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Does Crash Bandicoot Have a 'Fast' Metabolism?

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Abstract

This paper describes the process of calculating Crash Bandicoot's expended energy on spinning, jumping and running through the entirety of the first game released in the series, with his total calorific intake via wumpa fruit also being calculated. With these values, it was then possible to estimate Crash's metabolism, and compare it to that expected from a character of his nature. It is found that Crash Bandicoot has an extremely fast metabolism, burning an estimated 41 times his recommended intake.

Introduction

The Crash Bandicoot series is a well-recognised and respected video game platformer, with the character himself being an icon of the 1990's and the PlayStation 1. Throughout the first title released within the series '*Crash Bandicoot*', Crash is subjected to the task of traversing across various stages, by either running, jumping or spinning. In the process, various types of crates are broken and as a result wumpa fruit hidden inside certain crates are collected, alongside the free-standing in the stages themselves [1]. With these parameters, it is possible to calculate estimations for Crash's expended energy on movement, his total energy intake from collected wumpa fruit and subsequently his metabolic rate.

Total Energy Expended

To calculate the total amount of energy Crash utilises on movement, a number of initial assumptions need to be made:

- Crash's height is 30 inches (0.762 m) and weighs 30 kg (assumed from visual depictions within the game as there is no single reliable source for this information).
- As Crash appears human-like, it is assumed he is equivalent to 20 years old i.e. a young adult.
- Crates have a height that is equal to $2/3$ of Crash's height (therefore 0.508 m).
- Crates have equal dimensions (height = width = length)
- Crates are made from dry white pine wood [2].
- Crates are struck near the centre of all 6 sides of the crate [2].
- Only '*? crates*', '*Basic crates*' (Ba) and '*Bounce Crates*' (Bo) are considered.
- Spin attacks are only completed against crates and not enemies.
- All jumps are equal in height (1 m) and last 1 s.
- Crash's average heart rate is 150 bpm.

Taking these initial parameters, it is possible to calculate the stored energy in a single side of a crate at the point of fracture [2]:

$$U_0 = \left(\frac{\sigma_0^2}{12E}\right)hlw, \quad (1)$$

where U_0 is the stored energy, σ_0 is the modulus of rupture for dry white pine, E is the Young's modulus of dry white pine, h is the height of a single side of a crate, l is the length of a single side of a crate and w is the thickness of the wood. Assuming the wood is 2 cm thick and both σ_0 and E take the same values as experimentally determined for dry white pine in the paper 'The Physics of Karate' [2] (3.6×10^6 Nm^{-2} and 1.4×10^8 Nm^{-2} respectively), the stored energy is calculated as 39.8 J. Therefore, the minimum energy required to break all sides of a single crate is equal to 238.9 J. From this, it is therefore assumed the entire action of spinning requires 238.9 J for ease of calculations. Assuming all '*? crates*' and '*Basic crates*' are broken by spin attacks, it is possible to determine the amount of energy that Crash puts into breaking these crates throughout a single run through of the game (N. Sane Trilogy) [3]:

$$E_? = No.of\ ?\,crates \times 238.9 = 130 \times 238.9 = 3.11 \times 10^4\,J. \quad (2)$$

$$E_{ba} = No.of\ Ba\ crates \times 238.9 = 550 \times 238.9 = 1.31 \times 10^5\,J. \quad (3)$$

For '*Bounce crates*', Crash jumps on the crates multiple times to break them. A complete run of the game was made with each jump being counted as either contributing towards progression of the game or for breaking open these types of crates [3]. The total number of jumps counted was equal to 2580. With this, it is possible to calculate an estimate of the total energy used jumping in a single run through of the game by using the Lewis formula for jumping [4]:

$$E_{jump} = 9.81 N_{jumps}\sqrt{4.9mh} = 3.07 \times 10^5\,J. \quad (4)$$

Lastly, to calculate the energy expended on running, the total time spent running needs to be determined. Within the game, there are designated 'time trials' that are associated to each level to gain relics, and if it is assumed each level is completed in the time to gain a platinum relic [4], and that within each level 75% of the time is spent running (with the other 25% being spinning, jumping or standing) it is possible to calculate energy expended on running using the following formula [5]:

$$E_{run} = \frac{(0.2017A - 0.09036W_{lbs} + HR - 55.0969)t}{4.184} = 550\,kcal = 2.30 \times 10^6\,J, \quad (5)$$

where A is the age in years, W_{lbs} is weight in pounds (lbs), HR is heart rate in bpm and t is the time in minutes. Therefore, the total expended energy on movement is as follows:

$$E_{expended} = E_? + E_{ba} + E_{jump} + E_{run} = 2.77 \times 10^6\,J. \quad (6)$$

Total Energy Consumed

To calculate the total energy consumed, it is assumed the calorific value of a single wumpa fruit is equal to that of a large peach (≈70 kcal [6] = 2.93×10^5 J). The total number of wumpa fruit collected also needs to be determined. This can be done by assuming all '*? crates*' yield 5 wumpa fruit, all '*Basic crates*' yield 1 wumpa fruit and all '*Bounce crates*' yield 10 wumpa fruit [3]:

$$?\,crate\ fruit = N_{?crates} \times 5 = 130 \times 5 = 650 \quad (7)$$

$$Ba.crate\ fruit = N_{Ba\ crates} \times 1 = 550 \times 1 = 550 \quad (8)$$

$$Bo.crate\ fruit = N_{Bo\ crates} \times 10 = 110 \times 10 = 1100 \quad (9)$$

$$Free\ standing\ fruit = 495$$

$$\therefore Total\ wumpa\ fruit = 2795$$

$$\therefore E_{consumed} = 2.93 \times 10^5 \times 2795 = 8.19 \times 10^8 J. \quad (10)$$

