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A2_3 Peake Savings: Send Suzie to Space

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Abstract

Manned International Space Station (ISS) missions cost the economy hundreds of millions US Dollars (USD), so astronaut selection processes for such assignments are rigorous and exhaustive. We evaluate cost comparisons of sending the winner of the BBC programme, "*Astronauts* : *Do you have what it takes*?", on the same six-month ISS mission that Tim Peake embarked upon in 2015/16. We find that the winner of the programme, Suzie Imber, would make a financial saving of 23 million USD over Tim Peake.

Introduction

The winner of the BBC programme "*Astronauts* : *Do you have what it takes*?" is associate professor of Planetary Science at the University of Leicester, Suzie Imber. We have decided to approximate the cost of launching and feeding Suzie for a six-month mission to the ISS, should she be successful in her astronaut application with her special recommendation from Commander Chris Hadfield. This is then compared with how much it approximately cost to launch and feed astronaut Major Tim Peake in his 2015/16 mission. Evaluating the costs using the official NASA Basal Metabolic Rate (BMR) [1] models, and the base of nutritional content for simplicity will be taken to be freeze dried strawberries [2].

Theory

The initial cost of launching astronauts is difficult to calculate due to the life support systems required for the journey. Therefore, we have taken the average launch cost to be based on 70 million USD per seat to the ISS on a Russian Soyuz rocket [3], with the cost 43,180 USD per pound on the Cygnus used for food resupply [4].

In order to calculate the food costs required, we need to consider the heights, weights and ages of astronauts of each gender. The average BMR for females and males respectively are given by:

$$BMR_F = 655 + (9.6 \cdot W) + (1.7 \cdot H) - (4.7 \cdot a) \quad (1)$$

$$BMR_M = 66 + (13.7 \cdot W) + (5 \cdot H) - (6.8 \cdot a) \quad (2)$$

Where W is weight in kg, H is height in cm, and a is age in years [1].

For a general population of males and females with a healthy BMI of 22.5 [5], we need a standardised baseline; this is done using equations (1) and (2) to generate a graph of height vs. cost (see Figure 1). An age of 38 yr is used as the average age of selection candidates is 34 yr, and the typical age of first space flight comes 4 years later [6].

The majority of food consumed in space is freeze dried to make it lightweight with a longer shelf life [2]. We chose to use freeze dried strawberries in this model due to it being a readily

available astronaut food that can be bought on Earth with easy access to its nutritional contents. It was found that the food contains 1 cal per 0.28 g [2]; this information was used to calculate the average amount of mass per calorie needed to sustain an astronaut of given physique:

$$Cost_{food} = M_{cal} \cdot (BMR_{F/M} \cdot t)) \cdot Cost_{cargo} \quad (3)$$

Where M_{cal} is the mass per calorie, t is the time in orbit in days (183.5 days), $Cost_{cargo}$ is the price in USD per unit mass to the ISS (19,586 USD kg^{-1}) [4]. To find the costs associated with Suzie, she kindly sent us her height, weight and age (1.71 m, 58 kg, 33 yr respectively). To obtain a figure for Tim's height, we referred to a comment he made that his space height was 1.8 m [7], which is roughly 3% higher than on Earth [8]; concluding in 1.75 m. His weight was calculated by passing his height back through the BMR model; 68.85 kg. Tim's age is 45 yr.

Results

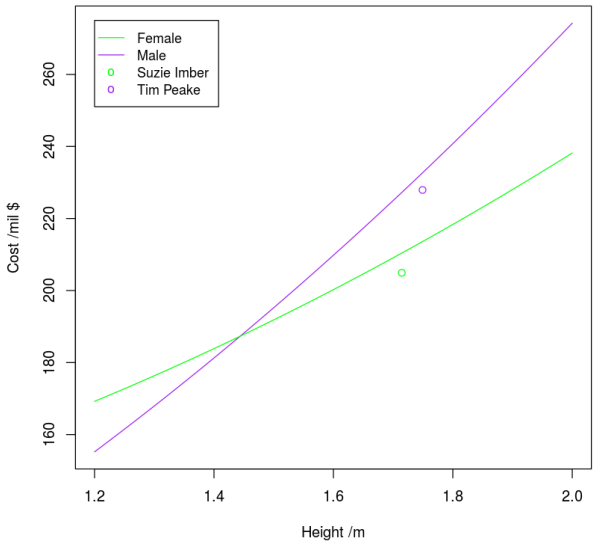

Figure 1: Graph showing the baseline metabolic models and depicting where Suzie and Tim fall relative to it.

The results obtained allow us to draw comparisons in the costs of launching and sustaining the general, healthy population to the ISS, as well as specifically Suzie and Tim.

The baselines in our model (Figure 1) show an intersection at a height and cost of approximately 1.43 m and 187 million USD respectively. This suggests that beyond this point, due to differences in the average BMRs provided by NASA, generally speaking it would be more cost effective to send female astronauts on missions to the ISS. Taking a look at just Suzie and Tim's data points, we find that Suzie would be almost 23 million USD cheaper.

Conclusion

In conclusion, we have found that sending Tim Peake to the ISS cost 228 million USD. If we were to send Suzie, it would costs 205 million USD. Therefore, by comparison, Suzie Imber would be a more financially beneficial astronaut to use for a six-month ISS mission.

References

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