Mismatch or mass marketing? Stone Age diets, industrialisation and ultra-processed foods.

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Introduction

I write this just as the UK Government has announced its childhood obesity strategy[1]. Widely derided as "weak" and "underwhelming" (O'Dowd 2016: i4576), accusations are flying that food industry lobbyists worked successfully to get the Government to dilute its core messages. The British Medical Association (BMA) stated that the lack of plans for regulation of advertising and marketing in the food industry was "incredibly disappointing" (O'Dowd 2016: i4576). In its strategy, the UK Government is responding to the massive rise in obesity (seen globally), and which, at least in industrialised nations, begins prior to adulthood. These children live in obesogenic environments where calories are generally cheap and plentiful, and physical activity can be very low. Highly-processed sugary foods and particularly drinks are seen as a major contributor to childhood obesity, hence the UK Government's plan to introduce a 'soft drinks industry levy', aimed to reduce added sugar. The proceeds from this 'sugar tax' will be used to support measures to improve diets and increase physical activity, especially in schools. Sugars (including refined carbohydrates such as high-fructose corn syrup) are added to foods not only as flavour enhancers but also as preservatives, texture modifiers and bulking agents, and are an important component of many industrialised and highly-processed foods, even those not generally regarded as 'sweet' (Ulijaszek et al. 2012).

The situation seems slightly better – for the moment – in Turkey. Although there are high levels of overweight and obesity, which have risen for both adults and children over the past two decades (Erem 2015), market research by Euromonitor in 2015 (reported in Ferdman 2015) suggested that the Turkish population ate much less than half of the sugar consumed by UK inhabitants (35.4 g compared to 93.2 g). According to a United Nations Food and Agriculture Organisation briefing in 2012 (FAO 2012), bottled water dominated soft drinks sales. Nonetheless, increasing urbanisation has brought dietary change, and Turkey seems to fit within the model of transitional economies experiencing rapid shifts in eating behaviour, as traditional diets give way to those dominated increasingly by convenience and processed foods (USDA 2016). Less than a generation ago, small grocery shops and outdoor markets dominated the food retail sector in Turkey but the increase in the urban population, decline in household size (with people starting to live outside a traditional family structure), more women working outside the home, and international trade deals increasing the amounts of imported 'value-added' (i.e. industrialised processed) foods, have increased the proportion of supermarkets, reduced cooking in the home and increased demand for convenience

[1] available from https://www.gov.uk/government/publications/childhood-obesity-a-plan-for-action/childhood-obesity-a-plan-for-action

packaged foods (USDA 2016). Although this is seen as a largely positive trend by global food companies (e.g. Mikhail 2015), it is clear that if these patterns of consumption continue, Turkey is likely to experience the profound negative changes in diets and eating habits seen in many other industrialised and industrialising countries in the latter part of the 20th and beginning of the 21st Centuries.

The widespread industrialisation of food contributes significantly to obesity and chronic disease risk (Moodie et al. 2013). The area of industrialised food production that has captured most attention and created most criticism in the wake of the UK childhood obesity strategy is advertising and marketing. Industrialised food, which is developed, processed, packaged and distributed by large, often multi-national, companies depends on slick marketing and advertising to make us buy it. Many advertisements are specifically targeted at children, who are seen as lucrative players in the food market, through their 'pester' and independent spending power, as well as because building brand loyalty in children helps to set adult patterns of consumption (Story and French 2004). The majority of foods advertised to children are highly processed, including large amounts of fat and / or (especially) sugar (Story and French 2004). Highly- (or 'ultra-') processed foods promote obesity not only because they can contain large quantities of 'hidden' high-calorie ingredients such as sugars, but also because fibre and micronutrient contents also tend to be reduced, meaning that feelings of fullness and satiety may be reached only after considerable energy intake (Ulijaszek et al. 2012). Added to this is the de-coupling of food procurement and physical activity, which reinforces the sedentary behaviour that is a hallmark of modern industrialised life more generally.

