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Olfactory training using nasal inserts is more effective due to increased adherence

Anja L. Winter[1], Sofie Henecke[1,4], Evelina Thunell[1], Mattias Swartz[1], Joakim Martinsen[1], Pernilla Sahlstrand Johnson[2,3*], Johan N. Lundström[1,4,5*]

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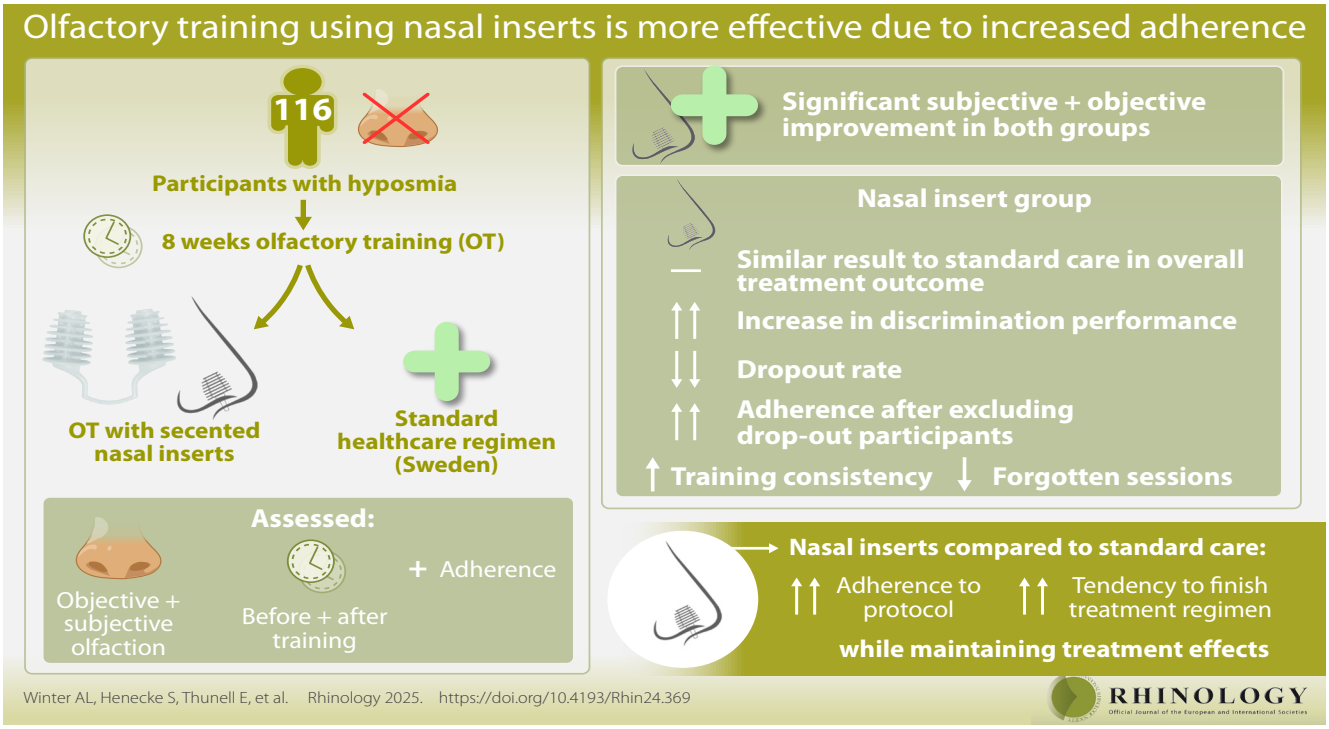

Abstract

Background: The recommended treatment for hyposmia (a clinically reduced sense of smell) is olfactory training using odor containers that the patients smell twice a day for several weeks. Adherence to the olfactory training regimen is, however, generally low. We aimed to investigate if a new form of odor delivery, using scented nasal inserts, could enhance adherence to olfactory training by allowing participants to be mobile during the training and thereby lower the perceived intrusion on everyday life.

Methods: Using a randomized controlled parallel-group design, individuals (N = 116) with hyposmia underwent 8 weeks of olfactory training. One group was assigned olfactory training using scented nasal inserts (nasal devices that retain nasal patency) while the other group was assigned the standard care regimen currently recommended by the Swedish healthcare system. We assessed objective and subjective olfactory ability before and after olfactory training as well as adherence to training.

