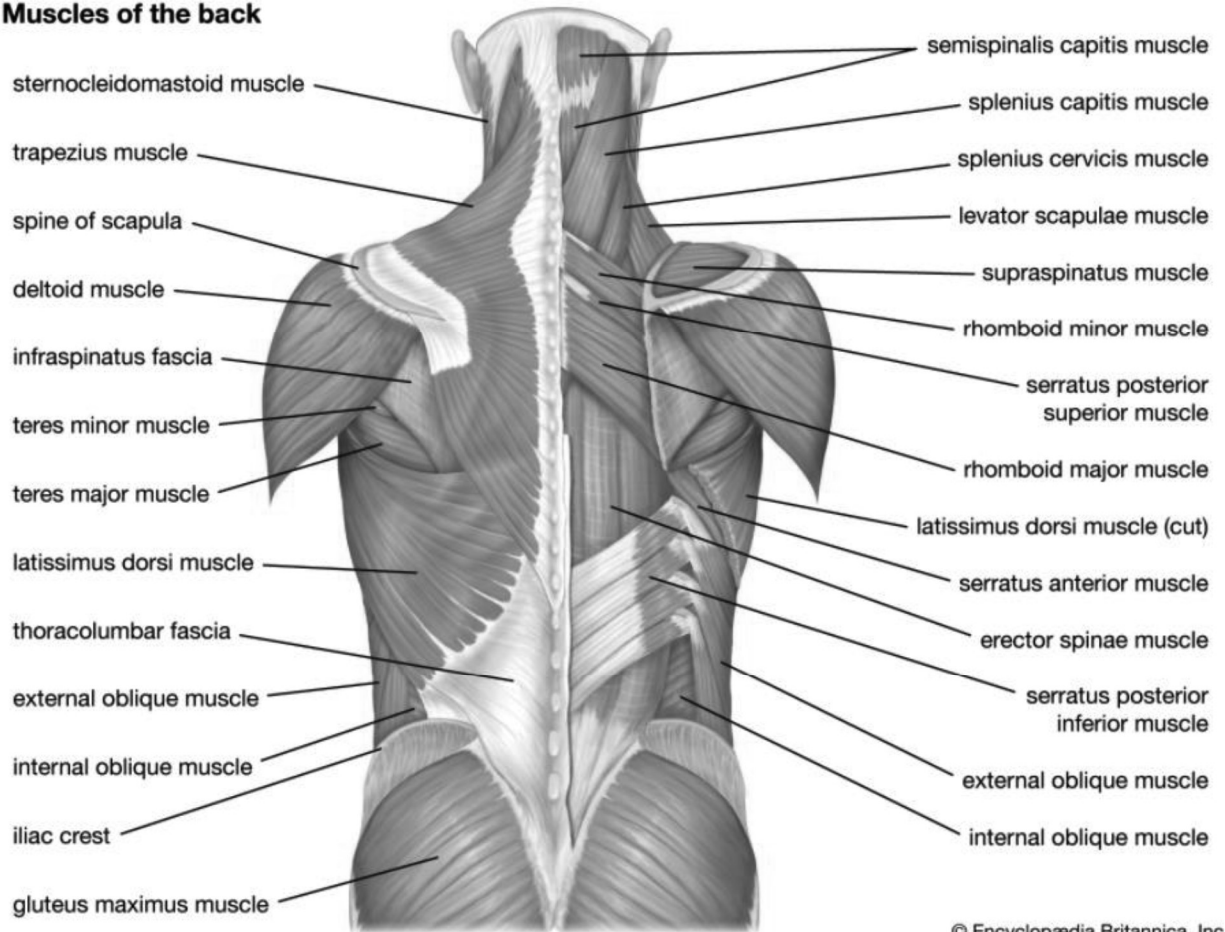
Figure 27: View of the Abdominal Wall Muscles

