EVALUATION:

Conclusion:

The purpose of this investigation was to discover the relationship between the amounts of time hair was exposed to chlorinated water, and the force that the strand of hair could hold before breaking. In this experiment, the hair used was of two different types, from a person who swims often and has long-term exposure to chlorine and a person who swims rarely who has little exposure to chlorine. In all cases, the chlorine exposed hair showed a significant decrease in strength. This is likely due to the disruption of bonds in the protein structure of the hair, specifically sulfur-residues and peptide bonds (3, 4). Chlorine also breaks down the outermost layer of the hair strands, which contain oils. This removal of oils results the loss of shine and flexibility of the hair strand, as well as making the protein core of the hair more prone to damage (3).

The data suggest that both types of hair lose more strength when soaked longer in chlorinated water, but non-swimmer hair loses strength more rapidly after two days. Because swimmers are exposed to the effects of chlorine on a more frequent basis, the hair has developed in a way that decreases the effects of chlorine – more oils are produced by the body to protect the hair in response to the chlorine present, and the hair grown, although damaged, is more resistant to chlorine. Environmental changes are known to change the amount of oily coating secreted by the sebaceous glands on the scalp (6). These physiological changes may cause the hair to become less damaged by the chlorine exposure over a set period of time than non-swimmers. On the other hand, it is possible that there is only so much damage that chlorine will do to the hair and that since swimmer hair is already weakened by chlorine exposure it simply has less strength to lose. Further research is needed to determine the answer.

Evaluation:

One weakness of this lab is that fata was only collected over three time periods and no data were collected prior to soaking (day 0). This produced insufficient points to make a line graph and determine the mathematical relationship between length of soaking time and loss of strength. The hair soaked in tap water served as a measure of starting strength but it would be better to also collect data after five minutes of soaking in tap and pool water to provide a starting point. More lengths of time should also be tested, such as every day for a week. Further, there was an anomalous result in the control hair strength for the non-swimmer. No reason could be found for this, and it is possible that having a much larger sample size would change the result. Instead of ten trials per condition, 100 or 1000 could be done, as time permitted.

Another concern was lack of control over the way the hair was pulled to exert force on the force meter. Although every effort way made to pull with a consistent strength and speed, there were no quantitative controls. This would increase the variability of the data. An automated method of pulling, perhaps using a motor to wind the hair around a spindle, would increase consistency and reliability of the data.

Other weaknesses have to do with the composition of the water. Tap water varies from place to place and may have chemical contaminants that could affect the strength of hair. For example, fluoridated water might cause a loss of hair strength because fluorine and chlorine, both being halogens, could act similarly on hair proteins (4). Distilled water would be a better control group in some ways, although the subject's hair would be primarily exposed to tap water when washing. The pH of the water also needs to be controlled. The effects of chlorine on keratin depend on pH, having less of an effect at alkaline pH value than neutral of acidic pH values (4). Tap water with a pH matching the pool water

could be used, or the distilled water could have its pH altered to match the pool water. While this would change the distilled water composition, at least the specific amount and nature of the contaminant would be known.

Further research could be done on the effect of stirring the hair and water samples. It has been shown that stirring or mixing will increase chlorine damage (5), and this would more accurately mimic the constant motion of swimming in a pool. A magnetic stirrer could be added to agitate the samples.

Works Cited:

1. "Disinfectants." *Chlorine as Disinfectant for Water*. LennTech, n.d. Web. 10 Feb. 2013. <http://www.lenntech.com/processes/disinfection/chemical/disinfectants-chlorine.htm>.

2. "Structure and Composition of Hair." *Health and Beauty*. Guardian, n.d. Web. 10 Feb. 2013. <http://www.guardian.com.sg/article/beauty-tips/hair/find-out-about-structure-andcomposition-hair-so-you-can-understand-how>.

3. Suwalski, Marianne. *The Effect of Chlorine on Human Hair*. Working paper. Waterloo Wellington Science and Engineering Fair, n.d. Web. 10 Feb. 2013. <http://wwsef.uwaterloo.ca/archives/2005/05suwalski.pdf>.

4. Duvel, L., et al. "Analysis of hair lipids and tensile properties as a function of distance from scalp." *International Journal of Cosmetic Science* 27.4 (2005): 193-197.

5. Fair, N. B., and B. S. Gupta. "Changes in properties of keratin fibers." *J. Soc. Cosmet. Chem* 38 (1987): 359-370.

6. Diana Draelos, Zoe. "The biology of hair care." *Dermatologic Clinics* 18.4 (2000): 651-658.