Can evolutionary medicine help explain the current obesity epidemic in the UK?

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1073 SSM1 Dr Dillon

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I would like to thank Dr Dillon and Dr O'Neil for putting together such a fantastic SSM. My thanks also go out to the many people who arranged our sessions and allowed me to have such a facinating time.

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Abstract

Britain has an increasing number of obese people, explinations for this trend have focused on lifestyle choices such as diet and exercise. The consequences of this growth in obese people in the country is that there is an associated increase in a variety of morbidities, including cardio-vascular disease and type 2 diabetes. I sought to reconsider this worrying trend from a different perpective, that of evolutionary medicine, to see if there was a deeper explanation that could help us combat this trend. To acheive this I used internet searches and searches of medical databases to locate appropriate literature on the issues, the causes and the consequences of obesity. I then looked at literature on evolutionary origins of obesity to understand the context in which obesity is framed. After looking at these sources I can see that many of the lifestyle choices of people are in fact based upon their genetic programming and that the population's tendancy to store weight may well be an evolved response to the hardships of our ancestors' lives. This means that evolutionary medicine can help explain why obesity develops and can offer hope used to help combat this dangerous condition.

1. Introduction

The world is currently facing an obesity epidemic, the WHO has calculated that about 250 million people worldwide are obese and the figure is rising, with an estimate of 300 million by 2025[1]. Currently it is the industrialised world that has the greatest proportion of the world's growing obese population, yet disturbingly there are signs that obese populations are increasing within developing countries as well[2]. The WHO defines obesity[1] as a BMI greater than 30 kg/m^2. Although there are flaws with this system because it does not take account of the lean mass of an individual[3] it serves as a useful guide and tool for measuring the prevalence of the condition. The reason that this increase is of concern is that obesity is an important risk factor in a number of conditions, such as cardiovascular disease, type 2 diabetes and hypertension[1]. As a result of this obesity is linked to increased health care costs and thus has economic implications

Evolutionary medicine, also known as Darwinian medicine[4], is the application of Darwinian principles to medical practice. It is the usage of evolutionary theory to explain the wonders, curiosities and flaws of the human body and why as a consequence are we vulnerable to such a myriad of conditions and diseases. The fundamental concept of evolutionary theory is the ability to reproduce; those organisms capable to reproducing pass on their genes, those that cannot die out. An organism that is described as being fit within its environment is one that is capable of reproducing. This is an important because in evolution conflict between traits that enhance reproductive ability and traits that promote longevity will always be resolved in favour of traits promoting reproductive ability[4].

In this work I am looking for evidence that there is an historic advantage in the ability to gain additional body fat that over time is no longer relevant, or has this trend a simply random cause[5].

2. Method

The first thing I did after deciding on my title was to e-mail Sue Aitken (an evolutionary psychologist), whose e-mail address was given to me by Keith Morgan. I asked for suggestions for articles to start with and appropriate places to look for journals. I then performed two Google Scholar searches, the first (Darwinian medicine obesity) received 2900 results and the second (evolutionary medicine obesity) received 23,000 results. I then located the full articles that I was interested in using the library discover tool. Using the Scopus medical database, I searched for ((“thrifty genes”) AND (obesity)) under a keyword, abstract and title search limited to publication dates after 2005 and found 34 results.

I performed a keyword search using the library discover tool of (obesity AND Darwinian AND medicine) and received 57 results. Another library discover keyword search of (obesity AND “public health”) received 48,853 results that I narrowed down to 270 by restricting it to a title search of academic e-journals that were published in the last 6 years. I used the references from articles found through these searches to identify further material, the detail of which was then obtained through the library database.

3. Results

Sue Aitken had initially sent me a selection of articles and then some additional articles a chapter from a book that are more focused on my area of study. I supplemented this initial material by selecting the most relevant from each of my Google Scholar searches. These articles were read in depth for references to useful articles with which I could begin a more detailed search. The Scopus search was a response to coming across some terms I had not heard used before and led to some very interesting papers. I selected a series of articles from the two library searches. Using these I located additional papers through the references of the articles I had found so far. This, in conjunction with my meeting with David Lawrence, has provided me with the evidence to produce this piece of work.