Table 6: Abdominals

#	Exercise	Description:
1	Sit-ups	<p>Lie on your back with your knees bent, arms crossed over your chest, and feet flat on the floor. Lift your torso towards your knees, return to starting position and repeat. Image - [14] (See Appendix for Figure 28)</p> <ul style="list-style-type: none"> <li>- Mods: Add weight, machine, etc.</li> <li>- Muscles Exercised: abdominals, obliques, chest, and neck</li> </ul>
2	Mountain Climbers	<p>Start in a pushup position with one knee up between your elbows and only the back foot supporting weight. From there, jump and switch your rear foot forward and front foot backwards. Repeat for the planned number of repetitions. [8] (See Appendix for Figure 29)</p> <ul style="list-style-type: none"> <li>- Mods: N/A</li> <li>- Muscles Exercised: abdominals, hamstrings, triceps, quadriceps, and shoulders</li> </ul>
3	Planks	<p>Position yourself on your hands and knees. Support your weight on your forearms and extended such that your weight is supported on your toes. Hold this for time increments you are comfortable with. [8] (See Appendix for Figure 30)</p> <ul style="list-style-type: none"> <li>- Mods: Pushup plank, add weight.</li> <li>- Muscles Exercised: abdominals, back and shoulders</li> </ul>
4	Russian Twists	<p>Sit on the ground with your feet extended in front you with knees bent at 60-degree angles. Touch the floor to your left then twist and touch the floor to your right making sure to extend yourself and activate your abdominals and obliques. [8] (See Appendix for Figure 31)</p> <ul style="list-style-type: none"> <li>- Mods: Add dumbbell, lift feet</li> <li>- Muscles Exercised: abdominals, obliques, latissimus dorsi</li> </ul>
5	Flutter Kicks	<p>Lie on your back and raise your legs so that they're about 6 inches off of the ground. Keep your legs straight with toes pointed and move each leg up and down in a kicking motion where the bending motion takes place at your hips. Generally, sessions last between 30 and 60 seconds for this exercise. [8] (See Appendix for Figure 32)</p> <ul style="list-style-type: none"> <li>- Mods: place hands under lower back, scissor kicks, etc.</li> <li>- Muscles Exercised: abdominals and quadriceps</li> </ul>
6	Bicycle Crunch	<p>Lie on your back and extend your legs while holding them above the ground. Place your fingers lightly on your temples and bring one knee up towards your chest and twist your torso so that the opposite elbow comes over towards it. Lower your leg and elbow and repeat such that your opposite knee and elbow make the same motion. [8] (See Appendix for Figure 33)</p> <ul style="list-style-type: none"> <li>- Mods: N/A</li> <li>- Muscles Exercised: abdominals and obliques</li> </ul>
7	Double Leg Raise	<p>Lie down flat on your back on the ground and keep your legs as straight as possible then raise them until they are vertical, then pause, lower them and repeat. [3] (See Appendix for Figure 34)</p> <ul style="list-style-type: none"> <li>- Mods: Single leg and add resistance band.</li> <li>- Muscles Exercised: abdominals, obliques, and quadriceps</li> </ul>



## Muscles of the back



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Figure 35: View of Back Muscles

Table 7: Back

#	Exercise	Description:
1	Hyper-extension	Position the hyperextension machine such that you can bend down without impeding your ability to bend at the hips. Stand on the machine and lean forward. Cross your arms over your chest and bend at the hips till you reach your maximum angle. Then return to the starting position and repeat. Image - [TG 15] (See Appendix for Figure 36) - Mods: N/A - Muscles Exercised: lower back
2	Bent over row	Start with one knee resting on a weight bench. Lean forward, supporting yourself with one hand. Let your other arm hang straight below your shoulder. Slowly raise the weight until your elbow lines up just below your shoulder. Image - [16] (See Appendix for Figure 37) - Mods: N/A - Muscles Exercised: upper back and back of shoulder
3	Dumbbell pullover	Lie flat on a bench, holding a dumbbell in both hands above your chest with straight arms. Lower the weight behind your head in a slow and controlled movement, keeping your arms straight, then raise it back to the start position. [5] (See Appendix for Figure 38) - Mods: N/A - Muscles Exercised: pectorals, back, triceps, core
4	Lateral pull down	If using a machine, position the pad so it is touching your thighs. Stand up and grab the bar such that it is shoulder-width apart and sit back down. Slowly pull the bar down toward your chest, bending your elbows and directing them toward the ground. Keep your torso straight during this, return to starting position and repeat. [7] (See Appendix for Figure 39) - Mods: Using a resistance band - Muscles Exercised: latissimus dorsi, biceps, deltoids, and trapezius muscles
5	Barbell Deadlift	Stand straight with feet about shoulder width apart and knees slightly bent behind the barbell. While keeping your back straight, begin to hinge at the hips and slowly bend your knees reaching toward the barbell. Grasp the bar with both palms facing yourself in an overhand grip. Push back up, pause, return to starting position and repeat [7] (See Appendix for Figure 40) - Mods: N/A Muscles Exercised: lower back, erector spinae muscles and hamstrings
6	Superman	Lie down with your stomach on the floor. Lay your arms straight in front of you and lift both your arms and legs such that they do not touch the ground. Hold that position in time increments that you are comfortable with. Image - [17] (See Appendix for Figure 41) - Mods: N/A Muscles Exercised: abdominals, gluteals, back
7	Wide dumbbell row	Hold a dumbbell in each hand and bend at the waist such that your body makes a 20-degree angle with the ground with your palms facing your thighs and your neck should remain neutral. Pull your elbows up to a 90-degree

