Could vaping be a new weapon in the battle of the bulge?

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Abstract

As the prevalence of tobacco smoking has been decreasing, obesity has increased. Obesity is set to overtake tobacco smoking in many developed countries as the primary preventable cause of conditions such as diabetes, cancer and heart disease. Obesity is a complex condition that is challenging public health prevention efforts. Tobacco smoking mitigates weight gain through nicotine's effect on the brain and metabolism.

The prospect of gaining weight upon stopping smoking acts as an inhibitor to quitting and weight gain post-cessation is a common cause of relapse. Vaping nicotine is a new and controversial phenomenon that is highly attractive to smokers, but raises fears for health among public health and tobacco control advocates. There have been some reports among vapers that vaping is helping to mitigate weight gain after stopping smoking and or vaping is helping them to control their weight. There are several potential mechanisms by which vaping, in addition to the direct effects of nicotine, could facilitate weight control, these include taste perception, physical mouth feel and sensation and behavioural replacement. Research on the potential for vaping to support weight control may be worth pursuing given the human and economic costs of the global obesity epidemic and the failure of current obesity prevention strategies.

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Introduction

The top three leading causes of morbidity and mortality in virtually every country in the world are smoking, high blood pressure and obesity (1). Smoking tobacco is still the largest preventable cause of death and disease. An estimated 400 million adults worldwide will be killed by smoking between 2010 and 2050 (2). The obesity epidemic, however, is fast becoming one of the world's largest health problems with prevalence rates continuing to rise in developed nations (1, 3) despite experimentation with a range of policies and interventions.

Obesity is a complex condition (4) that increases an individual's risk of developing a range of non-communicable diseases including type-2 diabetes (T2D), cardiovascular disease (CVD) and several forms of cancer (5, 6). Current public health strategies to curb obesity focus on food and nutrition policies (7, 8), availability of and access to healthier food (9, 10) and community-based interventions (11). However, the conventional wisdom that we get fat solely because we consume more energy than we expend does not explain the substantial world-wide increase in obesity (3, 12). Furthermore, efforts to cure obesity by inducing a negative energy balance, through counselling people either to eat less or exercise more, are often ineffective because of numerous interconnected physiological, psychological, social and environmental factors (13). Progress in obesity management will require greater understanding of the biological, behavioural, and environmental factors associated with lifestyle changes (14, 15).

The use of electronic cigarettes (e-cigs) has been suggested as a possible method to combat obesity. The first modern e-cigs were commercialised in 2003 with the sole purpose of aiding smoking cessation. However, there may be a side effect of weight control for users. E-cigs create a vapour by heating nicotine that is suspended in a liquid of propylene glycol and glycerine. When inhaled the vapour provides the user with a 'smoking' sensation in their mouth and a throat 'hit' familiar to smokers. In addition, the associated physical actions of vaping such as lifting the device to the mouth, inhaling and exhaling a visible 'cloud', mimic actions strongly conditioned with smoking (16). The e-liquids used in e-cigs can be bought readymade or as base liquids that can be mixed with flavours to suit individual preferences for taste, vapour density, visibility and

amount, sensation and nicotine concentration. There are literally thousands of e-liquid flavours on the global market. New vapers, who smoke or are switching from smoking tobacco, reportedly often start with tobacco flavours but later switch to fruit and other food-related flavours (17, 18).

In this article we ask two questions. First, could the use of e-cigs or nicotine vapourisers help appetite control, and second, could vaping assist with weight control. If vaping could influence either of these, it could play a supportive role in obesity prevention, particularly among smokers who stop using combustible tobacco and are at an increased risk of weight gain. In order to explore these two questions, however, it is first necessary to understand the links between: smoking, nicotine, appetite and weight regulation; and how taste, flavour and aroma perception may influence appetite and satiety or influence body weight. Understanding these mechanisms provides the background for future research that may address practical considerations about the potential role of vaping to achieve weight control, especially in smokers who are committed to cessation.

Nicotine's influence on appetite regulation

Smoking decreases appetite and smokers often report that they smoke to control their body weight (19). There is evidence that smoking is causally associated with lower body mass index (20) and cessation is frequently followed by rapid weight gain (21). Weight gain is a major deterrent to many smokers who want to quit (19, 22). Indeed, the significant increase in the prevalence of overweight and obesity in recent years has been attributed in part to decreases in smoking prevalence. One analysis suggests that up to 14% of the rise in obesity rates could be attributable to the concurrent drop in smoking, at least in the USA (23).