Metabolism

As Crash does not appear to lose/gain weight throughout the game, it is assumed that all the energy of the wumpa fruit that is consumed is either used for movement or is metabolised:

$$\therefore E_{metabolised} = E_{consumed} - E_{expended} = 8.19 \times 10^8 - 2.30 \times 10^6 = 8.17 \times 10^8\,J = 1.95 \times 10^5\,kcal \quad (11)$$

Assuming the course of a single run of the game, with respect to in-game time, takes a week, Crash's basal metabolic rate (BMR) can be estimated to be 1.15×10^8 J day^{-1} (2.79×10^4 kcal day^{-1}). Taking the Mifflin St Jeor equation [7]:

$$BMR = 10W_{kg} + 6.25h_{cm} - 5A + 5\,, \quad (12)$$

where W_{kg} is weight in kg, h_{cm} is the height in cm and A is the age in years. It is then therefore possible to calculate the expected BMR of a hominoid-bandicoot with the same stature as Crash to be 681 kcal day^{-1}. As a result, Crash consumes ≈ 41 times his 'recommended' daily intake.

Conclusion

In conclusion, within the boundaries formed by the various assumptions, Crash's metabolism proves to be extremely higher than expected for a bandicoot of his size, burning 41 times more calories than predicted. It can therefore also be confirmed that Crash has an extremely fast metabolism.

References

[1] Sony Computer Entertainment (1996) *Crash Bandicoot* [Computer game] PlayStation 1, Naughty Dog.

[2] Wilk, S.R., McNair, R.E. & Feld, M.S. (1983). *The physics of karate.* American Journal of Physics, 51(9), pp.783-790.

[3] Activision (2018) *Crash Bandicoot N. Sane Trilogy* [Computer game] Nintendo Switch, Vicarious Visions.

[4] Harman, E., Rosenstein, M., Frykman, P., Rosenstein, R. & Kraemer, W. (1991). *Estimation of Human Power Output from Vertical Jump*. The Journal of Strength and Conditioning Research, 5(3), p.116.

[5] Koning, B. (2012). *Formula for Calories Burned*. Brian Koning, Fitnowtraining.com. [online] Available at: http://fitnowtraining.com/2012/01/formula-for-calories-burned/ [Accessed 7th April 2019].

[6] Thompson, C. (2010). The Peach: 10 Healthy Facts. WebMD. [online] Available at: https://www.webmd.com/food-recipes/features/peach-10-healthy-facts#1 [Accessed 7th April 2019].

[7] Mifflin, M.D., St Jeor, S.T., Hill, L.A., Scott, B.J., Daugherty, S.A. & Koh, Y.O. (1990). *A new predictive equation for resting energy expenditure in healthy individuals*. The American Journal of Clinical Nutrition, 51(2), pp.241-247.

Appendix

Level	Name	No. of Boxes	No. of ? crates	No. of Basic crates	No. of Bounce crates	No. of Jumps	No. of Single Fruit	Plat. Relic (sec)
1	N. Sanity Beach	49	8	32	5	52	0	25.76
2	Jungle Rollers	43	7	20	6	76	0	46.89
3	The Great Gate	38	1	21	3	101	93	48.07
4	Boulders	16	2	11	1	32	25	47.48
5	Upstream	36	3	19	2	65	9	46.51
Boss	Papu Papu	0	0	0	0	26	0	0.00
6	Rolling Stones	87	6	39	6	90	0	46.49
7	Hog Wild	24	12	7	0	1	0	43.42
8	Native Fortress	48	2	14	8	175	80	125.80
9	Up the Creek	48	3	31	1	98	6	76.31
Boss	Ripper Roo	0	0	0	0	10	0	0.00
10	The Lost City	82	5	22	23	185	34	100.52
11	Temple Ruins	67	10	42	5	97	21	85.34
12	Road to Nowhere	42	2	10	2	111	35	57.85
13	Boulder Dash	35	3	16	4	74	11	78.08
26	Whole Hog	24	10	13	0	1	0	26.87
14	Sunset Vista	90	9	28	9	238	31	221.85
Boss	Koala Kong	0	0	0	0	12	0	0.00
15	Heavy Machinery	86	9	44	9	190	71	96.29
16	Cortex Power	42	3	20	6	95	3	39.70
17	Generator Room	52	6	27	2	85	7	59.72
18	Toxic Waste	39	5	13	4	53	0	55.75
Boss	Pinstripe Pototoo	0	0	0	0	0	0	0.00
19	The High Road	45	13	16	0	101	15	64.61
20	Slippery Climb	51	1	19	2	128	0	146.08
21	Lights Out	15	0	0	1	50	0	66.87
27	Fumbling in the Dark	18	0	0	0	75	0	101.59
22	Jaws of Darkness	112	7	66	5	173	21	96.26
23	Castle Machinery	27	0	11	6	95	33	129.89
Boss	Dr. Nitrus Brio	0	0	0	0	9	0	0.00
24	The Lab	36	4	11	3	50	0	44.92
25	The Great Hall	0	0	0	0	22	0	0.00
Boss	Dr. Neo Cortex	0	0	0	0	8	0	0.00
	Total	**1252**	**131**	**552**	**113**	**2578**	**495**	**1978.92**