But what does this have to do with Stone Age (otherwise known as Palaeolithic or Palaeo) diets? The Stone Age diet, a concept that first appeared in the literature in the 1950s (Mackarness 1959) but became prominent in the 1980s and 1990s with the work of Eaton, Cordain and colleagues (Eaton and Konner 1985; Eaton and Eaton 1999; Eaton et al. 1999; Cordain et al. 2000), seeks to replicate the pre-agricultural human diet as a way to arrest the modern epidemic of obesity and chronic disease. Many interpretations exclude common domesticated and processed foodstuffs from this diet because it is argued that humans are not adapted to eat them. The importance of foods readily available prior to agriculture is stressed, particularly wild meat or game, as well as unprocessed plant foods (including nuts, berries, seeds, fruits and tubers; Eaton and Konner 1985; Eaton and Eaton 1999; Eaton et al. 1999; Cordain et al. 2000). The Stone Age diet as conceptualised today is high in fibre, protein and essential nutrients, low in salt and sugar, and does not include domesticated grains, pulses (legumes) or milk (Eaton and Eaton 1999; Eaton et al. 1999). Some foods (including honey, fish, and shellfish) that would have been available throughout human evolutionary history (and exploited today not only by modern hunter-gatherers but also by a range of non-human primates and other mammals) are downplayed (Eaton and Eaton 1999; Eaton et al. 1999). The importance of physical activity is also included in the general concept of the Stone Age diet. Although most people in industrialised nations now use very little energy while foraging and cooking (going no further than pushing a trolley round a supermarket and opening a packet or jar), for many of our ancestors, even those living only two or three hundred years ago, procuring and preparing food went hand-in-hand with physical activity, whether it was labouring in the fields, preparing food manually, walking with animals, chopping wood, transporting grain, or pumping water.

Consistent with a prominent part of the 'Darwinian' or evolutionary medicine literature, the discordance between modern, industrialised life and the environments in which humans evolved is emphasised in the literature on Stone Age diets. Such 'mismatch' seems only too obvious when the products and marketing tactics of the modern food industry are scrutinised. In industrialised regions (North America, Europe, Australasia), diets increasingly depend on products such as burgers, frozen pizza and other 'convenience' foods, biscuits and sweets, sugary drinks, and crisps and other snack foods (Moodie et al. 2013). These are often attractive to consumers because they are highly palatable, require minimal knowledge to cook, and – important in our increasingly time-pressured lives – quick to prepare and have long shelf lives (Moodie et al. 2013). Coupled with aggressive marketing, it is not surprising that industrialised foods are becoming dominant in our diets and are an ever-more pressing public health issue (Monteiro 2009; Moodie et al. 2013).

One of the reasons that the Stone Age diet has captured the public imagination is because of the obvious obesity and chronic disease risks of modern life. These are evident, indeed prevalent, in transitional, industrialising economies as well as in those that have already industrialised. As occurs in a prominent part of the evolutionary medicine literature, it is tempting to blame 'mismatch' between modern environments and genes / biological traits that may have been neutral or even advantageous in the past for the rise in obesity and chronic disease. It is certainly true that for much of human history – indeed until well after the industrial revolution that occurred around 200 years ago – the types of highly processed foods that now make up the majority of the Western diet were completely unknown (Ulijaszek et al. 2012). Similarly, our ancestors would not have been exposed to sophisticated mass-marketing and behavioural manipulation to make them procure and eat certain foods. But is it accurate to talk about 'Stone Age' diets and stress their benefits? Would we really be healthier if we all ate a 'Palaeo' diet? And even if we would, is the concept useful in promoting public health messages to the majority of people living in industrialised or transitional economies? In this contribution, I address these issues and examine whether we are victims of 'mismatch' or 'mass-marketing', by exploring the Stone Age diet, extending my previous work (Elton 2008, Ulijaszek et al. 2012) and providing an updated review of perspectives on the topic.

