

LOWER WEIGHT GAIN AFTER VAPING CESSATION THAN AFTER SMOKING QUITTING*

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ABSTRACT

Background. Smoking is frequently a way to control appetite and weight. The data concerning the body mass gain after quitting among the users of electronic cigarettes who have no prior history of smoking traditional cigarettes is inconsistent.

Objective. In our study we have compared smoking and vaping impact on weight gain and glycaemia.

Material and methods. 3 groups of rats were used. The group A was exposed to vapour and group B were exposed to smoke. Rats in the group C constituted the control group without nicotine exposition.

Results. During 6 weeks of experiment weight gain of rats in the A and B groups was comparable, while animals from group C had gained significantly more. During 2 weeks after cessation of exposition to nicotine animals from group B gained more weight than rats of A and C group. Blood glucose was higher in group B than in groups A and C 24 h after last exposure to nicotine and 2 weeks after nicotine exposure cessation.

Conclusion. Effects of vaping on weight increase is similar to smoking, but after vaping cessation weight gain is lower and comparable with nicotine nonusers.

Key words: nicotine, cigarettes, weight, smoking, vaping, electronic cigarettes

STRESZCZENIE

Wprowadzenie. Palenie papierosów jest często stosowaną metodą utrzymywania niskiej masy ciała i kontroli apetytu. Badania dotyczące przyrostu masy ciała wśród osób, które nigdy nie paliły tradycyjnych papierosów i zaprzestały stosowania papierosów elektronicznych są niejednoznaczne.

Cel badań. W naszym badaniu porównaliśmy wpływ papierosów tradycyjnych i elektronicznych na przyrost masy ciała i poziom cukru we krwi.

Material i metody. Do badania użyto 3 grupy szczurów. Grupa A była eksponowana na parę z podgrzania płynu papierosa elektronicznego, grupa B została poddana działaniu dymu tytoniowego. Zwierzęta grupy C stanowiły grupę kontrolną bez narażenia na nikotynę.

Wyniki. W trakcie 6 tygodni trwania eksperymentu przyrost masy ciała szczurów z grupy A i B był porównywalny, natomiast zwierzęta z grupy C przybrały istotnie więcej. Podczas 2 tygodni następujących po zaprzestaniu ekspozycji zwierzęta z grupy B przybrały więcej niż szczury z grupy A i C. Glikemia była najwyższa w grupie B zarówno bezpośrednio po zakończeniu ekspozycji, jak i po 2 tygodniowej przerwie w narażeniu na nikotynę.

Wnioski. Wpływ stosowania papierosów elektronicznych na przyrost masy ciała jest porównywalny do palenia papierosów tradycyjnych w trakcie ekspozycji. Natomiast po zakończeniu narażenia na pary liquidu przyrost masy ciała jest mniejszy, podobnie jak w grupie kontrolnej.

Słowa kluczowe: nikotyna, papierosy, masa ciała, palenie, papierosy elektroniczne.

INTRODUCTION

The maintenance of the correct body mass is one of the most important factors determining the

health and well-being of people. Currently, obesity constitutes a major civilization problem and leads to the development of numerous diseases [16]. The studies conducted among smokers, and female

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*The study is the part of grant of Minister of Science and Higher Education No MNmb 246.

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smokers in particular, indicate that one of the main factors deciding whether to start and continue smoking is the decrease in body weight caused by smoking [3, 7, 19, 23]. Smoking is frequently a way to control appetite and weight [7]. The results of many studies confirm that smokers weigh on average 4-5 kg less than non-smokers and quitting smoking leads to evening of these discrepancies [3, 6, 28]. The increase in body weight after smoking cessation is connected mainly with the increased food intake, metabolic changes including energy expenditure as well as eating sweets to minimize the symptoms of nicotine withdrawal [26, 28]. Supplements containing nicotine belong to the products easing the quitting of smoking. Nevertheless, their effectiveness in reduction of weight gain after smoking cessation is not clear [1, 23]. One of the methods enhancing smoking cessation is the use of electronic cigarettes [14, 23, 26]. Inhalation of aerosol from vaporized liquid (vaping) containing nicotine is used as treatment of smoking dependence and they may be useful to those smokers who also suffer from the obstructive pulmonary diseases or cancers [8, 11, 18, 19, 20, 23].

