CHANGES IN PUFFING TOPOGRAPHY AND SUBJECTIVE EFFECTS OVER A 2-WEEK PERIOD IN E-CIGARETTE NAÏVE SMOKERS: EFFECTS OF DEVICE TYPE AND NICOTINE CONCENTRATIONS

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Abstract

Introduction: This study aimed to document changes in puffing topography and, the effects of device type and nicotine concentration on puffing topography, subjective effects and smoking behaviour over two weeks of e-cigarette (EC) use.

Methods:EC naïve smokers (N = 50; 64% female) were randomly allocated to a cigalike (18 mg/mL) or tank containing either 18 (Tank18) or 6 mg/mL nicotine concentrations (Tank6). In 3 separate sessions (Baseline, 1 and 2 weeks post-baseline), participants vaped 20 mins ad-libitum. Puff duration, puff number, inter-puff intervals (IPI), exhaled carbon monoxide (CO), cigarettes per day (CPD), cigarette dependence, craving, withdrawal, and subjective effects were recorded.

Results: Two weeks post-baseline, puff duration and IPI significantly increased whilst puff number decreased. Cigalikes were associated with greater puff number and shorter IPI compared to Tanks; there was no difference between Tank18 and Tank6. CPD, CO and cigarette dependence reduced significantly from baseline to week1 but did not differ between conditions. During each session, there was a significant reduction in craving, whilst withdrawal symptoms were only alleviated in week1 and 2; there was no difference between conditions. Tank18 consistently rated highest on positive effects including satisfaction; satisfaction scores for Cigalikes and Tank6 declined overtime.

Conclusions: Cigalikes and tanks were both effective for reducing craving, withdrawal symptoms and CPD although for the former, this may only be achieved through more frequent puffing. That the Tank18 yielded greater satisfaction suggests tank devices and higher nicotine concentrations may be more suitable in the early stage of a smoking cessation attempt.

**Keywords**: E-cigarettes, Puffing topography, Cigalikes, Tanks, Device Type, Nicotine concentrations, Compensatory puffing, Satisfaction, Craving, Withdrawal symptoms

# Introduction

E-cigarettes (EC) are now the most popular method for smoking cessation in England1 with increasing evidence for their efficacy2,3. In Europe, current and former smokers have the highest prevalence of use 4, whilst in the US between 2017 and 2018, the increases in EC use were observed in never and former smokers5. The steady increase in the proportion of former smokers who currently use EC6 suggests an increase in the proportion who successfully switch from smoking to exclusive EC use. Yet since 2016, EC prevalence has plateaued. Whilst many smokers report having tried EC, most fail to maintain use and continue to smoke7 with lack of satisfaction appearing to be the chief reason8.

Although the categorisation and appellation of EC has evolved, there still remains three distinct categories: i) first on the market, cigalikes (or closed systems) are similar in size and shape to conventional cigarettes, consist of pre-filled cartridges and use fixed power; ii) tanks (or open systems) are characterised by a refillable reservoir and are equipped with a combination of functions that allow greater power (watts) to emit larger volume of aerosol (e.g. through lower resistance coil ohms, higher voltage) compared to cigalikes; iii) pod-based systems are small and like the cigalikes use fixed power but differ from the free-base nicotine found in the cigalikes and tanks, rather their nicotine solution is in a protonated form (salt-based). Although tank models continue to be the most popular type of EC and the newer pod-based systems are increasing in popularity8, cigalikes still hold a sizeable market share and are an attractive entry product for many8,9. Thus, exploring the relative subjective effects and puffing patterns associated with the use of cigalikes versus tanks contributes relevant information that can be used by those supporting smokers using EC in a quit attempt.

EC nicotine concentration is an important factor influencing their potential to displace smoking. High nicotine concentrations are associated with more effective nicotine delivery10–12, greater satisfaction and, withdrawal and craving reduction13. That former smokers who completely switched to EC are more likely to use higher nicotine concentrations compared to dual users (i.e. those who concurrently smoke and use EC)14, further adds to the proposition that higher nicotine concentrations are better suited to support successful cessation. Nevertheless, how the user puffs on the device (puffing topography) is also an important determinant of nicotine delivery. Indeed, despite reducing the nicotine concentration in e-liquids over time, nicotine intake remains constant15,16, this supports the notion that EC users alter their puffing in order to maintain constant blood nicotine levels.

Experienced EC users typically achieve higher nicotine blood levels thereby higher craving reduction and satisfaction compared to EC-naïve smokers17,18. This is achieved by exerting a more efficient puffing topography (measurable characteristics of puffing such as puff number, duration and inter-puff interval [IPI]) via longer puff duration19,20. The changes in puffing topography is also evidenced in longitudinal studies in experienced users21 22. Thus, transitioning to EC may necessitate a readjustment of puffing topography to optimise nicotine absorption and compete with satisfaction levels associated with smoking.

Type of e-cigarette device is another factor likely to influence puffing topography and determine nicotine delivery. Although many smokers initiate use with smaller starter kits, most successfully reduce their smoking to eventually quit, only after transitioning to more advanced tank style models23. This may be due to the marked differences in efficacy and ability of different EC types to provide satisfaction24 and alleviate craving and withdrawal symptoms11,23,25. For instance, tank system ECs have been reported to deliver nicotine more efficiently11,25 and are more likely to promote cessation compared to cigalikes26. However, the complexity and technicalities associated with these advanced tank devices have been reported to be a barrier to many smokers7,27,28. Moreover, for some smokers it is important that the device ‘*looks and feels* *like smoking*’29. Thus, although the evidence suggests that cigalikes may not be as effective in promoting cessation, for some, cigalikes may serve as an introductory product facilitating the transition to more advanced devices23.

Users’ puffing topography, device types and nicotine concentrations are likely factors influencing nicotine delivery and in turn likely to influence satisfaction. These factors are important as they may further the understanding of EC product discontinuation and/or the need to transition to more advanced models23; this can be informative to smokers who are yet to transition away from smoking. This study will explore how puffing behaviours and nicotine delivery in smokers unfamiliar with ECs, change over time and vary according to device type and nicotine concentration. It aims to explore how EC-naïve smokers’ puffing topography a) change over time, b) differ according to device types (cigalike vs. tank) and c) nicotine concentrations (18 vs. 6 mg/mL); and secondly to explore the effects of the device type and nicotine concentrations on craving and withdrawal symptom, satisfaction and other subjective effects over a two-week period.

1. Materials and Methods

2.1 Participants

Seventy (63% female) EC-naïve smokers were recruited between December 2015 to December 2016 in the East London area, UK. Inclusion criteria were: must smoke daily ≥5 cigarettes, have been a smoker for ≥1 year, not currently using an EC, willing to abstain 1 hr before the start of the session and willing to make a quit attempt (not expressly seeking treatment). Exclusion criteria included being under 18 years, not fluent in English, pregnancy or lactating, or a known neurobiological or heart condition.

## 2.2 Study Design

A 3X3 mixed-participants design with the between-subject factor Device type (Cigalike, Tank18 and Tank6) and the within-subject factor Time (Baseline, Week1 and Week2) was used. Participants were randomly allocated (using SPSS) to either a) a cigalike containing 18 mg/mL, b) a tank model containing 18 mg/mL (Tank18); or c) a tank model containing 6 mg/ml (Tank6).

## 2.3 Measures

Key outcome measures: Number of puffs, puff duration and IPI (Inter-puff intervals; in seconds) were captured via video-recording at each session (Baseline, Week1 and 2) and analysed in line with previous protocols19 by 2 investigators using a video-processing software ‘Adobe Premiere Pro CS5’ consisting of a frame-by-frame analysis at 29.97 fps (frame per second). Puff duration was demarcated as the time at which the e-cigarette was clearly placed in the mouth with both lips closed until the first frame capturing when the e-cigarette was removed from the mouth. IPI was demarcated as the time frame when the e-cigarette was removed from the mouth until a subsequent puff, the time at which the e-cigarette was repositioned in the mouth with both lips closed. Video-recordings has been previously used18,30,31 and pilot-tested using an inter-rater reliability and an e-cigarette equipped with a built-in puff counter10.