		<p>angle and squeeze your shoulder blades together. Continue the rowing motion until your repetitions are done. [7] (See Appendix for Figure 42)</p> <ul style="list-style-type: none"> <li>- Mods: Exercise resistance band</li> </ul> <p>Muscles Exercised: upper &amp; middle back, latissimus dorsi, shoulders, and triceps</p>
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Table 8: Aerobics

#	Exercise	Description:
1	Running	<p>Run with a pace you are comfortable with. 1 mile suggested such that one can time it. Image - [18]</p> <ul style="list-style-type: none"> <li>- Mods: N/A</li> </ul> <p>Muscles Exercised: Glutes, calves, hamstrings, and quadriceps</p>
2	Swimming	<p>Swim at a pace and using a stroke you are familiar with. This is a low-impact aerobic exercise. [10]</p> <ul style="list-style-type: none"> <li>- Mods: Butterfly, backstroke, breaststroke, free style</li> </ul> <p>Muscles Exercised: Shoulders, pectorals, triceps, trapezius, gluteals, hamstrings, and quadriceps</p>
3	Cycling	<p>Use either a stationary bike or an actual bike to practice cycling. The most beneficial speed to stay at for cycling is 80-100 RPM's. [9]</p> <ul style="list-style-type: none"> <li>- Mods: Stationary bike</li> </ul> <p>Muscles Exercised: Quadriceps, hamstrings, calves, and gluteals.</p>
4	Elliptical	<p>Use the elliptical for the amount of time and at the intensity required for your training. [9]</p> <ul style="list-style-type: none"> <li>- Mods: N/A</li> </ul> <p>Muscles Exercised: Gluteals, hamstrings, quadriceps, chest, back, biceps, triceps, and core muscles.</p>
5	Burpees	<p>Start in a squat position with your knees bent, back straight and feet shoulder-width apart. Put your hands on the floor in front of you just inside your feet. Transition the weight to your hands and kick your feet back such that you are in a pushup position. Do a pushup, frog kick such that your feet land in the starting position and quickly jump in the air. Repeat.</p> <ul style="list-style-type: none"> <li>- Mods: Skip the pushup, add a box jump, add dumbbells, etc.</li> </ul> <p>Muscles Exercised: full-body calisthenics - legs, hips, gluteals, abdomen, arms, chest, and shoulders.</p>
6	Jumping Rope	<p>Jumping rope is a good aerobic exercise to raise your heartrate. [9]</p> <ul style="list-style-type: none"> <li>- Mods: N/A</li> </ul> <p>Muscles Exercised: Quadriceps, hamstrings, gluteals and calves.</p>
7	Tin mans	<p>Stand with your feet shoulder width apart and keep your back straight. While keeping your leg straight, left your leg up as high as you can while reaching your arm forward to touch your toe. Take a step forward with your raised foot and repeat with the opposite leg and arm.</p> <ul style="list-style-type: none"> <li>- Mods: Jump in between each step</li> </ul> <p>Muscles Exercised: Obliques, hamstrings, quadriceps</p>

**Moonbuggy Specific Workouts:**

The workouts associated with the Human Exploration Rover Challenge are essentially cycling exercises paired with a full body workout. Exercising your entire body helps build up strength and endurance within the muscles which benefits both general health and the performance on race day. The most pertinent muscle groups to train are your legs and arms to assist with pedaling and wheel-chairing the rover. To help the rider track their performance, a workout log has been attached as a reference.

Figure 43: Workout Log [23]

# WORKOUT LOG

GOALS:



Track your fitness and strength training progress.

