

VO₂ Testing

Equipment:

VO₂ testing machine, original BWM generator, modified BWM generator, 5 gallon bucket (x2), BWM pump, BWM bucket seat for hand crank position, new bucket seat for pedaling position

Testing Sample Size:

2 Males and 2 Females

Testing Goal:

To prove that switching to a foot powered arrangement will result in the user expending less energy to power the pump for a more sustained period of time than is currently possible with the hand crank arrangement.

Procedure:

- 1) Fill up one of the 5 gallon buckets with water
- 2) Weigh the bucket to get an accurate measurement of how much water is in the bucket
- 3) Place the pump into the bucket full of water and set up the empty bucket at the pump output to hold the water that gets pumped
- 4) Arrange the bucket seat close enough to the pump so that the 12 Volt car adapter cable on the generator can connect to the pump
- 5) Place the generator on the generator stand
 - a. For the bucket seat designed for foot power, adjust the position of the generator to match the user's optimal pedaling position
- 6) Connect the generator to the pump with the 12 Volt car adapter cable
- 7) Attach the VO₂ testing mask onto the user's face and hook it up to the VO₂ testing machine
- 8) Calibrate the VO₂ testing equipment to get baseline measurements for the user prior to using the crank generator
- 9) Begin using the generator
- 10) Continue cranking/pedaling the generator until the user becomes too fatigued to continue
- 11) End data recording and print out results
- 12) Weigh the bucket that was full initially to see how much water was pumped, the difference between the two will be the amount of water that was pumped
- 13) Repeat steps 1-12 for each user

Discussion:

The point of VO₂ testing is to determine how much work a person has to do for a specific activity. Our group was interested in: 1) seeing how much work a person would have to do to hand crank the necessary power to pump enough filtered water to survive, and 2) seeing if lowering the input speed, increasing the resistance, and switching to pedaling would improve the ease of use of the generator.

Overall there were three different trials performed on three separate days: preliminary testing with the original hand crank generator, testing with the pedaling arrangement without any internal changes to the generator, and final testing with the pedaling arrangement and new motors.

The preliminary testing gave the team some baseline results as to how much energy had to be expended to run the pump. The outcome of this test showed that the hand crank is too difficult to use for women and children because the amount of energy required to crank the generator is too demanding at such a high crank speed and very little water could be produced. The results of the Metabolic Report will be reviewed in the next section. The second trial was for testing with just the pedaling arrangement for the generator and bucket seat. Ultimately it was discovered that without the reduced speed and increased resistance in the generator, it would be impossible to maintain the necessary pedaling speed to even power the pump. This trial resulted in a complete failure to generate any metabolic results. The third and final trial consisted of testing the new pedaling arrangement with new motors inside the generator. Even though the group confirmed that there was about a 12% reduction in the input speed needed to crank the generator to power the pump, the pedaling speed was still too high and the resistance of the motors too low to maintain the necessary speed to power the pump. This trial also resulted in a failure to generate any metabolic results.

Results:

As stated above, the only test trial that generated any metabolic results was the preliminary testing with the original hand crank generator. As shown in Figure 1, the test only ran approximately 5 minutes and 30 seconds because that was how long the test users could crank the generator before becoming too fatigued to continue. There are two important things to note about the Metabolic Report. The peaks in the VO_2 and VCO_2 lines represent time when the test user is cranking the generator but then stops for a short period of time for rest. This means that even though the test ran for five and a half minutes, the test users spent a good portion of the time resting. The second important thing to note is the trends of the VO_2 and VCO_2 lines. VO_2 is a measurement of how much oxygen consumption there is while performing an activity and VCO_2 is a measure of how much carbon dioxide is being produced while performing an activity. For the first half of the test the oxygen consumed and carbon dioxide produced are about the same, but at around 3 minutes into the test the carbon dioxide produced outweighs the oxygen consumed. This indicates that the user is exerting more energy than they can maintain and shows where the user is becoming very fatigued. Basically once the carbon dioxide produced outweighs the oxygen consumed it is bad for the user. The amount of water produced from this preliminary testing was very small and would certainly not be sufficient for someone to survive on.

Overall, the preliminary test was successful in showing what made the system so difficult to use, but the changes we implemented in the second and third tests did not improve ease of use of the generator.

Metabolic Report

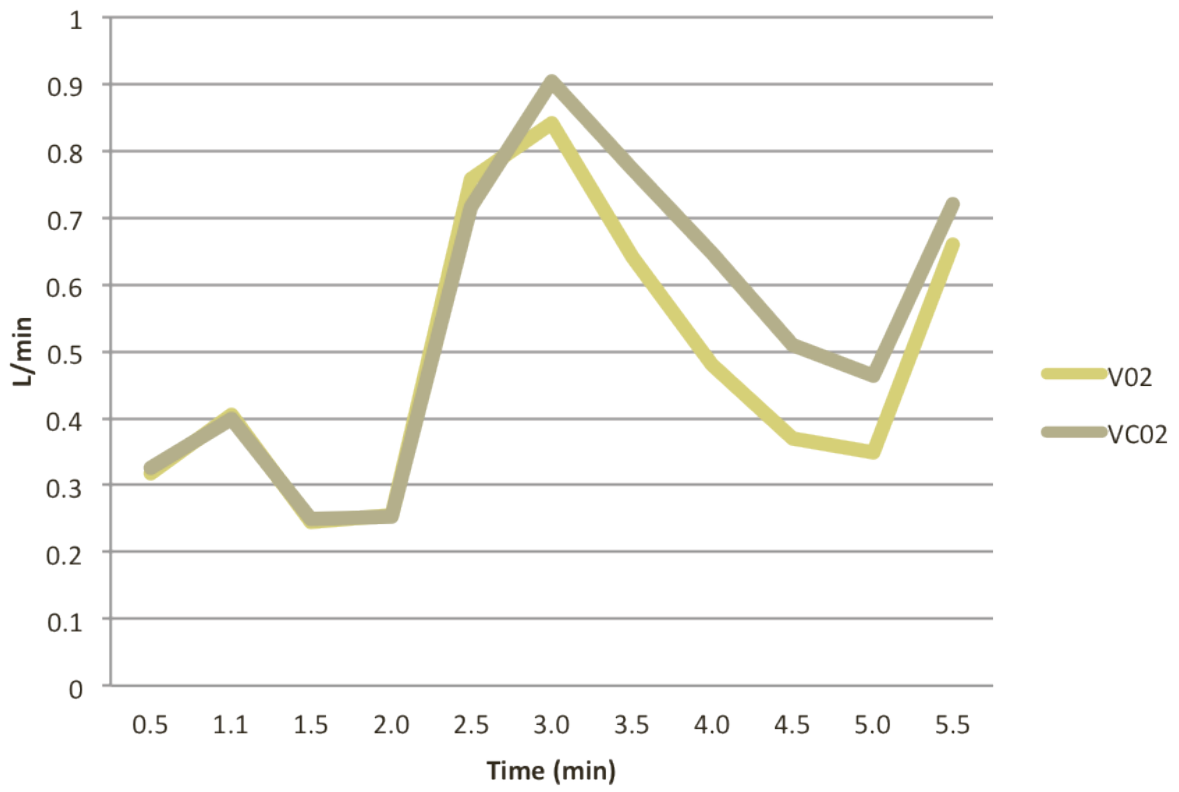


Figure 1: Metabolic Report of the Preliminary Testing of the Hand Crank Generator