The gain of body weight after quitting the traditional cigarettes (t-cig) smoking in electronic cigarettes users (e-cig) is smaller than in non-users [23]. What is more, the data concerning the body mass gain after quitting among the smokers of electronic cigarettes who have no prior history of smoking traditional cigarettes is inconsistent. Currently, the usage of e-cigarettes does not concern only those in the in the quitting process. E-cigarettes are becoming a substance popular among adults and youth who have no prior history of any kind of nicotine intake [7, 13, 22]. Many young people from different social backgrounds use e-cigarettes in particular in the situation when they have perceived themselves as overweight [7, 29]. Exclusive vaping without smoking is still a short term phenomenon and that is why no consistent conclusions can be drawn concerning the impact of e-cigarette usage over the period of many years upon living organisms [10].

In our study, we have compared smoking and vaping impact on weight gain and glycaemia. Additionally, we have studied if the cessation of smoking or vaping can lead to the increase of weight and decrease of glycaemia.

MATERIALS AND METHODS

Our experiment was conducted on 30 male *Wistar* rats. The animals were divided into three groups: A, B, C. The animals in the group A have been exposed to vapour of scent free liquid with total nicotine dose of 7 mg per 24 hours. During the 10 minute

exposition the rats were placed in a PCV cage of the 0.1m³ volume and they were given the inhalation of 0.6ml liquid (propylene glycol, water, nicotine) by using suction and pressure device. The rats in the group B were exposed to smoke from 10 traditional cigarettes total nicotine dose of 7 mg per 24 hours. The exposition was conducted 5 days a week over the period of 6 weeks. In total, each experimental group was given 210 mg of nicotine. The rats in the group C constituted the control group and they were exposed to the same inhalation-related stress that other rats but without the nicotine element. The animals were weighed twice every 2 weeks. Each rat was placed in the metabolic cage over the period of 24 hours 6 weeks and 8 weeks after the experiment has begun. The water intake and urine excretion as well as the weight of the food consumed and faecal matter excreted and the number of debris were measured. Measurements of blood glucose in rats were done with glucometer 6 weeks and 8 weeks after the beginning of the experiment. Normal glycaemia have been previously established at 117.06±1.96 mg/d [5]. All work was conducted with the formal approval of the local animal care committees (30/2015).

RESULTS

Body weight gain during experiment.

Mean weight of rats at the beginning of experiment starts was 187.82±12.56g. During first 6 weeks of experiment animals of the group A (e-cig) gained 55.93%, group B (t-cig): 57.54 and group C: 66.86% (Figure 1 and 2). 2 weeks after cessation of exposition to smoke and vapour the animals of group A gained 9.73%, group B: 13.20%, group C: 7.20% (Figure 3).

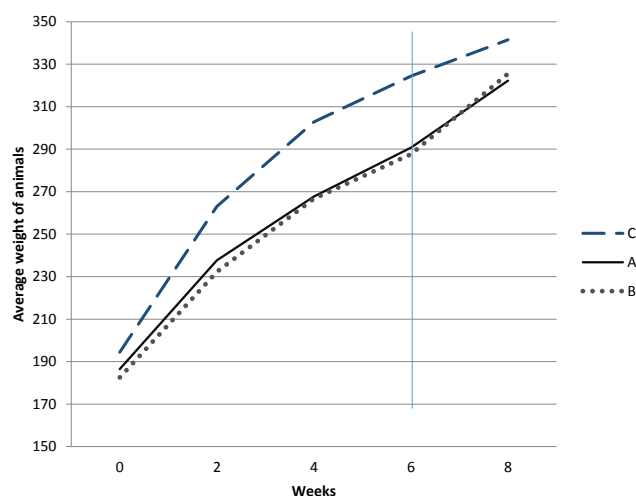


Figure 1. Changes of weight during experiment in each group (C: control, A: e-cig, B: t-cig).