4. Discussion

The problem of obesity

The prevalence of obesity is on the increase, in British men between 1986 and 1993 the prevalence of obesity went from 6% to 13% and in women it leapt from 8% to 16%[6]. More worrying still is the growth in childhood obesity, with a 50% increase in the number of obese English and Scottish children between 1984 and 1994[6]. In the developed world obesity is more prevalent within the lower socio-economic groups[1-3, 7, 8].

The rise of mechanised agriculture has had a significant impact in reducing the price and availability of food[2], with food production no longer requiring the massive resource allocation necessary in the past. The corresponding fall in food prices has meant that food is no longer as significant an economic investment as it once was, there has been a steady decline in the percentage of household expenditure that goes on food since the Great Depression. As a result most of the population has easy access to abundant food and additionally because there is a little to no need for manual labour there is almost no calorie expenditure[2]. The social acceptability of being overweight also has an influence on its prevalence, social stigma will keep it in check but the social perception is influenced by frequency, the more common obesity is the less abhorrently it is viewed[2]. The greater prevalence seen in some ethnic minorities[3] is believed in part to be down to the social perceptions being less negative[3, 6, 8]; thus there is a corresponding rise in the numbers of obese people. In a society where eating is a social activity there is a desire to produce and consume larger and more delicious meals, which can exacerbate problems of obesity[8]. The increasingly sedentary nature of our lives[9], with less free time to exercise due to other commitments such as work[8] and the increasing cost of exercise, due to expenses such gym membership[2] means that there are far less opportunities for people to burn off their accumulated calories.

Obesity is a serious public health issue, being a risk factor for numerous conditions. BMI is noted to have an effect on mortality, Visscher et al[1] showed that a BMI higher than 27 kg/m^2 shows an increased the risk of all cause mortality, they based this on the Nurse's Health Study and the US Health Professionals Follow-Up Study. Yet the effect of BMI on mortality decreases with age[1, 6], Visscher et al[1] provided evidence for this by looking at BMI-mortality relation in 62 000 men and 262 000 women,

followed up between 1960-1972. The WHO calculated that about 64% of type 2 diabetes cases in US men and 74% of cases in US women could be prevented if there were no BMI over 25[1]. The total healthcare costs of obesity in the US in 1995 were calculated to be around $50 billion, with another $4 billion dollars being lost due to decreased productivity[6]. Being obese considerably increases the risk or cardiovascular disease; specifically increased abdominal adipose tissue is associated with cardiovascular disease[1]. Compared to men with a BMI of less than 23 kg/m^2, men with a BMI of 29-33 kg/m^2 have a twofold increase in the risk of developing coronary heart disease.

Diet

Carbon isotope analysis and fossils of our ancestors indicate that we evolved to include meat within a previously vegetarian diet around 2.6 million years ago[10]. In the Paleolithic period our hunter-gatherer ancestors ate an omnivorous diet as indicated by our dental structure[11] that is well adapted to eating soft fruits, nuts and meat. Ancient bones have been discovered with fractures and cuts[11] that have opened up the bone to expose the marrow, to do so requires tools and is evidence that early humans and hominins were using tools to maximise the amount of nutrition they could get from a carcass because by breaking open the bones they could access the fatty bone marrow.

Bellisari[11] has suggested that the hunter gatherer diet seen prior to the advent of agriculture could have provided 3,000 calories a day, this and the physical activity required to obtain it, through hunting and foraging, would have resulted in tall stature and good general health. The evidence for this comes from analysis of their skeletal structure and so is still open to questioning, yet nutritional evidence suggests that the Paleolithic diet was of high quality. Especially important to note is the large amount of meat consumed, up to 50%[10, 11] of the Paleolithic diet was lean red meat, with a fat content between a seventh and a tenth of current red meat[6]. Meat is considerably more nutritious than vegetation providing much needed protein and fats that gave humans an energetic advantage over other primates[11]. Meat it is much easier to digest, evidence of which can be seen by comparing our gastro intestinal system to our closest primate relatives. We have a relatively short colon and an expanded small intestine[6, 12]; the opposite is true in most other primates. This is because they require a

longer colon so that symbiotic bacteria in their colon can release nutrients from indigestible plant material[6, 12].

Around 10,000 years ago hunter-gatherer populations began to settle in areas and develop agriculture[11]. The consequence of this was a fundamental change in the entire basis of our ancestors' diet; the Neolithic period saw a dramatic drop in food diversity and quality. The primary base of the diet in this period was carbohydrate as apposed to protein. From Table 4.1 below we can see that the vast majority of the Western diet consists of foods that were not present during our evolution. There was great reduction in the variety of both plant material and animal material that we consumed, Bellisari[11] highlights the fact that of the 3,000 seed bearing plant species that hunter-gatherers foraged from we only domesticated around 200 and only 4 species now dominate agriculture: maize, rice, sugar cane and wheat. The story is the same for the domestication of animals with an estimated 50 animal species domesticated world wide[11], but only a select few used for food in each area.

Consequently our diet in its now limited form provides us with far less of some nutrients and there is a very low fibre content[10] relative to our past diet due to the consumption of refined of grain, which constitutes the basis of our diet. We now have drastically higher levels of saturated fatty acids and reduced levels of monounsaturated and polyunsaturated fatty acids[10] because of the fatter meat and dairy products we eat. The diet we were fine tuned for has gone[13], and has been replaced by a diet that is both more palatable and ironically less nutritious.

Table 4.1: Food and Food Types Found in Western Diets Generally Unavailable to Preagricultural Hominins[10]

Food or Food Group	% Total Energy in US Diet
Dairy Products	
Whole milk	1.6
Low fat milks	2.1
Cheese	3.2
Butter	1.1
Other	2.6
Total	10.6
Cereal Grains	
Whole grains	3.5
Refined grains	20.4
Total	23.9
Refined Sugars	
Sucrose	8.0
High-fructose corn syrup	7.8
Glucose	2.6
Syrups	0.1
Other	0.1
Total	18.6
Refined Vegetable Oils	
Salad, cooking oils	8.8
Shortening	6.6
Margarine	2.2
Total	17.6
Alcohol	1.4
Total Energy	72.1
Added Daily Salt (NaCl)	9.6g

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Adaptations to our past environment

The human species has evolved to become exceptionally efficient as calorie conservation as can be seen in the fact that there are 253 quantitative trait loci and 135 candidate genes that appear in the human genome that are believed to be associated in some way with the development of obesity, they are found on all the chromosomes except Y[11]. This frequency of genetic markers suggests that these traits have been selected to produce one particular outcome, the ability to store fats[6]. In fact in overfed humans around 75% of the excess energy is stored[6], with no increase in heat production, the result is that humans will store any additional energy.

The reason that fats, salt and sugar are so palatable[7] is because this conferred the important advantage of encouraging an early humans or hominins to consume as much of these resources as they could[13]. This conferred a selection advantage because on the African Savanna these are rare nutrients and so their palatability ensured that our ancestors made as much use of these nutrients as they could. These foods also stimulate our reward pathways[14] to further encourage this.

Behavioral adaptations also constitute part of our evolved strategy of efficiency; examples suggested by Prentice et al[15] include slothfulness and gluttony. In times of calorie restriction a propensity to do as little activity as possible and so expend as few calories as possible could have been life saving. Likewise the drive to consume as much as is possible could have provided a selection advantage by ensuring our ancestors did not waste available reasources[13]. Other survival adaptations also come in to play, the desire to hoard food acts to ensure an energy stockpile outside of the body[15] and survival tactics such as willingness to steal[15, 16] enhances advantages during calorie restricted periods.

Selection pressures

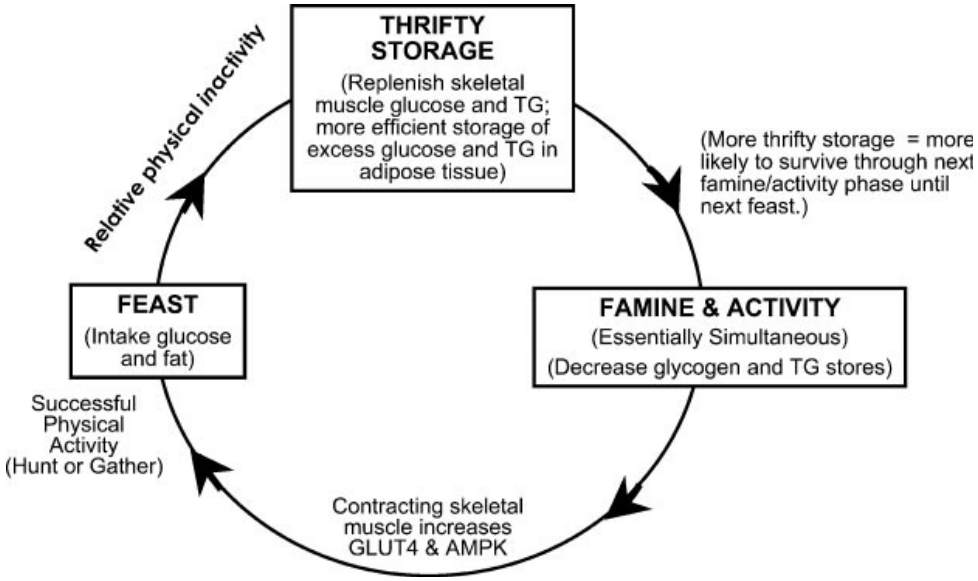
In evolutionary medicine there is an ongoing debate as to when the pressures selecting traits that predispose us to obesity were selected, or indeed if there was positive selection of them at all.

Chavkravarthy et al[9] suggest that humans needed genotypes that allowed us to endure the hardship of the feast famine cycle, see figure 4.1, that hunter gatherers had to endure. Metabolic adaptations allowed our ancestors to build up a store of energy that increased their chances of survival through these famines. Chavkravarthy et al[9] restrict evolution of these traits to the late Paleolithic era around 50 000 to 10 000 BC, saying that by the end of the Paleolithic period 95% of all human biology had been selected and that consequently as well most of our innate behavior had also been developed.

There are some significant flaws in this concept, one outlined by Speakman[5] was that if dominant genes predisposing us to gaining weight even had just a slight survival advantage of 0.1% then over the course of our 2 million year evolution, which equates to roughly 100,000 to 70,000 generations then those genes would have reached a >99% prevalence. Speakman[5] then points out that if this were true then surely the prevalence of obesity would be far higher because almost all of us would posses the genes for obesity.

Yet there is also another possibility, that some of the genes that result in a genetic tendency to gain weight appeared within the Neolithic period[16], the evidence for this is that in reality prolonged famines rarely occurred in hunter gatherer societies[17]. Prentice[17] bases this theory on the fact that hunter-gatherers in their small social groups were mobile enough to move to a new feeding ground as soon as they depleted the food in one area. This meant that although it was common for hunter-gatherers to go without food for a few days they never experienced the prolonged famines that would have selected the ability to store large reserves of fat. In contrast the Neolithic period was characterized by repeated famines, from 500-1500CE France witnessed 75 crop failures with local famines capable of doubling or tripling the death rate[6].

Figure 4.1 The feast famine cycle[9]



The mortality evidence from famines though is not supportive of the theory that they could have acted as a great selective pressure, Speakman[5] points out that even during prolonged famines mortality is rarely above 10% and this can be quite easily skewed by migration out of the famine area. This, he points out, is not a high enough mortality rate to cause the selection of obesity predisposing genes within the 400-600 generations he approximates would have passed in the 12,000 years since the development of agriculture. The alternative Speakman[5] proposes is in fact that the genetic predisposition of a significant minority of the population to develop obesity is due instead to genetic drift after the removal of the limiting factor of predation. This he hypothesises occurred around 2 million years ago when our ancestors developed increasingly complicated social structure, weapons and then later fire.

There is however another aspect to the Neolithic evolution as suggested by Prentice et al[16], that it would not have been based so much on mortality rates during famines but on fertility selection[15, 16, 17] during both famines and the annual hungry seasons witnessed by all subsistence agricultural societies. Evidence for this can be seen in a 30-50% drop in the rate of conceptions in the annual hungry season in Bangladesh and Gambia[15, 16]. They also use evidence from the age distribution data taken 20 years after Chairman Mao's 'Great Leap Forwards' that showed a virtual absence of 19-20

year olds[16]. Such fertility selection would act as a very powerful selection pressure[16] and could produce the current prevalence of the genotypes associated with obesity. Yet Speakman[5] has questioned some of this evidence, he points out that the birth rate following the 'Great Leap Forwards' is 50 births per 1,000 people per year in areas hit by the famine, compared to 36 births per 1,000 per year prior to the famine. This elevated level is continued for 4 years and so would cancel out any drop in birth rates during the famine. This evidence indicates again some equalising of the previous selection pressure.

5. Limitations

I think that there is room for continued research into the evolution of mankind and the selections pressures that may or may not have influenced our evolution. Hopefully new technologies will appear that can help us further elucidate the nature of our genome and why it is the way it is. Additionally continued archaeological evidence as to the lifestyle and physical statue of our ancestors would improve the basis for many of the theories. I also believe that research should continue around the effects obesity has on our health because the more evidence on what obesity does the more we can look to see why this comes about using evolutionary medicine as a framework.

6. Conclusion

The UK is witnessing a growing problem of obesity in all ethnic and socio-economic groups, the causes can be put down to economic features such as the low prices and abundance of highly palatable foods[2]. Similarly our increasingly more sedentary lifestyle means that those calories we accumulate are being stored instead of spent. Socially our culture uses food as a method of enhancing social bonds and to enhance the advantages we focus on procuring and consuming the most delicious food[8]. These foods taste so good because we evolved on a diet which had low concentrations of these nutrients[13] and so to ensure that such nutrients are used our bodies reward us for eating them[14]. Yet we did not evolve to metabolise the quantities of these nutrients we are now able to consume. These traits to consume as much food as we could and store it were selected because they gave us the ability to reproduce when others in our species could not[16, 17], the adverse consequences of these genes were not selected against since we managed to reduce the risk of predation through our development of social structure, tools and fire[5]. This dissonance between the environments we are designed for and the environment we currently inhabit[9] must be recognised and we must implement steps to ensure that the obesity problem does not further deteriorate because of the associated morbidity problems. Using the perspective of evolutionary medicine it is possible for us to look at obesity in a new light and develop steps to deal with the problem.

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8. Appendix

Timetable

Monday 24th January	Attended introductory meeting at Health Inclusion Offices in Ellesmere Port run by Dr O'Neil.
Tuesday 25th January	Visited the Neuro Support Centre and was given a guided tour and explanation of what the centre provided. Talk by Kathy James on Motor Neurone Disease
Wednesday 26th January	Visited the Fade library and had a talk on the history of art by Dr Duncan Young in the morning. In the afternoon we had a meeting with Dr Dillon and then were given a introductory talk and explanation of search techniques by Kieran Lamb.
Thursday 27th January	Went to the bread making church above News From Nowhere bookshop on Bold Street in the morning. In the afternoon I had a talk on spirituality given by Reverend Jonathan Jelfs at St Bride's Church on Percy Street.
Friday 28th January	I was given the morning to work on my SSM. In the afternoon I had a meeting with David Lawrence on anthropology and history in the café of the World Museum on Brown Street. After which I decide on my topic.
Monday 31st January	In the morning Dr Katy Gardener took us

	on a tour of some health centres. In the afternoon I attended a session run by Maggie Hammond on patient narratives.
Tuesday 1st February	In the morning I went on a guided tour of the Liverpool Medical Institute by Adrienne Mayers In the afternoon I met Dr Ian Williams who did a presentation on graphic medicine in the Healthy Inclusion Offices in Ellesmere Port.
Wednesday 2nd February	In the morning Keith Morgan ran a session on evolutionary psychology about domestic violence in the Liverpool University Guild of Students. I was given the morning off to work on my SSM
Thursday 3rd February	Visited the Toxteth Town Hall in the morning to find out about the gardening therapy session run from there. In the afternoon I went to the convenor review run by Dr Dillon and Dr O'Neil and gave them a presentation on my chosen SSM topic.
Friday 4th February	I found and read articles relevant to my choice of SSM.
Monday 7th February	I researched my topic using article found through my internet searches. I also found some more articles via internet searches.
Tuesday 8th February	I finished my notes on the articles I had been reading. I finished the plan for the whole essay and wrote my introduction,

	method, results and began my discussion.
Wednesday 9th February	I improved the work I had done so far and wrote my discussion.
Thursday 10th February	I wrote my conclusion, edited parts of my discussion, cut the work down to the word limit, structured it correctly and laid it out correctly.
Friday 11th February	Uploaded the completed SSM onto vital.

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