The 'ancestral' human diet: processing and diversity

The types of foods eaten by our ancestors, and the ways in which they procured them, is the source of much research activity and debate in palaeoanthropology. However, much of the data used in the prominent literature on 'Stone Age' diets are based primarily on observations of modern hunter-gatherers, especially those living in open, arid tropical and subtropical environments (Elton, 2008). The uncritical use of modern, often marginalised, human populations, in such reconstructions has been discussed extensively elsewhere (e.g. Foley 1991), and this discussion is not repeated here, other than to stress that no modern human is a 'living fossil', and that palaeoanthropologists have many methods of reconstructing palaeodiets, of which analogy with living humans, primates and other mammals is only one. Similarly, hominin ecological diversity and implications for dietary flexibility and variability have been reviewed length elsewhere (e.g. Elton 2008; Ulijaszek et al. 2012; Turner and Thompson 2013, 2014), and will not be discussed further here, other than to note that the Stone Age diet was probably much less inflexible than that usually characterised by proponents of 'mismatch'. Nonetheless, humans undoubtedly have diets that are distinct from those of our closest living relatives, the African apes. This is reflected in dental adaptations as well as the human gut, which is shorter and simpler than the great ape gut. Most humans routinely feed from several trophic levels (eating animal-derived as well as plant-derived foods), and have diets that are much higher in quality than those of apes (Ulijaszek et al. 2012). Meat-eating is often seen as synonymous with such dietary quality, especially as its traces are identifiable in the archaeological record (via cut-marks on animal bone, for example), and meat is often a prestige and hence important food in modern human and chimpanzee societies (e.g. Fiddes 1994; Gomes and Boesch 2009). However, methodological advances in examining use-wear on tools, residue on other archaeological artefacts, and additional trace evidence (such as food particles trapped in dental calculus) have helped to change our perspectives on past diets, and in particular have drawn attention to the role that plant foods, including starches, have played in human dietary evolution (e.g. Revedin et al. 2010; Henry et al. 2011; Hardy et al. 2015). Although often nutrient-rich, plants tend to be harder to digest than animal products and thus can be seen as low quality foodstuffs (in that energy is less easy to liberate). However, when processed, the digestibility of plant foods increases considerably.

There are two main categories of food processing, mechanical and chemical. Somatically, mechanical processing occurs in the mouth, with teeth used to bite and grind food into smaller particles. Extra-somatically, mechanical processing can be as simple and straightforward as using the fingers to strip a seed of its outer layer prior to ingestion; this type of behaviour is very common in primates as well as other manually-foraging mammals, for example. Mechanical processing outside the body can also be more complex, requiring tools – for example, capuchin monkeys using hammerstones and anvils to break into very hard seeds or nuts, or birds cracking snails against hard surfaces in order to get the meat inside the shell. In humans, extra-somatic mechanical food processing has been taken to extremes, with such industrialised products as mechanically-recovered meat and highly refined flour, but tool-based food processing has a long evolutionary history (dating to over 3 million years ago [Ma]; McPherron et al. 2010; Harmand et al. 2015). Since then, and hence throughout much of the Stone Age, humans, our ancestors and close relatives (the hominins), have used mechanical processing to increase the digestibility of food prior to actually ingesting it. This would not only include smashing bones to get at the marrow inside but also cutting meat into strips to break down some of the muscle fibres and pounding underground storage organs into a paste to help break down cell walls (McGrew 1999; Milton 1999; Zink and Lieberman 2016). Indeed, it is possible that meat could only have been incorporated into the hominin diet in quantity if it was mechanically processed prior to eating (Zink and Lieberman 2016). Such food processing increases dietary quality and reduces the energy required to chew and further digest it, hence increasing the overall calorific value of food, which has been taken to extremes in modern industrialised food production. Mechanical processing can also extend the range of products included in the diet, because it can serve to remove or neutralise toxins, such as the phytochemicals produced as defence mechanisms.