C- control group, A: e-cigarettes group, B: traditional cigarettes group

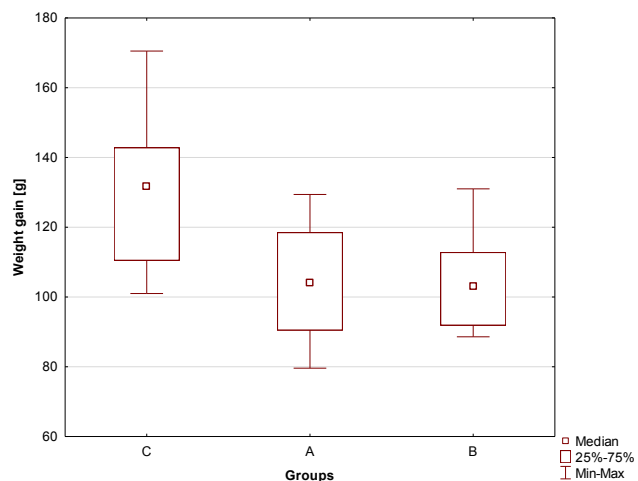


Figure 2. Weight gain after 6 weeks of electronic cigarettes (A) and traditional cigarettes (B) exposition. The *U Mann Whithney's* Test A:C p=0.01, B:C p=0.01, A:B p=0.96.

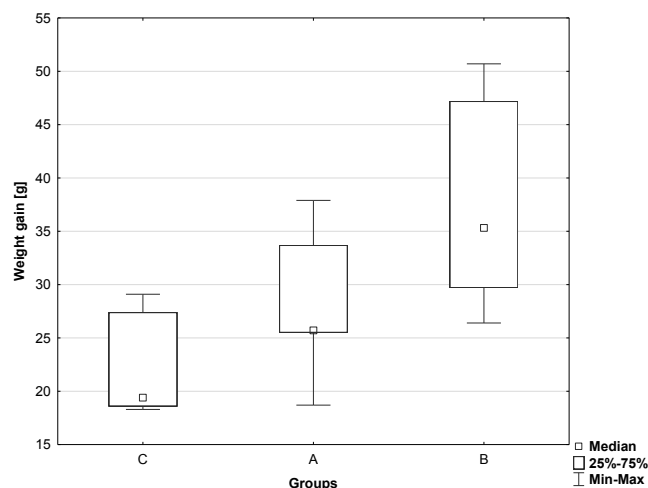


Figure 3. Weight gain after 2 weeks post nicotine exposure cessation. The *U Mann Whithney's* Test P value A:C p=0.29, B:C p=0.04, A:B p=0.14.

Metabolic parameters of rats

The amount of the consumed food and water intake and the volume of urine and faeces excreted

insignificantly varied during groups both while nicotine exposition (Table 1) and after the nicotine exposure cessation (data not included).

Table 1. Metabolic parameters measured in the metabolic cages. The difference in the water and food intake and the volume of excreted urine and faeces were not statistically relevant

Measured parameter \ Group	A	B	C	p value in the U test
water [ml] ±SD	24.00 ± 1.41	30.00 ± 5.00	27.50 ± 3.54	A:C p=0.44 B:C p=0.77 A:B p=0.25
urine [ml] ±SD	10.50 ± 0.71	11.00 ± 1.00	10.75 ± 1.06	A:C p=0.67 B:C p=0.80 A:B p=0.77
food [g] ±SD	19.05 ± 0.49	21.63 ± 2.01	21.5 ± 0.99	A:C p=0.25 B:C p=0.77 A:B p=0.56
faeces [g] ±SD	6.65 ± 0.35	6.40 ± 1.42	9.65 ± 0.78	A:C p=0.25 B:C p=0.15 A:B p=0.80

Blood glucose was higher in group B than in groups A and C 24 h after last exposure to nicotine and after 2 weeks after the nicotine exposure cessation. In group A glycaemia was insignificantly higher than

in group C, but after 2 weeks without e-cig exposure blood glucose was at the same level that in the control group (Table 2).

Table 2. Glycaemia after exposition for electronic (A) and traditional (B) cigarettes

Glycaemia \ Group	A	B	C	p value in the U test
after 6 weeks of nicotine exposure ±SD	139.40 ± 5.74 mg/dl	160.00 ± 9.22 mg/dl	123.40 ± 4.56 mg/dl	A:C p=0.14 B:C p=0.01 A:B p=0.04
after 2 weeks of exposure cessation ±SD	129.40 ± 4.39 mg/dl	152.00 ± 8.89 mg/dl	121.8 ± 18.32 mg/dl	A:C p=0.35 B:C p=0.03 A:B p=0.01

DISCUSSION

The mechanism through which smoking decreases body weight gain is complex [3]. Nicotine as a sympathomimetic agent, is responsible for the decrease of appetite, raising the resting metabolic rate and lipolysis. Catecholamine production, increased by nicotine, may limit the body weight gain even without the decrease in food intake [3, 15, 25]. Sympathomimetic drugs increase the energy expenditure by effecting the peripheral tissue and through regulation of metabolism in the brain. Nicotine promotes the local release of norepinephrine within body tissues and systemic release of epinephrine from the adrenal glands [3, 24].