The effects of smoking on body weight are caused by the anorexic effect of nicotine in tobacco smoke, that is, nicotine decreases food intake (24). Recent studies on weight gain after cessation have identified two main pathways (24). The first involves central appetite regulatory mechanisms in the brain that are responsible for nicotine's appetite suppressing effect (21, 22). Nicotine activates nicotinic acetylcholine receptors located on pro-opiomelanocortin (POMC) neurons in the arcuate nucleus of the hypothalamus.

POMC neurons stimulate several agonist and antagonist molecules that activate the melanocortin (MC) system involved in regulating food intake, effectively suppressing appetite and weight gain. Nicotine exerts its potent action via the brain MC system, and the weight gain associated with smoking cessation is due to a reduced activity of MC4 receptors, thus taking the brake off appetite control. The MC system plays a key role in the regulation of appetite and food intake.

The second pathway involves nicotine's effects on increasing energy expenditure and resting metabolic rate (19). Nicotine administration leads to an increase in the metabolic rate within minutes of smoking a cigarette (25) and, importantly, energy expenditure is reduced with smoking cessation (19, 25). Some of these changes could be modified with continued use of nicotine separate from tobacco smoking - through longer term use of nicotine replacement therapy, for example, or nicotine-containing e-cigs.

Other mechanisms that may contribute to weight gain after smoking cessation include the effects of nicotine on taste and brain reward systems (26, 27). Nicotine modifies taste responses (28), and the bitter taste of nicotine may influence food intake through a direct action on taste receptors and taste pathways (24). Nicotine also acts on the brain reward systems (29, 30), it influences food reinforcement and hedonic preference as well as palatability of food (31). Unfortunately, current pharmacological cessation therapies, such as varenicline and bupropion, have not been effective in controlling body weight (32). In addition, the plant alkaloid cytisine, a nicotinic agonist that has been used as a smoking cessation aid in Eastern Europe, does not alleviate post-cessation weight gain (33).

Taste perception, food hedonics and obesity

High levels of dietary sugars and fats are a main cause of obesity (34). Given that both sweetness and fat have a powerful hedonic appeal, preferences for sweet and fatty foods are important contributors to increases in body weight and metabolic disease risk (35, 36). For example, Ettinger, et al. (37) reported that overweight women had a higher detection threshold and lower perception of sweetness than normal weight groups, suggesting that overweight women may require higher concentrations to detect sweetness and may consume more sugar (38). Similar observations have been reported

for fat taste perception, with low-sensitivity fat tasters, who have low oral-intensity perception of linoleic acid, inclined to consume more fat and having a higher body mass index than high-sensitivity fat tasters (36, 39).

The relationship between oral sensory hedonics and eating preference is well established and plays an important role in the design of foods with distinct consumer attributes (40). Recent studies suggest that an individual's sensitivity for a particular taste, flavour or aroma may be linked with specific food choices (41, 42) and may serve as a potential risk marker for metabolic disease (43-45).

Taste perception, flavour and aroma influence satiety

The role of sensory-specific satiety is attracting increasing attention in light of the continuing world-wide escalation of overweight and obesity (3). Sensitivity to sweet and fat taste varies considerably between individuals (46, 47). Preference for sweet and fat taste is acquired early in life as children learn to like flavours that are energy dense (48, 49). Several studies have reported positive associations between the preference for sweet and fat taste and the consumption of sugar- and fat-rich foods (43, 50-52), and there is increasing interest in delineating the relationships between taste, flavour, aroma and satiety. These taste preferences may be important for vaping, where users can choose different flavours that could potentially address food cravings, as we explore further below.

Research that interrogates how taste and aroma enhance satiation will support the development of products that induce or increase the feeling of satiation while reducing food intake (53). Such approaches may exploit knowledge about enhanced sensory attributes generated through the smell, taste, colour, temperature and mouthfeel of food (54). In this respect, the role of taste perception and aroma as sensory triggers of satiety mechanisms show considerable promise (55). The proof of principle has been reported in several recent human studies demonstrating that the addition of capsaicin to a diet enhances anorexigenic sensations, including satiety and fullness (56). Interestingly, capsaicin in vaporisers has been found to reduce cravings to smoke, reduce negative affect associated with withdrawals and provide satisfaction possibly due to replication of respiratory tract sensations associated with smoking tobacco (57). The inclusion of

capsaicin in vaping e-liquids could have a role in assisting weight control but well-designed randomised controlled trials would need to assess this, and efficacy and possible modes of actions and mechanism of the observed effect need to be determined.

Could vaping assist weight control?

Within vaper's forums, the notion of vaping with or without nicotine, for weight control has arisen. Petitioners against vaping restrictions have also cited weight control as a potential benefit of vaping (58). Participants in a recent trial of vaping for smoking cessation did not report significant weight gain in the longer term (at one year post quit date) when compared with continuing smokers and reducers (59). In addition, only two participants cited appetite control as a main reason for initiating vaping in a large international survey, but more importantly 28 said vaping helped them control their weight/appetite; 37 said it helps with controlling weight and sugar cravings; 27 claimed they had experienced weight loss as a result of starting to vape; eight had increased weight; five experienced a decrease in their blood sugar levels (T2D) and three had reduced cholesterol levels (60).