Results: Both groups significantly improved both their objective and subjective olfactory abilities, and training with nasal inserts produced similar improvement as standard care in overall treatment outcome. However, there was a significantly greater increase in discrimination performance and lower dropout rate (6.7%) in the nasal insert compared to the standard care group (23.2%). Critically, after exclusion of the drop-out participants, the nasal insert group still showed significantly higher adherence to the training regimen.

Conclusions: Olfactory training with nasal inserts could serve as a more effective form of treatment for hyposmia due to patients' improved adherence to protocol and increased tendency to finish their treatment regimen.

Key words: hyposmia, olfactory disorder, olfactory training, smell, treatment adherence

Introduction

Olfactory training, sometimes also referred to as smell training, involves repetitive, regular, and purposeful exposure to odors and is currently the most common treatment for patients with olfactory dysfunction [1]. Patients are typically instructed to smell a number of either provided odors or common household odors, two to four times per day, for several weeks to months [2–4]. This cost-effective treatment has been considered fairly efficient, with a majority of patients who complete their treatment experiencing improved olfactory function [5–8]. However, as with many forms of extended at-home treatment regimens, adherence to olfactory training is low, with study dropout rates as high as 45% [9,10] and potentially even lower compliance outside experimental studies in everyday clinical practice.

Non-adherence to at-home treatment is a pervasive problem observed across various healthcare disciplines. The exact extent of non-adherence to olfactory training in clinical non-experimental populations is poorly explored, but with chronic medication non-adherence has been estimated to 50% [11] and for physiotherapy, of which olfactory training could be considered one form, the number can be as high as 70% [12]. Given that treatment adherence is a key factor to treatment success, increasing the low adherence numbers reported for olfactory training is vital.

One reason for the high number of patients not being persistent with their treatment regimen is that olfactory training, although promising in its potential to aid in the recovery of olfactory function, is often experienced as tedious and time-consuming. It restricts the individual by forcing them to remain within one location for a substantial length of time and to focus only on the training [13]. Engaging in repetitive exercises while confined to one place for an extended period demands both dedication and patience, and the necessity for consistent and long-term commitment could be challenging. An easier and more manageable method of training could increase adherence and thereby also enhance treatment effects on the group level. A potential remedy to some often-mentioned compliance problems with olfactory training is to enable participants to perform the training in a less intrusive manner. Modified versions of olfactory training have previously been studied [14,15] and the use of nasal clips filled with peppermint and eucalyptus for olfactory training have shown a significant effect on odor discrimination amongst idiopathic patients when worn during a 3-hour exposure period every day for one month [16]. Yet, this type of device was not designed to maintain nasal patency and deviated largely from standard olfactory training in odor variation and training protocol. A recent product innovation currently used to mask negative external odors, a scented silicon nasal insert that sits birhinally within the nostrils (while maintaining near normal nasal patency), could potentially serve as a mobile olfactory training system if modified to contain a range of odors representing distinct odor objects.

Here, we aimed to investigate how a modified version of olfactory training using scented nasal inserts compares to standard olfactory training as currently prescribed within the Swedish healthcare system. The scented nasal inserts provide continuous olfactory training and liberate participants from the constraint of remaining stationary during their training sessions. This provides the freedom to engage in other everyday activities while completing olfactory training. We hypothesized that the enhanced mobility would lead to an increased compliance to the olfactory training regimen, and as a result better treatment outcome as compared to standard olfactory training.

Materials and methods

Participants

Participants (n = 173) were recruited from two outpatient clinics and via social media advertisement. Inclusion criteria were post-viral or idiopathic functional hyposmia at baseline, defined as a TDI score (described below) between 15.25 and 31.25, and age between 18 and 65 years old. Exclusion criteria were any psychiatric diagnoses, non-viral or non-idiopathic causes of olfactory dysfunction (such as head trauma, sinonasal disease, surgery, etc.), and current enrollment in other olfactory training studies. After initial screening and excluding those with a TDI score outside our preregistered inclusion criteria (n = 50), a total of 123 participants were enrolled in the study. Seven of these were excluded before analyses; four due to problems with testing conditions, two due to nasal congestion, and one due to not being able to attend the second visit. The final sample consisted of 116 individuals (Table 1) who at their first testing session (baseline visit) were randomized into training either with nasal inserts (n=60) or standard care (n=56) for eight weeks. At the baseline visit, participants reported experiencing olfactory dysfunction for an average of three and a half years (41 months). At the baseline visit and after the 8-week long training period, olfactory functions were assessed (see below) and participants answered questionnaires on demographic information and quality of life (reported elsewhere following a future one-year follow-up). The second testing visit was seemingly identical to the first with the exception that questions about demographics were replaced with questions regarding adherence to the training protocol. Participants who did not attend the second testing visit were counted as dropouts. The mean duration between the first and second visit was 68 days. There were no statistical differences between groups (all $p > .05$) in age, sex, duration of olfactory dysfunction, baseline olfactory measurements scores, and time elapsed between the two visits (Table 1). All procedures were in accordance with the Helsinki declaration, approved by the Swedish Ethical Review Authority (Dnr: 2023-03779-01), and all participants provided written informed consent prior to participation.

Table 1. Descriptive statistics of research participants with statistical tests of difference between olfactory training groups.

Variable	Nasal Insert (N = 60)	Standard Care (N = 56)	Statistic	p	Total (N = 116))
Sex			χ^2 = .03	.86	
Female (percentage) Male (percentage)	50 (83.3%) 10 (16.7%)	45 (80.4%) 11 (19.6%)			95 (81.9%) 21 (18.1%)
Age			t = .90	.37	
Mean (SD)	49.3 (12.1)	47.5 (9.08)			48.4 (10.7)
TDI visit 1			t = .18	.85	
Mean (SD)	24.9 (4.58)	25 (4.62)			25 (4.58)
Duration hyposmia (months)	**(N = 59)**	**(N = 52)**	t = .09	.93	**(N = 111)**
Mean (SD) Median (Min, Max)	42.9 (41.6) 36 (1.5, 240)	43.7 (48.7) 39 (3, 360)			43.3 (44.9) 38 (1.5, 360)
Duration between visits (days)	**(N = 56)**	**(N = 43)**	t = .96	.34	**(N = 99)**
Mean (SD) Median (Min, Max)	68 (24.5) 62 (54, 204)	73.2 (30.1) 62 (53, 202)			68.2 (24.5) 62 (53, 204)

Procedure

Nasal insert training

Participants randomized to the Nasal Insert olfactory training group (NI) were provided with a set of individually packaged scented single-use nasal plugs (Nosaplugs, NosaMed AB, Stockholm; Figure 1A) that they were instructed to wear for 20 minutes in the morning and 20 minutes in the evening, every weekday for 8 weeks. The nasal plugs are inserted into the nostrils (Figure 1B) and administer one specific scent (vanilla, lemon, melon, rosemary, menthol, orange, peach, strawberry, cherry, or cola) while allowing the individual to retain near normal nasal patency. In the morning, participants used one scent for 10 minutes and then replaced it with another scent for the remaining 10 minutes of the session. Participants then repeated the same procedure in the evening but with two different scents. This means that during each day, participants used a total of 4 different scents. To assist in dispersing the different scents throughout the training period, participants were provided with a suggested 8-week schedule for when to use which scent; however, this was not enforced. After each session, the nasal plugs were disposed of. The instructions they received were to visualize and focus on the smell during training, which was aided by an image of the odor object printed on each individual nasal plug package. All participants were contacted twice during their 8-week at-home training period with information regarding where to reach out had they any questions, comments, or concerns: a text message was sent one week after the initial visit, followed by a phone call approximately three weeks later.

Standard olfactory training

Participants in the standard care olfactory training group (SC) were instructed to choose 4-6 household odors to smell for 20 minutes in the morning and 20 minutes in the evening, every weekday for 8 weeks. Standard clinical practice recommended by the Swedish healthcare system is typically a 12-week long training regimen [17] meaning that our training regimen follows standard clinical practice with two important changes: Training was done only on weekdays rather than daily, and for 8 weeks instead of 12. These adjustments were made to avoid the excessive non-compliance rates of around 80% that have been informally observed at the clinics. Participants were instructed to smell one item for 10 to 20 seconds before continuing to the next, meaning that the same scents were repeated throughout the 20-minute session. Identically to the NI group, all participants were instructed to visualize and focus on the smell during training and were contacted twice during their 8-week at-home training period with information regarding where to reach out had they any questions, comments, or concerns. We opted to include this additional patient contact, a deviation from standard care in addition to the 8-week long training, due to worries that too few participants in the standard care would complete the study to allow analyses with inference statistics. Critically, apart from the type of olfactory training, both groups received identical treatment and procedures throughout the study. After completing the study, participants in the SC group were offered to take home the same olfactory training kit that was provided to the NI group.

Measurement

Olfactory function

Objective olfactory function

Objective olfactory function was assessed before and after 8 weeks of olfactory training using the Sniffin' Sticks extended test battery (Burghart Messtechnik, Holm, Germany). This psychop-

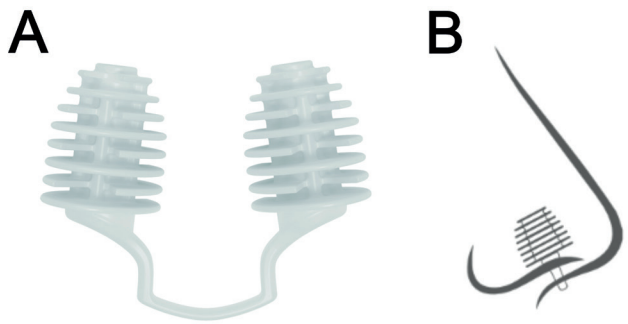

Figure 1. A. Nasal insert with its scented lamella that allow near normal nasal patency. B. Schematic drawing of a nasal insert positioned within the nose, viewed from the side.

hysical test consists of odorous pen-like tools used to evaluate nasal chemosensory performance on odor detection threshold for phenyl ethyl alcohol (T, range 1 to 16), odor quality discrimination (D, range 0 to 16), and cued odor identification (I, range 0 to 16). Combined, these three tests generate an additive TDI score (range 1 to 48) that reflects overall olfactory function, with higher scores indicating better function.

Subjective olfactory function

Subjective olfactory function over the past three days was self-assessed using a 10-point visual analogue scale (VAS), ranging from 0 (no sense of smell) to 10 (excellent sense of smell).

Compliance

Dropout

Dropout rate was defined per group as the percentage of individuals who did not attend the post-training visit. We obtained this number by counting the total number of participants who decided to discontinue their participation at any point before their post-training visit, either by informing the experimenter or ending their communication without explanation. Individuals who ended their training prematurely but still turned up at the post-training visit were not counted as dropouts.

Adherence

To measure treatment adherence, we used a five-item questionnaire [13] that participants answered during their second visit. The questionnaire separately assesses consistency, perceived tediousness, forgetfulness, and cause for potential discontinuation of the training. Specifically, the adherence questionnaire contained the following questions, "*Did you consistently perform olfactory training?", "Did you stop performing olfactory training on your own accord, because you felt that your sense of smell did not improve?", "Did you stop performing olfactory training on your own accord, because you felt that your sense of smell did improve?", "Did you feel that performing olfactory training twice a day was too often?", "How often did you forget to perform olfactory training?"*

Statistical analyses and availability of data statement

All raw data and analysis scripts are available at the Open Science Framework (OSF) https://osf.io/g6e53/?view_only=60e7df87bd8647a389630dfa55b6b527. The study hypothesis, inclusion/exclusion criteria and analysis plan were preregistered on clinicaltrials.gov, ID NCT06142565. Statistical analyses included t-tests, analyses of covariance (ANCOVA), Spearman's rank order correlations, and Chi-square tests of independence, which were all performed using the statistical software R (v4.3.3) [18] and the packages car (v3.1.2; Fox & Weisberg, 2019), dplyr (v1.1.4; Wickham et al., 2023), ggbeeswarm (v0.7.2; Clarke et al., 2023), ggplot (v3.5.1; Wickham, 2016), ggpubr (v0.6.0; Kassambara, 2023), haven (v2.5.4; Wickham et al., 2023), Hmisc (v5.1.2; Harrell, 2024), table1 (v1.4.3; Rich, 2023), tidyr (v1.3.1; Wickham et al., 2024), and tidyverse (v2.0.0; Wickham et al., 2019). The significance criterion for the statistical tests was set to $\alpha = 0.05$.

Results

Objective olfactory improvement

First, we assessed the overall effect of olfactory training on objective olfactory ability. By directly comparing the assessment score before training with the assessment score after training using a dependent samples t-test for both groups combined, we found a significant difference in TDI between the two visits, $t(98) = 5.7$, $p < .001$, demonstrating that olfactory function improved in the full sample (Figure 2). For an overview of olfactory scores at the baseline and post-treatment visit (Table 2).

We then assessed whether there was a difference in olfactory improvement between the two training groups. By using a one-way ANCOVA to compare the post-treatment TDI score between groups while using baseline TDI score as a covariate, we found no significant difference in treatment effects between the two groups after controlling for baseline TDI, $F(1, 96) = 3.37$, $p = .07$ (Figure 3A). Both groups did, however, on average independently improve their olfactory performance, as demonstrated by separate paired t-tests, $t(55) = 6.33$, $p < .001$ for the NI group and $t(42) = 2.18$, $p = .035$ for the SC group. On average, TDI values increased in the NI group by 3.63 (SD = 4.29), amounting to an average increase in TDI score from baseline of 15.6%, and in the SC group by 1.8 (SD = 5.46), an average TDI increase of 8.1%.

Having established that nasal inserts is a non-inferior alternative to standard care in regards of change in TDI scores, we further wanted to determine whether there was a difference in olfactory improvement between the two training groups in the three subtests. By using the same type of analysis as for the TDI, but this time for each of the three sub-tests scores, we found a significant difference in olfactory improvement for discrimination, $F(1, 96) = 3.96$, $p = .049$ (Figure 3C), between the two training groups. However, no significant differences in olfactory

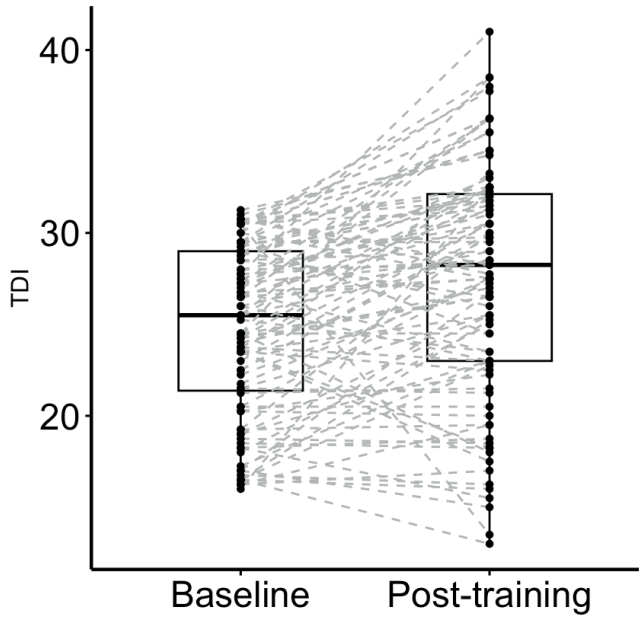

Figure 2. TDI scores at baseline and post-training visits with individual scores connected. Dots represent individual scores, and dashed lines connect TDI scores for the two visits for each individual. Solid bars represent group medians and boxes represent interquartile intervals.

improvement were detected between the two training groups for threshold, F(1, 96) = .7, p = .41 (Figure 3B), or identification scores, F(1, 96) = 1.9, p = .17 (Figure 3D), when controlling for each individual's sub-test baseline score.

It has been argued that a change of 5.5 or more on the TDI measurement represents a clinically relevant change in olfactory functions [19]. In the NI group, 36.7% of participants, and in the SC group, 19.6% of participants completing the olfactory training regime, reached a clinically relevant change after olfactory training. These numbers were further reflected in participants who, after training, scored in a range that qualified them as having a functional sense of smell (normosmia) on the olfactory test, defined as a summated TDI score above 30.75(20). A total of 20 individuals in the NI group had post-training score in the normosmia range (35.7% of patients finishing the study) whereas a total of 15 individuals in the Standard Care group (34.8% of patients finishing the study) obtained a TDI score above 30.75 and therefore can be considered to have transitioned to a normosic value range.

Subjective olfactory improvement

We also wanted to estimate the overall effect of olfactory training on subjective olfactory ability. By comparing the answers to the self-reported olfactory ability of the baseline visit with the post-training visit using a dependent samples t-test, we found a significant difference in subjective olfactory ability between the two visits, t(98) = 5.5, p < .001. We then wanted to determine whether there was a difference in subjective olfactory improvement between the two training groups. By using a one-way ANCOVA to compare the post-treatment subjective olfactory function score between groups while using baseline treatment subjective olfactory function score as a covariate, we found no significant difference in treatment effect, F(1, 96) = 3.5, p = .06. