# Impact of Calorie Restriction on Life Expectancy

James Devany, Kaitlin Halligan, Sungsoon Yim, Thiru Vikram S., Megan Syrell
Advisor: Dr. James N. Jensen

University at Buffalo
The State University of New York

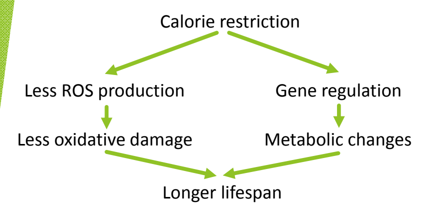
the academies
a living and learning community
experience it

## Background

Calorie restriction is the limitation of caloric intake levels. The response of the body to caloric restriction can be broken down into two phases. In the *adaptive phase*, metabolism (as measured by oxygen consumption) slows down. After a long period of caloric restriction, the body may enter a *steady state phase*. In this phase, glucose levels rise to normal levels and ketones serve as energy source to the brain.

Some studies have indicated that calorie restriction can increase the longevity of organisms, such as rats, and may have the potential to extend the lifespan of other mammals, including humans. Koubova and Guarente (2003) proposed two mechanisms for why caloric restriction might increase longevity (see Figure 1). First, a reduction is caloric intake might decrease production of reactive oxygen species (ROS), resulting in less oxidative damage and slower aging. Second, calorie restriction may lead to an increased life span through regulation.

**Figure 1: Possible Mechanisms for Increased Longevity from Calorie Restriction**




After Koubova and Guarente (2003). ROS = reactive oxygen species

## Methods

Statistical correlations were investigated for various countries between average life expectancy (LE) and average calorie intake (CI), as well as between LE and CI per unit of average body height (CI/BH). Height was selected as an indicator of body size instead of parameters related to mass (e.g., Body Mass Index, BMI), since it was thought $$$ is more independent of CI.

Data were analyzed by classifying countries by the degree of development (using the Human Development Index ranking, HDI) and by geographical location. Development served as a surrogate for the availability of medical care. Location served as a surrogate genetic, cultural and environmental factors that may affect human life expectancy.

**Figure 2: Life Expectancy as a Function of Caloric Intake by HDI**

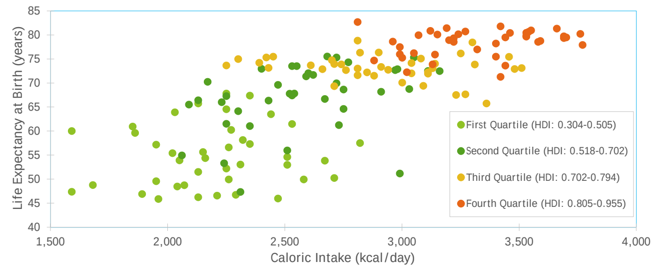



**Figure 3: Life Expectancy as a Function of Caloric Intake per Height by HDI**

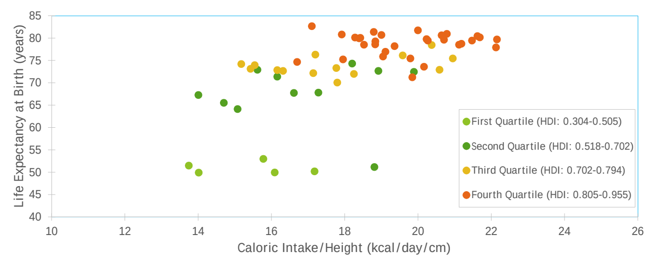



**Figure 4: Life Expectancy as a Function of Caloric Intake by Region**

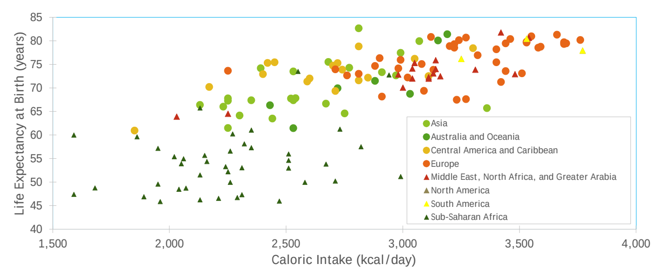
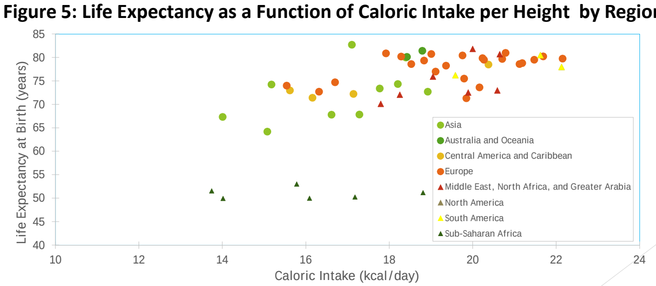



**Figure 5: Life Expectancy as a Function of Caloric Intake per Height by Region**




## Results and Discussion

*Effects of Caloric Intake*. For the 161 countries studied here, the correlation between life expectancy and caloric intake is weak (Figure 2). The correlation determination ($R^2$) is 0.551, so 55% of the total variation in life expectancy can be explained by a linear relationship between life expectancy and caloric intake. The $R^2$ value decreases to 0.361 when the caloric intake is normalized to height (Figure 3). Caloric intake divided by height appears to be a better predictor of life expectancy for countries with life expectancies over 60 years ($R^2$ = 0.538). Slopes are positive, indicating that increased caloric intake increases lifetimes.

*Importance of Development*. The dependency of life expectancy on caloric intake is *poorer* when the data are analyzed by HDI. This may be because the HDI includes life expectancy. Therefore, slicing the data by HDI (Figures 2 and 3) is really just slicing the data by life expectancy.

*Importance of Region*. Caloric intake is a much better predictor of life expectancy in the Middle East, North Africa, and Greater Arabia ($R^2$ = 0.741) and Australia and Oceania ($R^2$ = 0.736) than for all countries. Life expectancy is uncorrelated with caloric intake within Sub-Saharan Africa ($R^2$ = 0.089). For the three countries in North America, life expectancy decreases with increasing caloric intake, perhaps reflecting overindulgence in the U.S.

In general, normalizing caloric intake to height does not improve the correlation within regions. However, the relationship between life expectancy and caloric intake greatly improves for Central America and the Caribbean when caloric intake is divided by height ($R^2$ increases from 0.403 to 0.841).

## Conclusions

Looking across the world, there is no significant statistical correlation between life expectancy and caloric intake or caloric intake divided by height. This may be due the importance of other factors affecting the human life span, such as availability of medical care, personal and surrounding hygiene, dietary imbalances, and personal habits. This study points to some intriguing correlations. In particular, life expectancy is much more correlated with caloric intake in North Africa and environs than in Sub-Saharan Africa. Further work is required to explain these observations. In addition, dividing caloric intake by height provides a much stronger predictor of life span only in Central America and the Caribbean.

## References

UN World Population Prospects: 2012 revision. "Food Consumption Nutrients." Food and Agriculture Organization of the UN. <http://www.fao.org/fileadmin/templates/ess/documents/food_security_statistics/FoodConsumptionNutrients_en.xls>.
"The 2013 Human Development Report – The Rise of the South: Human Progress in a Diverse World". HDRO (Human Development Report Office) UN Development Programme. pp. 144–147. Retrieved 2 March 2013.

## Acknowledgments

We would like to thank the Academies and the Center for Undergraduate Research and Creative Activities for providing us with the opportunity to participate in and execute this research project.