	M	Tu	W	Th	F	Sa	Su	M	Tu	W	Th	F	Sa	Su	M	Tu	W	Th	F	Sa	Su	M	Tu	W	Th	F	Sa	Su
Date:																												
Weight:																												
Sleep (hrs):																												
Calories:																												
Time (minutes):																												
Notes:																												

Exercises	1RM*	Sets	Reps	Wt	Sets	Reps	Wt	Sets	Reps	Wt	Sets	Reps	Wt	Sets	Reps	Wt

\*1RM - One Rep Max (for reference)

Cardio exercises	Time	Dist	Int**	Time	Dist	Int	Time	Dist	Int	Time	Dist	Int	Time	Dist	Int

\*\*Intensity: L/M/V=Light/Moderate/Vigorous or E/M/H=Easy/Medium/Hard or Heart Rate

### Prior Rider Training Testimonials:

The following statements are from prior riders. They provided me with a description of how they trained and what they suggest for future generations of riders.

The following testimonial is from Scott Schlapman who was a rider for the Buzz rover.

“I mostly relied on years of cycling and training. I did start the first semester of moon buggy with a 50-mile trail run in my legs, but that’s about where the training stopped. But all that said, I do use a training app called Sufferfest. My goal training volume each week is 10 hours. For moon buggy it was probably more like 3-4 hours.

From my experience from years of competitive cycling, the riders should be doing at least 6 hours a week and should look something like, 1 – 2-hour ride for endurance, 2 – 30-45 minute of short but very high intensity intervals, and 2 one-hour recovery rides. This in my opinion would be a minimum. Lifting weights is of minimal benefit for moon buggy.”

The following testimonial is from Brent Perry. He was one of the riders for the Falcon 2019-2020 senior design class.

“I’d be glad to send you my weekly routine. We had tossed around the idea of using a rowing motion for the rear rider, so I started training my whole body and just kept the same routine when we settled on pedal power.

Monday/Thursday	Tuesday/Friday	Wednesday/Saturday
<b>Push Day</b> <ul style="list-style-type: none"><li>• Bench press</li><li>• Chest fly</li><li>• Hex press</li><li>• Push-ups</li><li>• Shoulder press</li><li>• Lateral raises</li><li>• Arnold Press</li></ul> Cardio – 20 min high intensity interval training on exercise bike	<b>Pull Day</b> <ul style="list-style-type: none"><li>• Pull-ups</li><li>• Lat pulldowns</li><li>• Low rows</li><li>• Barbell rows</li><li>• T-bar rows</li><li>• Dumbbell curls</li><li>• Hammer curls</li></ul> Cardio – run 5 km (lap around campus)	<b>Leg Day</b> <ul style="list-style-type: none"><li>• Squats</li><li>• Deadlift</li><li>• Calf raises</li><li>• Lunges</li><li>• Leg extensions</li><li>• Sit-ups</li></ul>

I did find a few things to help optimize my power output. First, for pedal power humans are most efficient at 80-100 rpm. My sweet spot was right at 90 rpm. Second, proper hydration is extremely important. In addition to increased stamina, I was getting roughly 20% more power output when I drank 100 or more ounces of water the previous day. Finally, I experimented with drinking pre-workout before riding the buggy with good results. I don’t expect anyone to take this as serious as I did, but this is what I did to try and gain a competitive advantage.”

The following testimonial is from Allyson Grieve. She was one of the riders for the Buzz rovers.

“So, my training was pretty basic. When I was at UAH, I played lacrosse so that was part of my training I guess but I did do small workouts a couple times a week outside of lacrosse practice. I didn’t do any weightlifting for moon buggy because I was already on the weight room every day. I would say definitely stretch and rollout with a foam roller really good before and after each workout. I only did stationary bike rides, so what I would do is a 5 min warmup just to get your heart rate up and then I would look for videos on YouTube that were about 20-40 min long that involved putting some resistance or doing an arm workout or something like that in the video and once I was done with that, I would do a 3 min cool down ride and that was it. Like I said it was pretty basic, but I had to fit those workouts in an already busy day. I would also talk to Scott Schlapman, he was my riding buddy for moon buggy, and he has A LOT more experience riding outside of moon buggy and could definitely give you some tips and workouts and all that! I hope this helps a little and good luck with moon buggy! Best part of my time at UAH other than lacrosse. Best of luck!”

The following testimonial is from Scott McNutt. He was one of the riders for Falcon 2019-2020.

“As far as training goes, you want to build up as much strength and endurance as possible. Mainly in the legs. A good set of workouts to focus on would be:

- Cardio
- Running 1-2 miles
- Sprints (jog 2 minutes to warm up) Then sprint for 15 seconds slow down to a jog for 30 seconds, and repeat. Do about 8-10 rounds of that. (1 round is a 15 second sprint and then a 30 second jog)
- Bike/elliptical for about 10 minutes on a resistance setting you're comfortable with.
- Row machine for about 5 minutes.
- The bike, rowing machine, and running should be your warm-ups before you start the leg workouts.

And of course, as much practice as you can get in on the previous buggies.

For weights (always shoot for 4 sets of 12 to 15 reps)

- Front Squats
- Leg extension
- Laying down hamstring curls
- Kettle bell swings
- Sled push/pull
- Goblet squats
- Deadlifts

I've also attached a workout that you can do at the end, or just at home that will really blast your legs and core. These are just body weight exercises.

- Squats
- Squat jumps
- Jump Squat 180s
- Lunges
- Lunge Jumps

- In & Outs
- Burpees
- Ice skaters
- High Knees

(Do each exercise for 30 seconds (or 15 seconds for beginners) before moving to the next one for as many rounds as you can handle. 1 round is all 9 exercises)

Some other good exercises to do are planks, sit ups, and leg raises to strengthen your core. Try and do the leg workouts twice a week in addition to your normal workout routines for back, chest, arms etc.”

### **Conclusion**

Overall, exercising is a rather complex practice that can be molded to each person’s needs. In the nutrition section, it is shown that there are two important times in which an athlete should eat a proper ratio of carbohydrates, proteins, and fats in order to have the most efficient workout. Pre-workout and post-workout nutrition provide different benefits to the rider. Pre-workout nutrition allows for the body to stock up its glycogen stores such that the rider can have a well-fueled training session. Whereas post-workout nutrition allows for the glycogen stores to be replenished so that the athlete is less tired and have the amino acids required to rebuild and grow muscles after training. Understanding the biological processes associated with glycogen and amino acids greatly assists the rider in preparing themselves for future training sessions. In order to plan these training sessions, it is important to know the four components of a training session and how to appropriately plan them. These components include warming up, conditioning, cooling down and stretching. For future rider’s reference, the training methods of prior riders have been included. With this training guide, I hope to facilitate the preparations of future riders and help them to pedal their way to victory.



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## Appendix

### Figures of Leg Exercises:



○ Figure 3



○ Figure 4



○ Figure 5



[11]

○ Figure 6



○ Figure 7

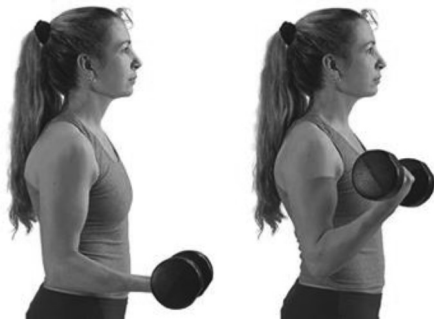


○ Figure 8

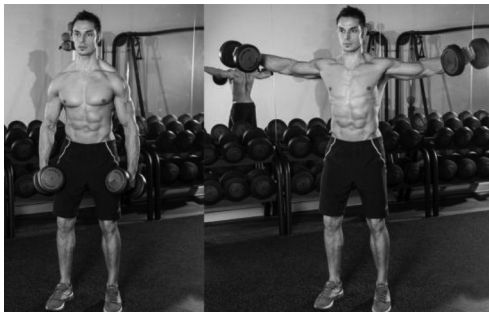


○ Figure 9

# Figures for Arm Exercises:



a. Figure 12



a. Figure 13



a. Figure 14



a. Figure 15



a. Figure 16



a. Figure 17



a. Figure 18

Figures for Chest Exercises:



a. Figure 20



a. Figure 21



a. Figure 22



a. Figure 23



a. Figure 24



a. Figure 25



a. Figure 26

Figures for abdominal exercises:



a. Figure 28



a. Figure 29



a. Figure 30



a. Figure 31



a. Figure 32



a. Figure 33



a. Figure 34

Figures for Back Exercises:



[15]

a. Figure 36



a. Figure 37



a. Figure 38



a. Figure 39



a. Figure 40



a. Figure 41



a. Figure 42