Socio-demographic data, smoking status and history, motivation to stop smoking (assessed with the Motivation to Stop Scale [MTSS])32 were collected at baseline. Cigarette dependence was recorded at baseline, week1 and 2 (using the Fagerström Test for Cigarette Dependence33 [FTCD]). Number of cigarettes per day (CPD) was recorded at baseline, thereafter daily in a weekly diary; and, average CPD was calculated for each participant at week1 and 2. Craving and withdrawal symptoms were measured before and after EC use at baseline, week1 and 2 using the Mood and Physical Symptoms Scale (MPSS)34. Subjective effects related to EC use were assessed at the end of each lab session using a two-part visual analogue scale (VAS) measuring positive and adverse effects35,36. Positive effects included 11 items (e.g. ‘satisfaction’, ‘hit’), adverse effects included 21 items (e.g. ‘dizziness’, ‘throat irritation’). Consistent with previous work10,29,37, means for each individual construct were combined, with the exception of satisfaction which is presented separately.

## 2.4 Equipment

E-cigarette products were purchased online between July 2015 and October 2016. For both conditions Tank18 and Tank6 the ‘*Totally Wicked* *mini curve’* was mounted with a 2 mL capacity tank which housed a standard atomiser of 1.5ohm resistance (see Figure S1 in supplementary materials for further details). For the Cigalike condition, initially, the ‘TECC Go e-cigarette’ was used (N = 11), however due to issues of leakages, this model was discontinued and replaced by the ‘BLU’ cigalike model (N = 13). Both kits had similar functions and operated in the same manner (see Figure S2 in supplementary materials for further details). E-liquid ingredients composition and flavours were kept consistent across all conditions using the same ratio of propylene glycol and vegetable glycerin (PG/VG: 50/50) and tobacco flavour. For the Cigalike condition, data were collapsed for both models as no statistical differences were found in puffing topography between models.

## 2.5 Procedure

The study received ethical approval by the University of East London ethics committee (UREC 1516-04\_5th October 2015). Participants were screened via phone interviews. Ahead of their baseline session, participants were instructed to abstain from smoking for an hour. Following informed consent, participants were randomly allocated to one of the three conditions, then CO, socio-demographic and smoking-related data were collected. They were then instructed to rate their craving and withdrawal symptoms (at the beginning and end of the session), before receiving instructions on how to use their EC and to vape ad libitum for 20 mins that is ‘to take as many or as few puffs as they wish in the next 20 mins’. Positive and adverse effects were measured at the end of the last puff. All vaping sessions were video-recorded. At the end of each session, participants were given the EC and were instructed to keep a record of the number of cigarettes smoked at the end of each day until their next and subsequent sessions i.e. between the second (at week1) and third session (at week2). Each participant was provided with a weekly supply of either, 60-80 mL of e-liquid in refill bottles for those in the tank conditions, or 15 cartridges for those in the cigalike condition at the end of each testing session, and asked to return all used and unused refill containers/cartridges. There were no reports of supply exhaustion. The session was repeated the following week, then one week later. Finally, participants were asked to keep the device and encouraged to try and replace as many tobacco cigarettes as they can with the use of their EC.

## 2.6 Data analyses

Changes in craving and withdrawal symptoms were computed by subtracting values at baseline from the endpoint, so, positive scores are indicative of a reduction with higher scores representing greater reduction. Negative scores are indicative of an increase from baseline scores to post EC use (i.e. a worsening of symptoms).

A series of mixed ANOVA was used. In cases where Mauchley’s test of sphericity was violated Greenhouse-Geisser corrected values are reported. Bonferroni Post Hoc t-tests are reported for any significant main effect of Time and Dunnett’s T3 for conditions due to unequal groups size. Simple effects analyses were used to explore significant time X condition interactions.

From the initial sample (N = 70) who attended their first session, all analyses were conducted on the N = 50 who returned for their 2nd and 3rd session (Cigalike, n = 11; Tank18, n = 20; Tank6, n = 19; see Figure S3 for the study participation flowchart).

1. RESULTS

## 3.1 Participants Characteristics

Table 1 displays the baseline characteristics for the final sample (N = 50).

