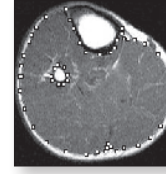


Astro Calves

Analyzing the effect of extended space flights on muscle mass



Introduction

This lesson requires ImageJ, available for free download from <http://rsb.info.nih.gov/ij/>. Help files are available at <http://rsb.info.nih.gov/ij/doc/index.html>. For more assistance, *Discovering Image Processing, v.2, (DIP)* revised and expanded in 2006, teaches the fundamental concepts of digital image processing and image analysis in ten step-by-step lessons. More information and a free sample *DIP* lesson is available on the Science Approach Web site at <http://www.science-approach.com>. Click **Purchase Products** and navigate to the DIP product page.

In “Astro Calves” you’ll explore a way in which digital imaging is used to conduct research that can help protect the astronauts who spend an extended time in space. This activity uses several skills; refer to the ImageJ Skill Sheets in *Discovering Image Processing* listed in the sidebar if you need extra help.

Your mission

After spending 119 days on the Mir space station, astronaut David A. Wolf arrived back on Earth—and could hardly lift his arm: “My wristwatch feels like a brick!” he said at the time.

Although he eventually recovered fully, for several months Wolf had difficulty turning corners and found himself running into doorways.

While in the zero gravity of space, astronauts can lose from 5 to 40 percent of muscle mass and function. Reduced muscle function can lead to falls and broken bones—hardly an appealing scenario if the crew members are enroute to Mars where they’ll spend three years away from Earth.

Developing a strategy to prevent muscle loss has been a high priority for NASA, and scientists have been measuring and comparing astronaut muscle mass before and after prolonged space flights.

Now you can do the same.

IP Skills

- recognize digital images, pixels, and pixel locations
- draw regions of interest
- measure and compare areas

ImageJ Skill Sheets

- Stacks & Animation
- Selecting
- Measuring

Protecting astronaut privacy

In this activity, data on specific crew member age, gender, or duration of mission is deliberately omitted in order to prevent the identification of specific astronauts. Although David Wolf is an actual astronaut, we have no way of knowing whose calves we’re examining.

The larger picture

The images are from a larger study of six astronauts, who spent an average of 203 days in orbit. The average time between landing and acquisition of the post-flight images was 20 days.

Each original pre- and post-flight MRI study included 32 images, but for easier download, they are presented here in one file as a stack of eight images.

Your toolkit

You will be using ImageJ to examine a pair of MRI images of the calf muscles of one astronaut, taken before and after an extended space flight.


The two image stacks are named **AstroCalf-Pre.tif** and **AstroCalf-Post.tif**. Each slice includes both legs, but keep in mind that the leg on the left side of the image is actually the astronaut's right leg. The slices are aligned so that Slice 10 from the pre-flight image is from the same location as Slice 10 in the post-flight image.

Each slice is 10 mm thick, and the pixels measure 0.59 mm on a side.

Step 1: Gathering the data

- a. The two image stacks you need, **AstroCalf-Pre.tif** and **AstroCalf-Post.tif**, are in the same folder where you found this lesson PDF.
- b. Launch ImageJ. Choose **File > Open**, and navigate to **AstroCalf-Pre.tif** and **AstroCalf-Post.tif** to open them. Examine the slices by using the > and < keys or the scrollbar to move forward and backward through the stack.

Step 2: Selecting the muscle tissue

- a. Using the pre-flight image, **AstroCalf-Pre.tif**, select a slice (1-8).
- b. Choose the Polygon tool . Pick either the right or left leg, and, starting on the outer edge, use your mouse to trace around the muscle tissue with a series of clicks.

Do not include the skin, tibia (the large bone), or fibula (small bone). You'll need to detour from the outer edge to exclude the fibula and return close to the same point you left from and continue around the perimeter. (See the illustration on the next page.)

To close the area you have outlined, click inside the small box that marks the first vertex.

More info...

You can learn more about stacks in the "Lights, Camera, Action!" lesson or the ImageJ Skill Sheets in *Discovering Image Processing*.

Getting to know the Status Bar

The status bar on the image window shows


- the current slice number and the number of slices in the stack (e.g. **1/8**),
- image dimensions (**480 x 250**),
- bit depth (**16-bit grayscale**), and
- image size (**1.8 MB**).

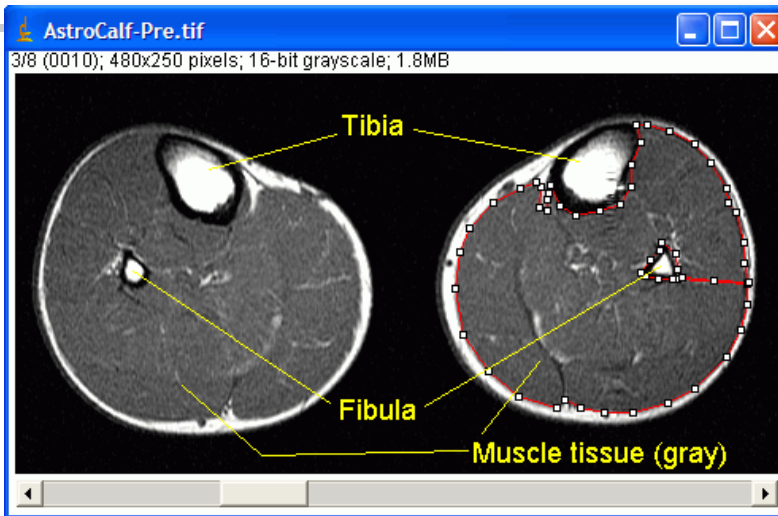
More info...

The images have been cropped (reduced in size, without altering pertinent image details) to 480 x 250 pixels from the original size of 512 x 512 pixels.

Tool tip ...

If needed, you can enhance the image by choosing **Image > Adjust > Brightness/Contrast**.

You can also zoom in by clicking the Magnifying Glass tool .



Qn. 1. Which leg and which slices did you use? Why? (Use the Data Sheet included at the end of this activity to record your answers.)

Step 3: Measuring the area

- a. Find the area of the outlined muscle by choosing **Analyze > Set Measurements**. Make sure the box next to **Area** is checked, and then choose **OK**.
- b. Next, choose **Analyze > Measure** to display the **Results** window and the area in square millimeters. Remove the enclosing polygon by clicking outside the leg.
- c. Repeat this process as a check, making sure both values are within 2 percent of each other. Use the two measurements to determine the average muscle area for that slice and that leg. Record the value in the table provided in the data sheet.
- d. Repeat the above procedure for three more slices of the same leg.
Be sure to record which slices you chose since you'll be comparing them to the same slices in post-flight images.
- e. Repeat these steps to acquire similar data for the post-flight image, **AstroCalf-Post.tif**. Be sure to use the same slice numbers and the same leg.
- f. Compare the results of your pre- and post-flight results.

Tool tip ...

Once the results window is open, just click **M** on your keyboard to make the measurement.

After this investigation into muscle loss, does it make sense that astronauts such as David Wolf often feel weak when they return to Earth?

Qn. 2. *Did you detect an increase or decrease in muscle area from the pre-flight images to post-flight?*

Qn. 3. *What was the size of this increase/decrease? Give your answer as a percent change in area.*

Mathematical reminder ...

Use the following formula to find the percent change:

$$\left(\frac{\text{pre-flight} - \text{post-flight}}{\text{pre-flight}} \right) \times 100$$

Researchers at NASA and other institutions are engaged in extensive studies to combat this muscle loss: exercises (of the right type), special gear, and nutritional supplements. To learn more about this work, visit one or more of the following Web sites:

[Muscle loss and workouts](#)

[Space cycle](#)

[Space boots](#)

[Nutritional supplements](#)

Mission accomplished!