In our study we have observed similar body weight gain in the group exposed to traditional and electronic cigarettes and higher in the control group, although the intake of water and food was similar. The decrease in the body weight without decreased appetite has been observed before by *Schechter et al.* in rats that received nicotine intraperitoneally [25]. On the other hand, *El Gholli et al.* [9] have shown a significant decrease in food and energy intake after nicotine or e-liquid were given intraperitoneally. In that study, rats treated with nicotine and e-cigarette have had lower body weight gain (41.9 ± 4.6 g and 45.7 ± 2.1 g, respectively) than rats from the control group (53.6 ± 4.6 g). On the contrary, *Ponzoni et al.* have observed similar weight in mice exposed to e-cig vapour and the mice from the control group, but mice exposed to conventional cigarettes had lower weight [21]. Studies conducted among young people have indicated that higher weight is associated with higher frequency of e-cigarette using, but probably they were more motivated to decrease their weight by vaping than slim people [4].

Smoking causes likewise hyperglycemia by activation of glycogenolysis and gluconeogenesis in hepatocytes [24]. These processes leading to release of free glucose into bloodstream, may be activated by high concentration of circulating epinephrine and norepinephrine due to smoking even without hypoglycemia [24]. Insulin resistance and increased percentage of visceral fat that enhances the risk of diabetes mellitus and atherosclerotic cardiovascular disease have also been described as the effect of nicotine administration [3, 28]. Moreover, it has been observed that smoking increases blood glucose level and can subsequently cause diabetes. The increased glucose level makes it more difficult to quit smoking and increases the pathological metabolic changes. Thus, high level of blood glucose not only constricts smoking or vaping quitting but also enhances the rewarding effects of nicotine that have been observed in diabetic rats [12].

In our study we observed the highest level of glycaemia in the group exposed to traditional cigarettes and just slight increase in the group exposed to electronic cigarettes. After cessation of the exposure to traditional cigarettes, rapid increase in body weight was observed, while in the groups exposed to e-cig weight gain was lower, comparable to the control group. Similarly, blood glucose was similarly higher both before and after quitting smoking in rats from group B when compared to the group A before or after vaping ceased.

Lower cytotoxicity of vapour exposition to vapour have been observed in certain studies. Smoking traditional cigarettes induces oxidative stress and increases reactive oxygen species (ROS) and pro-inflammatory cytokines production [17, 28]. ROS damage organs and induce apoptosis of cells of pancreatic islets which lead to the decrease of insulin production and diabetes mellitus development [24]. However, only high dose of vapour seem capable of inducing reactive oxygen species, causing DNA damage, and reducing cell viability [2]. In the study of *Mathew et al.*, aerosol of e-cig liquid have induced production of pro-inflammatory cytokines in the airway epithelium [17]. In contrary, electronic cigarette aerosol have neither activated the oxidant-stress sensing transcription factor NFR2 (nuclear factor, erythroid 2-like 2, NFE2L2,) nor up-regulated cytochrome p450 or cellular biomarkers of biologically relevant levels of free radicals in human coronary artery endothelial cells [27].

Conventional cigarettes seem more harmful than electronic cigarettes due to the tar substances present in the smoke [2, 6, 17]. More studies are needed to explain the differences observed in the effects of conventional and electronic cigarettes.

CONCLUSIONS

Electronic cigarettes may be a healthier alternative to traditional cigarettes for people addicted to nicotine at least in terms of weight gain. Effects of vaping on weight increase is similar to smoking, but after vaping cessation weight gain is lower and comparable with nicotine nonusers. Therefore, it may be useful to switch to e-cigarettes prior to complete quitting at least for individuals afraid of weight gain.

Acknowledgments

The study was funded by the grant of the Polish Minister of Science and Higher Education No MNmb 246.

Conflicts of interest

The authors declare no conflict of interest.

Ethical approval

All work was conducted with the formal approval of the local animal care committees (30/2015).

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Received: 15.04.2019

Accepted: 27.06.2019