Chemical processing forms the bulk of digestion, starting with the actions of salivary amylase in the mouth, and serves to break food down into its molecular constituents for absorption and use by the body. Although enzymes tend to be seen as the prime chemicals involved in digestion, guts also contain bacterial colonies that also serve to process foods. These are crucial for fermentation and hence effective digestion of plant matter in the primate gut (Lambert 1998). The vital role that gut microbes play in human digestion and health is also increasingly recognised, and bacterial flora can change rapidly in response to diet (Spector 2015). Changes in the fat and fibre content of the diet influence the structure of gut microbial colonies within days (David et al. 2014) and the type of bacteria present in the gut are associated with relative risk of colon cancer, with higher fibre, lower fat diets promoting better intestinal health than low fibre, high fat diets (O'Keefe et al. 2015). Microbial type and load is also implicated in obesity risk (Spector 2015), and there is concern that intestinal diversity – and hence the multiple benefits that it brings – is being irrevocably lost in the industrialised world (Segata 2015). In addition to somatic chemical processing, humans also depend heavily on extra-somatic chemical processing. The most obvious example of this is cooking with heat, which is used to alter the chemical properties of food, to break down bonds and increase digestibility and/or to transform and neutralise toxins, microbes or parasites and render foods safe to eat. In order to cook with heat, hominins needed to control fire, and the first clear evidence of this dates to around 790,000 years ago in Isreal (Goren-Inbar et al. 2004), although it is possible that controlled use of fire originated even earlier, around 1.4 Ma (Gowlett et al. 1981). Cooking probably revolutionised human diets (Wrangham et al. 1999), but hominins could also have employed numerous other chemical processing techniques, such as drying, soaking (as is important for consumption of manioc, for example, as it helps to remove toxins), smoking, burial and fermentation. Many of these leave few, if any, traces in the archaeological record but it is likely that they existed well before the origins of agriculture, and indeed recent work on meat processing in Late Glacial Maximum populations has provided compelling evidence that humans were fileting and smoking or drying meat (Soulier and Morin 2016).

Today, in industrialised nations, processing is quite understandably seen as causing a reduction in dietary diversity. This is not so much in the range of foods that we have access to – indeed, with globalisation the types of foods we can buy and eat from across the world has never been greater, and the creative power of the multinationals means that innovative products hit our shelves regularly – but because the foods that we typically choose to eat have been heavily processed, removing micronutrients and fibre. Most modern foods have been processed in some way and can be divided into three groups according to their level of processing: Group 1 is minimally processed, whereby whole foods have been subject to some form of limited treatment, such as washing, husking or pasteurisation; Group 2 incorporates products extracted from whole foods, such as sugars, oils or flours; Group 3 includes the ultra-processed foods made almost entirely from Group 3 products without (or with little) addition of Group 1 foods, such as many breakfast cereals, breads, pizzas, biscuits, confectionary and snack products, plus mechanically recovered meat products, and which bear little resemblance to whole foods (Monteiro 2009). Traditionally, Group 2 products would be used in the home as part of dishes mainly comprising Group 1 products (Monteiro 2009), although some Group 3 products, such as bread, have been staples for millennia, albeit made in the home or by local producers. Many Group 3 products are seriously devoid in micronutrients and are extremely energy-dense, often loaded with fat, sugar, or both, and with much of the dietary fibre (roughage) removed. It is the increasing dependence on Group 3 products, and the consequence loss of Group 1 products from the diets of many people in the industrialised and industrialising world, along with the dominance of a relatively small number of globalised, heavily industrialised food producers, that is cause for concern, and which the Stone Age diet concept fundamentally responds to.

Ironically, food processing by our ancestors would have increased dietary diversity, and enabled hominins to expand their ecological niche beyond the tropical environments and ripe-fruit diets of other apes (Ulijaszek et al. 2012). Stressing the need for a 'natural' unprocessed diet belies the fact that food processing has been integral to human diets for over 3 million years, and was certainly highly important to anatomically modern humans in the Pleistocene. For example, dental texture analysis points to the greater importance of food processing in Upper Palaeolithic modern humans compared to Neanderthals – whereas Neanderthal diets responded to shifts in climate and region, modern humans used technology much more effectively to extract resources from their environments, allowing better exploitation of foodstuffs and more flexibility in the way they responded to external environmental changes (El Zataari et al. 2016). Grains from grasses are among the foods that can be incorporated into the human diet much more readily by processing. The role of starchy foods – indeed carbohydrates as a whole – tends to be downplayed in the Stone Age diet, and grains are excluded altogether. Yet an increasing body of evidence points to the inclusion of such foods in the diet and active exploitation of grains well before the origins of agriculture. Starch grains from mid Upper Palaeolithic grinding tools have been recovered from regions as geographically dispersed as Italy, Russia and the Czech Republic, indicating that humans were producing flour in Europe from at least 30,000 years ago (Revedin et al. 2010). It is likely that starchy plant foods, i.e. carbohydrates, were fundamental to Pleistocene human evolution, helping to fuel brain growth, particularly when cooked (Hardy et al. 2015). Rather than avoiding carbohydrates, there is good evidence that our Stone Age ancestors developed technologies to extract and process them, innovations that were then extended with the emergence of agriculture. Other innovations of the early agriculturalists included the selective breeding of plants to make them more productive, fleshier, juicier, easier to harvest and process, and more pleasant to eat. The fruits and vegetables available to people following a modern 'Stone Age' diet are the products of agriculture, so it seems strange to encourage their consumption while at the same time discourage the eating of whole grains and pulses (both of which have proven nutritional value and even positive health benefits; see review in Ulijaszek et al. 2012), especially when grains, starches and pulses are an integral part of many traditional, healthy diets across the world (Turner and Thompson 2013, 2014).