Could vaping assist appetite control?

It is already established that nicotine has appetite suppressant actions in the MC system and assists glucose metabolism, as outlined above. It is also well known that some people practising dietary restraint may use smoking to attenuate food cravings. If vapour delivers similar or as effective levels of nicotine, these actions could be expected to be retained. Animal studies comparing the effects on weight following exposure to tobacco smoke and e-cig vapour generated conflicting results. One study using neonatal mice found reduced weight for both tobacco smoke and e-cig vapour (61) and another study reported that effects on body weight occurred only in the group exposed to tobacco smoke (62). Ritualistic behaviours, for example, mixing one's own liquids, putting the parts of the e-cig together (reminiscent of cigarette rolling), filling the e-cig and the act of vaping may, like smoking, also be used as an alternative to the act of eating. However, vaping could have unique properties in that the smell, taste and mouth feel created by flavoured vapour could play a role in mitigating food cravings.

Vaping is not without risks, although evidence to date suggests that it is much safer than continued tobacco smoking (63, 64). Concerns have been expressed about the constituents of some flavourings although to date these have not been formally explored in trials with people. Trace or very low levels of toxic contaminants have been detected in some flavoured e-liquids with some studies suggesting that the level of diacetyl in particular e-liquids has potential to be harmful even when present at levels 100 times lower than in tobacco smoke (65). Questions also remain about long term use and potential health consequences, for example of the irritant effect of vapour on the respiratory system (66).

Conclusion

E-cigs may have promise for smoking cessation and could play a valuable role in reducing preventable deaths by contributing to reductions in smoking prevalence. Obesity is set to overtake tobacco smoking in many developed countries as the primary preventable cause of conditions such as diabetes, cancer and CVD. It is possible that e-cigs could contribute to reductions in overweight and obesity alongside reducing smoking. More research on the potential of e-cigs to reduce disease risks is needed, and investigation of any potential role they may play in mitigating weight gain is a viable topic for future study.

Several lines of investigation are worth pursuing. First, studies with vapers should explore the perceived benefits in terms of weight control and document vaping use for this perceived purpose. Observational follow-up studies could usefully track if vaping 'weight-controllers' are all ex-smokers and whether they are hoping to mitigate post-cessation weight gain, or whether there are any ex- or never smokers adopting vaping specifically for this purpose, and if so why? Further questions include whether nicotine is used in e-liquids and at what concentration and frequency? The existing known usefulness of nicotine for suppressing weight gain (67) plus vaper reports of e-cig use for weight control would suggest that the use of vaping with nicotine and without nicotine has to be formally tested in a randomised controlled trial. Trials of vaping for smoking cessation are presently occurring but there are no known registered trials of smoking cessation via vaping specifically for people who are overweight or obese and who are concerned about further weight gain. Further questions include: are particular flavours perceived to be more useful than others, and if so why? Furthermore, well-designed

studies using human volunteers could formally test the effect of vaping specific e-liquids on satiety and investigate the role of taste, smell, sensation of inhaling vapour as well as the volume of vapour and mouth feel. Interestingly, some vapers perceive vegetable glycerine to be sweet, thus there is a need to test if appetite or food cravings vary in accordance with different proportions of vegetable glycerine to propylene glycol. If there is an effect of vaping on weight, is this effect only present in those quitting smoking or can it also be seen in those who are naïve to nicotine? Such questions could be explored in human laboratory experiments involving both smokers about to quit and never smokers.

Clearly, such research would not be without controversy. It could be considered unethical to introduce naive users to nicotine, a potentially dependency forming substance. Short-term nicotine vaping is unlikely to lead to nicotine dependency or tobacco smoking and should be sufficient to determine at what level an effect on appetite may be detected if at all. Vaping is not considered harmless even without nicotine (68), thus introducing current non-smokers to vaping even without nicotine could also be considered unethical. In addition, there is opposition to vaping among some public health researchers. Their alarm that smokers are switching to vaping, despite the estimated 95% lowered health risk (64) could increase at the thought of non-smokers being attracted to vaping for weight control if this concept begins to be discussed in the scientific or public realm. In the immediate term, therefore, the potential of vaping for weight control should be carefully explored in studies where e-cigs are used for smoking cessation. The research community, policy makers and the public need to be aware of the emerging perception that vaping may have potential benefit for appetite and weight control.

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Conflicts of Interest

The authors have no competing financial interests in relation to the work.

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