## 3.2 Puffing topography

Puffing topography data by condition and session are depicted in Table 2. With all conditions collapsed, there was a main effect of time for puff duration [*F*(2, 94) = 5.91, *p* = .004, *ƞ2p* = .112], puff number *F*(1.89, 94) = 6.88, *p* = .002, *ƞ2p* = .128 and IPI [*F*(1.48, 94) = 6.53, *p* = .006, *ƞ2p* = .122]. Puff duration increased from baseline to week2 (*p* = .013), but not from baseline to week1 (*p* = .077) and week1 to 2 (*p* = .927). Puff number decreased from baseline to week1 (*p* = .008) and week2 (*p* = .009) but did not differ between week1 and 2 (*p* > .05). IPI increased from baseline to week1 (*p* = .011), there was no further changes at week2 (*p* = .082), and no differences between baseline and week2 (*p* = .498).

There was a significant main effect of condition for puff number [*F*(2,47) = 9.25, *p* < .001, *ƞ2p* = .282] and IPI [ *F*(2,47) = 6.58, *p* = .003, *ƞ2p* = .22] but not for puff duration [*F*(2, 47) = 2.14, *p* = .129, *ƞ2p* = .083]. Participants took a greater number of puffs in the Cigalike compared to those in the Tank18 (*p* = .019) and those in the Tank6 (*p* = .048), but this did not differ between the Tank18 and Tank6 (*p* = .72). IPI was shorter in the Cigalike compared to the Tank18 (*p* = .001), and Tank6 (*p* = .007); those in the Tank6 did not differ from those in the Tank18 (*p* = .428). There was no significant time X condition interaction for puff duration [*F*(4,92) = 1.82, *p* = .133, *ƞ2p* = .073], puff number [*F*(4,92) = 0.69, *p* = .59, *ƞ2p* = .03] or IPI [*F*(4,92) = 0.66, *p* = .67, *ƞ2p*= .025].

## 3.3 Effects on Smoking related behaviours

Table 3 show mean [95% CI] scores in CPD, CO and cigarette dependence across conditions and time.

### 3.3.1 Cigarettes per day (CPD)

There was a main effect of time, *F*(1.29, 48.05) = 63.52, *p* < .0001, *ƞ2p* = .63. CPD significantly reduced from baseline to week1 (*p* < .0001) and from baseline to week2 (*p* < .0001), but not from week1 to week2 (*p* = .084). There was no main effect of condition *F*(2,37) = 0.705, *p* = .501, *ƞ2p* = .037, and no significant time X condition interaction, *F*(2.60, 48.05) = 2.20, *p* = .109, *ƞ2p* = .106.

### 3.3.2 Carbon monoxide levels (CO)

There was a main effect of time *F*(2, 94) = 12.88, *p* < .0001, *ƞ2p* = .215. CO reduced significantly from baselineto week1(*p* = .003) and baseline to week2 (*p* < .0001) but not from week1 to week2 (*p* = .771). There was no main effect of condition *F*(2, 47) = 0.204, *p* = .817, *ƞ2p* = .009 and no time X condition interaction *F*(4, 94) = 0.568, *p* = .687, *ƞ2p* = .024). At week1, there were two self-reports of complete cessation in the Tank18, one in the Tank6 (with CO readings of 3, 4 and 5 ppm respectively) and none in the Cigalike condition, these numbers remained consistent at week2.

### 3.3.3 Cigarette dependence

There was a main effect of time, *F*(1.75, 82.05) = 12.05, *p* = .0001, *ƞ2p* = .204. Cigarette dependence decreased from baseline to week1 (*p* < .0001), and week2 (*p* < .0001), but not from week1 to week2 (*p* = .274). There was no main effect of condition *F*(2, 48) = 0.50, *p* = .612, *ƞ2p* = .020 or interaction between time and condition *F*(3.49, 82.05) = 2.46, *p* = .06, *ƞ2p* = .095.

## 3.4 In-lab sessions ‘Changes in Craving’ (pre vs. post EC use)

In each of the sessions, use of the EC was associated with a significant reduction in craving (all ps < .0001) but there was no main effect of condition and no time X condition interaction (all ps > .05) (see Table S1 for means [95%CI], p and F values).

Across all 3 sessions, the ability of EC to reduce craving did not differ between devices [*F*(2, 47) = 2.193, *p* = .123, *ƞ2p* = .085] or change from baseline to week1 or week2 [main effect: *F*(1.78, 83.58) = 0.350, *p* = .681, *ƞ2p* = .007)] nor interact significantly with device type [*F*(3.56, 83.58) = .283, *p* = .869, *ƞ2p* = .012].

## 3.5 In-lab sessions ‘Changes in Withdrawal symptoms’ (pre vs. post EC use)

In each of the sessions, EC use was associated with a significant decrease in withdrawal symptoms at weeks 1 and 2 (all ps < .005), but not at baseline (p > .05). There were no significant effects of condition or significant Time X Condition interactions at any time point (p > .05) (See Table S2 for details).

Across all 3 sessions, the ability of EC to alleviate withdrawal symptoms did not differ between devices [*F*(2, 47) = 1.073, *p* = .350, *ƞ2p* = .044], but significantly increased from baseline to week1 (*p* = .003) and week2 (*p* = .004), but not from week1 to week2 (*p* >.05) [main effect of time, *F*(2, 94) = 8.99, *p* < .0001, *ƞ2p* = .161]. There was no significant time X condition interaction, *F*(4, 94) = 2.37, *p* = .058, *ƞ2p* = .092.

## 3.6 In-lab sessions Positive and Adverse effects (post EC use)

### 3.6.1 Positive effects following EC use

For overall positive effects, there was a main effect of time *F*(2, 94) = 10.159, *p* < .0001, *ƞ2p* = .178. Overall positive effects decreased from baseline to week1 (*p* = .044) and baseline to week2 (*p* < .0001), but not from week1 to week2 (*p* = .128). There was no main effect of condition *F*(2, 47) = .981, *p* = .383, *ƞ2p* = .040, but a significant time X condition interaction *F*(4, 94) = 2.623, *p* = .040, *ƞ2p* = .100. Overall positive effects significantly reduced from baseline to week2 (*p* < .0001) for those in the Cigalikes and those in the Tank6 (*p* = .036) whilst remaining stable for those in the Tank 18 (*p* = .589) (see Figure 1).

For satisfaction, there was a main effect of time *F*(1.64, 77.25) = 6.24, *p* = .005, *ƞ2p* = .117. From baseline to week2 (*p* = .013), satisfaction decreased; this did not differ at any other time-points (baseline to week1 *p* = .221 and week1 to week2 p = .099). There was a main effect of condition *F*(2,47) = 7.42, *p* = .002, *ƞ2p* = .240, with higher satisfaction scores for Tank18 (*p* = .002) and Tank6 (*p* = .008) compared to the Cigalike. Tank 18 and Tank6 did not differ (p > .05). There was no significant time X condition interaction *F*(3.287, 77.248) = 1.60, *p* = .193, *ƞ2p* = .064.

3.6.2 Overall adverse effects following EC use

There was no main effect of time on the overall adverse effects reported following EC use in the lab sessions, *F*(1.51, 70.92) = .875, *p* = .394, *ƞ2p* = .018, no main effect of condition *F*(2, 47) = .864, *p* = .428, *ƞ2p* = .035, no significant time X condition interaction *F*(3.02, 70.92) = .636, *p* = .595, *ƞ2p* = .026.

# DISCUSSION

The current study aimed to explore how EC-naïve smokers’ puffing patterns change over time and differ according to device type (cigalikes vs. tanks), and nicotine concentrations (18 vs. 6 mg/mL). Secondary aims were to explore the effects of the device type and nicotine concentrations on craving and withdrawal symptoms, satisfaction, and other subjective effects over a two-week period. Regardless of the device used, EC-naïve smokers learnt to adjust their puffing rapidly by taking fewer and longer puffs with longer inter-puff intervals. Participants using the cigalikes exerted more intensive puffing patterns with more frequent puffs and shorter intervals between puffs compared to those using the tank device. Smoking and cigarette dependence reduced regardless of the device used as did in-lab craving from pre to post EC use. In contrast, withdrawal symptoms alleviation occurred one and two weeks after first use, but not in the initial baseline session. Participants using the cigalikes and the Tank6 reported a decrease in overall positive effects unlike those using the Tank18. Those using tank devices also reported greater satisfaction levels. Finally, three reported a complete switch away from smoking (CO < 10 ppm verified).

Puffing topography measures found here are in line with earlier studies38–40, with one report of similar changes in puffing patterns (i.e. longer puffs) one week after initial use21 and another reporting significant increase in blood nicotine levels after a period of 4 weeks22. This adjustment in puffing is likely to be a result of smokers’ need to regulate their nicotine intake to habituated and satisfactory levels in a way that is consistent with more effective nicotine delivery, as documented by others22.

Those using the cigalike took more puffs and shorter IPI than those using the tank device. Although puff duration did not differ significantly between devices, using cigalikes led to more frequent puffs compared to tanks. These findings are consistent with previous reports of similar puff duration but different puff volume and IPI between cigalikes versus pen-like devices41. The continued discrepancy in puff numbers between the cigalike and the tank is indicative of the need to compensate for the poorer nicotine and/or aerosol delivery. These alone have also been found to affect sensory smoking cues adversely42, thus likely to affect craving, withdrawal symptoms and satisfaction.

Along with cigarette dependence, there was a reduction in CPD and CO suggesting that regardless of the device type or nicotine concentration, EC can help promote smoking reduction, at least in the short term; although, it is worth mentioning, of the three self-reports of complete cessation, all used the tank device. That the cigalike was associated with a comparable reduction in CPD compared with the tank devices is surprising and in contrast with previous studies which report more effective nicotine delivery in tanks25. This suggests that changes in puffing topography can partly compensate for poor nicotine delivery, at least in the short term. Alternatively, non-nicotine aspects of dependence, for example, visual appearance29,43 or other psycho-motor cues are important and may have contributed to the effects seen in smoking reduction and other related behaviours such as craving.

Whilst there was no change over the two-weeks or difference between conditions in craving, participants were unable to achieve withdrawal symptoms alleviation in the baseline session. Withdrawal symptom scores reduced only after one and two weeks of EC use. This steady increase in alleviation mirrors the changes in puffing topography which is akin of the ‘*learning curve’*44 when trying to transition away from smoking to exclusive EC use. As the puffing increased in duration whilst decreasing in frequency, use of the EC allowed to effectively relieve withdrawal symptoms. The inability of EC to deal with craving and provide satisfaction are often cited as chief reasons for discontinued use8, therefore greater emphasis must be put on educating smokers on how to use their devices for craving relief.

Overall positive effects declined over time for those allocated to the cigalike or Tank6 whilst remaining stable for participants using Tank18. Both, Tank6 and Tank18 yielded greater level of satisfaction compared to the cigalike,suggesting that tank systems are preferred for satisfaction; this is consistent with previous work29. For the overall adverse effects, there were no changes over time or differences between conditions.

The current study is not without its limitations. Whilst the study was conducted in a controlled laboratory environment, this may not be a true reflection of real puffing behaviour38,45. Secondly, we did not measure puff volume and velocity; whilst, puff duration is the most commonly reported measure46, the changes in puffing topography could have occurred through deeper inhalation. That said, studies have identified puff duration as the primary determinant of nicotine exposure delivered via EC47,48 and, the apparatus used to measure this can affect the user’s experience hindering the capture of naturalistic behaviours49. Thirdly, we did not verify accuracy of nicotine concentrations as labelled on packs, and do not report volume consumed. An attempt was made to quantify the volume of e-liquid used; however, this was undermined by a series of factors. Budget restraints did not allow to source the required apparatus to enable the extraction of the nicotine liquid from the used and disused cartridges, which would have been necessary for an accurate comparison with the liquid contained in refill bottles. Moreover, some participants admitted discarding some used refill bottles. Finally, given the wide variations in device models and brands’ ability to deliver nicotine, and in e-liquid formulation, the current findings cannot be generalised to other EC device types and e-liquids.

The current study adds to the body of knowledge of how EC-naïve smokers adjust their puffing topographies in the early phase of use. These changes are characterised by a shift to longer and less frequent puffs. The cigalike was associated with more erratic puffing with higher puffs frequency which persisted after 2 weeks of initial use, yet with concurrent reduction in satisfaction levels. That the Tank18 consistently performed the best at maintaining satisfaction levels lends support to the proposition that higher nicotine concentrations and tank style EC should be recommended over cigalikes to smokers considering using EC in a quit attempt.

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| --- | --- | --- | --- | --- | --- |
| **Table 1** Participants characteristics for the overall sample and per conditions | | | | | |
|  | **Overall sample N = 50** | **Cigalikes N = 11** | **Tank18 N = 20** | **Tank6 N = 19** | **Tests for differences1** |
|  | **n = Frequency** | **n = Frequency** | **n = Frequency** | **n = Frequency** | **p value** |
| **Gender** |  |  |  |  | *p* = .60 |
| Male | 18 | 3 | 9 | 6 |  |
| Female | 32 | 8 | 11 | 13 |  |
| **Ethnicity** |  |  |  |  | *p* = .17 |
| White/Caucasian | 30 | 6 | 12 | 12 |  |
| Black Afro-Caribbean | 5 | 0 | 2 | 3 |  |
| Mixed Race | 3 | 0 | 3 | 0 |  |
| Asian | 2 | 2 | 0 | 0 |  |
| Other | 10 | 3 | 1 | 1 |  |
| **Occupation** |  |  |  |  | *p* = .21 |
| Employed | 17 | 6 | 4 | 7 |  |
| Non-employed | 1 | 0 | 1 | 0 |  |
| Studying | 32 | 5 | 15 | 12 |  |
| **Qualification** |  |  |  |  | *p* = .28 |
| Postgraduate study | 9 | 3 | 5 | 1 |  |
| Undergraduate study | 11 | 2 | 6 | 3 |  |
| A- and O-levels or equivalent | 21 | 5 | 8 | 8 |  |
| Vocational | 4 | 1 | 1 | 2 |  |
| GCSEs or equivalent | 4 | 0 | 0 | 4 |  |
| No qualification | 1 | 0 | 0 | 1 |  |
|  | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** |  |
| **Age (years)** | 29.52 (9.31) | 28.55 (10.62) | 31 (10.05) | 28.53 (7.89) | *p* = .87 |
| **Years smoking** | 11.84 (8.64) | 10.64 (9.77) | 12.60 (9.26) | 11.74 (7.62) | *p* = .81 |
| **Baseline CPD**2 | 13.09 (6.66) | 10.27 (4.88) | 13.63 (5.71) | 14.16 (8.16) | *p* = .16 |
| **Baseline CO3** | 15.66 (9.59) | 13.36 (10.57) | 16.60 (9.27) | 16 (9.67) | *p* = .55 |
| **Baseline FTCD**4 | 4.16 (2.45) | 2.82 (1.47) | 4.4 (2.62) | 4.68 (2.54) | *p* = .06 |
| **Baseline MTSS**5 | 4.88 (1.55) | 5.18 (1.08) | 4.50 (1.57) | 5.11 (1.73) | *p* = .91 |
| **Self-confidence**6 | 2.16 (.84) | 2.27 (.65) | 2.05 (.83) | 2.21 (.98) | *p* = .95 |
| *Note. p values based on Fisher’s exact tests are reported for all categorical variables due to small sample size and expected count cells of < 5 and One Way ANOVA for discrete variables; 2CPD signifies Cigarettes smoked Per Day; 3CO signifies exhaled carbon monoxide; 4FTCD represents Fagerström test for Cigarette Dependence questionnaire; 5MTSS represents Motivation to Stop Smoking scale questionnaire; Self-confidence represents Self-confidence to quit* | | | | | |

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| --- | --- | --- | --- | --- | --- |
| **Table 2**. Mean [95%CI] for Puff Number, Puff Duration and IPI per condition at Baseline, Week1 and 2 | | | | | |
| **Sessions** | **Condition** | **Puff Number** | **Puff Duration** | **IPI1** | **N** |
| **Baseline** | **Cigalike** | 46.09 [35.39-56.79] | 2.77 [2.09-3.44] | 31.19 [4.56-57.82] | 11 |
|  | **Tank18** | 23.80 [15.86-31.74] | 2.40 [1.90-2.90] | 79.53 [59.78-99.28] | 20 |
|  | **Tank6** | 24.26 [16.12-32.41] | 2.49 [1.98-3.00] | 61.91 [41.65-82.16] | 19 |
|  | **Total** | 31.39 [26.18-36.59] | 2.55 [2.23-2.88] | 57.54 [44.59-.70.49] | 50 |
| **Week1** | **Cigalike** | 39.09 [30.49-47.70] | 3.46 [2.58-4.33] | 40.35 [-.15-.95.72] | 11 |
|  | **Tank18** | 17.65 [11.27-24.03] | 2.57 [1.92-3.22] | 137.97 [96.91-179.05] | 20 |
|  | **Tank6** | 21.47 [14.93-28.02] | 2.71 [2.04-3.38] | 103.69 [61.59-145.82] | 19 |
|  | **Total** | 26.07 [21.89-30.26] | 2.91 [2.48-3.34] | 94.00 [67.07-120.94] | 50 |
| **Week2** | **Cigalike** | 33.36 [26.62-40.07] | 3.86 [3.07-4.65] | 36.34 [8.13-64.55] | 11 |
|  | **Tank18** | 18.15 [13.18-23.12] | 2.45 [1.86-3.04] | 92.22 [71.30-113.14] | 20 |
|  | **Tank6** | 23.16 [18.06-28.26] | 2.77 [2.17-3.37] | 72.28 [50.81-93.74] | 19 |
|  | **Total** | 24.89 [21.63-28.15] | 3.03 [2.64-3.41] | 66.95 [53.23-80.66] | 50 |
| *Note. 1 IPI signifies Inter-puff intervals; Puff duration and IPI are expressed in seconds* | | | | | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 3**. Mean [95%CI] in CPD (cigarette per day), CO (Carbon Monoxide) and Cigarette dependence at Baseline, Week1 and 2 | | | | | | | | |
|  |  | **CPD1** |  | **CO2** |  | | **Cig dependence3** |  |
| **Session** | **Condition** | **M [95%CI]** | **N** | **M [95%CI]** | **N** | | **M [95%CI]** | **N** |
| **Baseline** | **Cigalike** | 9.63 [4.88-14.37] | 8 | 13.36 [7.47-19.25] | | 11 | 2.82 [1.37-4.27] | 11 |
|  | **Tank18** | 13.41 [10.05-16.76] | 16 | 16.60 [12.23-20.97] | | 20 | 4.4 [3.33-5.48] | 20 |
|  | **Tank6** | 14.50 [11.15-17.85] | 16 | 16 [11.52-20.48] | | 19 | 4.68 [3.58-5.79] | 19 |
|  | **Total** | 12.51 [10.28-14.75] | 40 | 15.32 [12.46-18.19] | | 51 | 3.97 [3.26-4.67] | 51 |
| **Week1** | **Cigalike** | 6.02 [2.03-10.00] | 8 | 11.27 [5.57-16.97] | | 12 | 3.00 [1.49-4.51] | 11 |
|  | **Tank18** | 6.02 [3.20-8.84] | 16 | 12.1 [7.87-16.33] | | 20 | 3 [1.88-4.12] | 20 |
|  | **Tank6** | 7.30 [4.49-10.12] | 16 | 12.32 [7.98-16.65] | | 19 | 3.63 [2.48-4.78] | 19 |
|  | **Total** | 6.45 [4.57-8.33] | 40 | 11.90 [9.12-14.67] | | 51 | 3.21 [2.48-3.94] | 51 |
| **Week2** | **Cigalike** | 5.41 [1.74-9.08] | 8 | 9.91 [4.88-14.94] | | 12 | 2.55 [1.13-3.96] | 11 |
|  | **Tank18** | 4.59 [2.00-7.18] | 16 | 10.55 [6.82-14.28] | | 20 | 2.95 [1.90-4.00] | 20 |
|  | **Tank6** | 6.93 [4.34-9.53] | 16 | 12.21 [8.39-16.04] | | 19 | 2.84 [1.77-3.92] | 19 |
|  | **Total** | 5.64 [3.92-7.37] | 40 | 10.89 [8.45-13.34] | | 51 | 2.78 [2.09-3.47] | 51 |
| *Note. 1CPD signifies Cigarettes smoked per day; 2Co signifies exhaled Carbon Monoxide (in ppm); 3Cig Dependence signifies Cigarette Dependence* | | | | | | | | |

***Figure 1.*** *Mean (SE) ratings on overall positive effects following EC use per condition at baseline, week1 and 2.*