Transitions and the evolving and innovating human

One common theme in the palaeoanthropological and human ecological literature, also echoed in formulations of the Stone Age diet concept, is that of 'transition'. The biological and behavioural differences between humans and our closest living relatives appear so extreme that identifying distinct transition times or events is viewed, either explicitly or implicitly, as being vital to understanding our evolutionary and ecological history, and even future. When thinking about transitions in human dietary evolution, researchers have drawn attention to nutritional transition caused by urbanisation and globalisation, the industrial revolution, 17th Century exploration and subsequent colonial globalisation, the agricultural revolution, the first controlled use of fire, the origin of *Homo*, and the first appearance of stone tools as crucial points of transition. However, as more is discovered about the past, our ancestors, relatives and their behaviour, at least some of these transitions start to seem less distinct, or are shifted in time. For example, many features (e.g. of the brain and hand), that have traditionally been used to demarcate *Homo* from australopiths, and hence underline the adaptive importance of the transition to our own genus, have been shown to be present in some australopiths, and the discovery of new species has shown that *Homo* itself is far more variable than previously supposed (Kimbel and Villmoare 2016). In addition, the first evidence of stone tools has been pushed back from ~2.6 Ma to ~3.3 Ma, prior to the emergence of *Homo*, and comparative study of other animals demonstrate that tool use, and hence some form of food processing, are not confined to hominins or even primates.

Particularly relevant to the Stone Age diet concept, the agricultural 'revolution' now appears to be less of a revolution than a set of cumulative innovations over a relatively long period of time, with Pleistocene innovations such as starch processing (Revedin et al. 2010) and ceramic storage pots (Boaretto et al. 2009) being followed in the early Holocene by sheep and pig domestication (~12,000 – 9,000 years ago; Dobney and Larson 2006) and, in the Fertile Crescent abutting modern-day Turkey, the domestication and cultivation of founder crops einkorn and emmer wheat, barley, lentils, peas, flax, bitter vetch, and chickpea ~ 10,000 years ago (Brown et al. 2009). Domestication and cultivation of food crops occurred elsewhere in the world slightly later and, far from being a revolution, the process of domestication and adoption of agricultural practices took many generations, with many populations probably using a flexible shifting system of foraging and cultivation / husbandry for considerable periods of time (reviewed in Ulijaszek et al. 2012). The flexibility and fluidity of this transition makes 'mismatch' much less likely (Elton 2008; Turner and Thompson 2013). Indeed, evidence from modern populations engaged in traditional horticulture, even if dependent on a monocultural staple, indicates that chronic disease prevalent in the industrialised world is not very common (Ulijaszek et al. 2012; Turner and Thompson 2013). Another key criticism of the Stone Age diet concept is that it neglects to consider properly the role of evolution and adaptation in humans after the development of agriculture, dismissing dietary adaptation in the past 10,000 years as less relevant than previous evolution (e.g. Elton 2008; Ulijaszek et al. 2012; Turner and Thompson 2013, 2014). In fact, there is compelling evidence for genetic adaptation to diets since the transition to agriculture, including lactase persistence in populations with a history of dairying (Tishkoff et al. 2007) and increased copy number variation of the salivary amylase gene *AMY1*, related to differential dietary starch consumption across populations (Perry et al. 2007). In addition, the greater attention being paid to the microbiome underlines the fact that dietary adaptation in humans does not have to be restricted to humans themselves: our bacterial commensals can also evolve in response to dietary change, and they do so very rapidly (Spector 2015).

The industrial revolution and subsequent industrialisation of food production, alongside shifts in subsistence patterns and eating behaviours because of urbanisation and regimented work schedules, have been argued to be a more crucial transition in human diets than the widespread adoption of agriculture (Strassman and Dunbar 1999; Ulijaszek et al. 2012). There is no doubt that industrialisation of food has happened at a much more rapid pace than the adoption of agriculture, and at a speed that would outpace any genetic adaptation in humans. The pace of change in the second half of the 20th Century and first decades of the 21st Century has been particularly fast, with consequent extreme changes to dietary norms and feeding behaviours. In the United States, a 'carbohydrate transition' (Ulijaszek et al. 2012) has occurred, whereby whole grain (Group 1) foods have declined, but the manufacture of Group 2 grain-derivatives, especially high fructose corn syrup (HFCS), and subsequent consumption of Group 3 foods into which it is incorporated have increased massively. The process of extracting HFCS from maize was developed in the 1920s and refined in the 1960s, and its production allowed maize farmers in the US to maintain a revenue stream after corn oil was supplanted by soy bean oil (Ulijaszek et al. 2012). What followed was a classic example of an industrial surplus driving massive transformation and innovation in food production, with consequent negative effects on health, as HFCS replaced many other sweeteners and found its way into an array of ultra-processed foods (Ulijaszek et al. 2012), including 'savoury' foods such as crackers and soup.

Other dietary commodities that are both big business and implicated in the rise of obesity are carbonated soft drinks and snack foods, exemplified in the UK Government's recent Childhood Obesity Strategy. However, the production and sale of these foods in the enormous quantities seen in the developed and developing economies of the 21st Century was not the product of the industrial revolution itself but of much more recent packaging innovation. For example, the two litre plastic bottles to hold carbonated soft drinks that are now ubiquitous on our supermarket shelves were not developed and patented until the 1970s, and the microwaveable cartons that enable rapid but crisp cooking of popcorn, pizza, and French fries were not brought to market until the mid 1980s (Risch 2009). The two-litre plastic carbonated drinks bottles allowed often sugared beverages to be sold in much larger unit sizes, in greater overall quantities and in a wider range of outlets. Interestingly, consumption of sugared drinks does not seem to induce feelings of satiety, despite their high calorific value (Mattes 2006), and hence they are consumed on top of 'standard' food; their ready availability thus contributes considerably to obesogenic environments. Snack foods also contribute to obesogenic environments, as they too tend to be consumed in addition to standard meals. Improvements in microwaveable cartons turned foods such as French fries and pizza from a meal that required some preparation (and consequent delayed gratification) to a snack that could be removed from the freezer and consumed within a matter of minutes, whether it was a formal mealtime or not. Thus, very recent innovation in packaging has been important in shaping eating behaviour and encouraging the consumption, as snacks and drinks as well as meals, of ultra-processed foods.

Consumption of high energy (high fat, high sugar, low fibre) ultra-processed foods is seen as being at odds with human dietary adaptation and evolution and thus at the heart of 'mismatch'. However, the consumption of sugars and fats, as well as the propensity to eat a set volume of food regardless of calorific value, is playing to human, and indeed mammalian, evolved food preferences (reviewed in Ulijaszek et al. 2012). What is 'mismatched' is the ready availability of energy-dense, low bulk foods high in fats and sugars, the product of industrial ultra-processing. These have replaced higher fibre, more nutrient rich foods such as pulses, and bulky foods such as starchy carbohydrates, products excluded in the Stone Age diet concept but which nonetheless induce feelings of satiety and hence limit caloric intake.

Stone age diets and individual and public health

The Stone Age or Palaeo diet concept has spawned hundreds, if not thousands, of diet books, websites, magazine articles, television programmes, and even a few restaurants. Yet, there have been surprisingly few controlled clinical studies on its efficacy (Tarantino et al. 2015), and those that have been undertaken have included relatively few participants. A recent systematic review of four randomised controlled trials investigating whether the Palaeo diet influenced metabolic syndrome, involving a total of 159 participants, concluded that there was moderate evidence that the diet could control symptoms (Manheimer et al. 2015). However, the same review noted that whereas several components of the Palaeo diet dovetailed with standard and well-researched nutritional advice, including modest reduction of carbohydrate consumption, avoidance of high glycaemic index (GI) foods, decreased dietary salt, and a higher proportion of omega 3 to omega 6 fatty acids, there was no clear scientific evidence for avoiding dairy foods and whole grains, which in fact are implicated in positive health outcomes in other studies (Manheimer et al. 2015). Similar notes of caution appear elsewhere and emphasise the need to have further and more extensive controlled trials (Tarantino et al. 2015).

Another area of 'mismatch' that has been noted in the evolutionary medicine literature relates to the 'hygiene hypothesis' and associated rise in autoimmune disorders, sometimes attributed to changes in the body's microbiota (reviewed in Okada et al. 2010). Dietary therapy is often used by patients with autoimmune inflammatory bowel disease (IBD; Crohn's disease and ulcerative colitis) to control their symptoms, even though few trials have been undertaken to ascertain robust dietary recommendations. As a prominent exclusion and 'natural' (i.e. non-industrialised) regimen, the Palaeo diet may be attractive to some IBD patients, not least because of the publicity surrounding gluten and lactose intolerance and their effects on the gut, often conflated with the quite separate aetiology of IBD. However, there is little evidence that a diet based on the Stone Age concept helps to control symptoms, and indeed, it is possible that fermentation of high-protein foods such as meat (a mainstay of the Palaeo diet) in the bowel may cause inflammation (reviewed in Hou et al. 2013). Further, exclusion diets, including the Palaeo diet, may exacerbate dietary deficiency in people already at risk of inadequate nutrition because of IBD symptoms such as diarrhoea and poor nutrient absorption (Hou et al. 2013). In the general population, vitamin D and calcium deficiency is a real possibility in people following a Stone Age diet (Metzgar et al. 2011; Tarantino et al. 2015). Thus, there is scant, if any evidence that the Palaeo diet may help control IBD, and along with the nutritional risks of exclusion diets, compliance with such a regimen may be limited in the longer term and also may be a considerable financial burden (Hou et al. 2013).

Compliance with, plus the financial implications and nutritional adequacy of, the Paleo diet have been subject to small studies of their own in healthy populations. In a study of 39 Australian women randomly assigned to either a Palaeo diet group or a group following the Australian Guide to Healthy Eating (AGHE), there was high compliance with both diets, although the Palaeo group reported a significantly higher financial cost to the diet (Genoni et al. 2016), a finding consistent with a US study that found a 9.3% increase in income would be needed in a low-income cohort to follow the Palaeo diet and achieve adequate micronutrition (other than calcium, which was difficult to compensate for; Metzgar et al. 2011), and qualitative Swedish research that indicated that the cost of the Palaeo diet was a barrier for some participants (Hammarström et al. 2014). The greater financial costs of a Stone Age diet are partly the emphasis on lean protein, such as game and grass-fed meat (both of which tend to command high market prices) but also the exclusion of whole grains, which are not only cheap and readily available in industrialised food systems but also filling (Elton, 2008; Metzgar et al. 2011; Hammarström et al. 2014; Genoni et al. 2016). Familiar food environments also have strong social meaning for people, who may find it difficult to depart from the normative diet. Grains and starches (in the form of bread, pasta, rice, maize meal [e.g. pap and polenta], porridges of manioc, barley or tapioca, and so on) are staple foods in all industrialised and industrialising economies, and indeed in most populations throughout the world, so excluding them not only requires considerable planning and individual control but can also be socially disruptive. It is for this reason that adhering to the Palaeo diet probably requires considerable social support (Metzgar et al. 2011; Hammarström et al. 2014). Given the equivocal nature of the evidence actively in favour of the Palaeo diet compared to standard healthy eating guidelines, plus the additional social, financial and micronutrient costs, the precise benefits of adopting such a rigid, exclusionary diet are unclear, and indeed it has been argued that the regimen may have limited effectiveness in clinical dietary intervention and public health (Genoni et al. 2016).

Conclusions

There is no doubt that the Stone Age diet concept contains some important messages, including the emphasis on physical activity and the encouragement to eat more fresh fruit and vegetables. However, the 'Palaeolithic dietary prescription' (sensu Turner and Thompson 2013), especially in its more extreme commercialised guises, can be enormously misleading. Aside from the various misunderstandings of evolutionary and ecological principles, and use of outdated or incomplete palaeoanthropological and palaeoecological evidence, exclusion diets are expensive and may deter people from seeking healthier alternatives to the ubiquitous ultra-processed foods that bombard us in day-to-day life and which are cleverly marketed to make us buy and eat them. 'Eating like a Stone Ager' should not be about excluding the accessible and affordable complex carbohydrates, pulses and (in some regions) dairy foods that have helped to shape rich, diverse and generally healthy food traditions across the world in the past 10,000 years. It should not be about increasing protein consumption via costly and hard-to-procure game animals. Instead, it should be about minimising consumption of sugar-filled, calorie-laden beverages, and eating a diverse diet that has balanced and adequate quantities of fibre, protein, 'good' fats, complex carbohydrates and micronutrients that fuel us but also keep our resident microbiota healthy. The advocates of the Stone Age diet concept are right to point out that the industrialised food environment is at odds with an adequate diet and good health. But this is not because humans have stopped evolving, and it is not even because modest processing is novel and inherently bad for us – after all, food processing of various types is standard in many traditional, non-industrialised and generally healthy diets, and processing has been employed by hominins for millions of years, allowing us to exploit diverse foodstuffs and a very broad ecological niche. It is ultra-processed food that is the problem, not minimally processed whole grains, pulses, or dairy. Stressing the importance of eating a Stone Age diet and excluding such nourishing and filling foods seems to be throwing the baby out with the bathwater.

Humans have few genetic and physiological adaptations to diet – and some of those we do have, such as genes for lactase persistence or starch digestion, have been under strong positive selection in the relatively recent evolutionary past to enable us to consume foods found and domesticated in our regional environments. We, like many other mammals, also have strong evolved preferences for fat and sugar, and eat when food is available and plentiful. It is for those evolved reasons that we need to be protected from exploitation by multinational food corporations that simultaneously strip food of nutrients, increase its energy density so that the calories we consume per unit mass soar, and employ powerful marketing tactics to persuade us to buy their products, radically altering traditional diets in the process. What our ancestors ate is largely irrelevant for the majority of people in modern life, who eat what is in their local food environments. For many people in industrialised economies, these local food environments are controlled more and more by multinational corporations that out-compete smaller independent retailers. As the shopping experience becomes more homogenised and beyond the control of most consumers, the massive range of industrialised processed food on sale and the time-efficiencies of shopping at a single superstore come at the cost of true food diversity, adequate nutrition and, ultimately, health. This is partly why the BMA and other bodies are so adamant that the UK Government needs to go beyond a 'sugar tax' and tackle big business and its tactics much more actively if it is to address childhood obesity and, more generally, poor nutrition.

And what about Turkey, which sits on the cusp of profound nutritional transition? To promote good nutrition, do doctors and public health experts need to encourage the population to resist current changes in subsistence practices by mimicking Stone Age diets? Not at all. The traditional Turkish diet, with roots in early agriculture, and including yoghurt, lamb, fish, bulgur wheat, breads, chick peas, beans and other pulses, as well as a whole array of fresh fruits and vegetables, is diverse, nourishing, and mainly sourced from Turkey itself. Enormous changes in day-to-day eating behaviour would be required for people to adopt a Stone Age diet. Rather than excluding food items, consumers and policy makers need to do everything they can to retain the traditional dietary diversity of Turkey and its rich cultural food heritage, including supporting small, independent retailers and markets, and resisting the homogenisation of the local food environment and dominance of ultra-processed foods that have occurred in many other industrialised and urbanised nations.

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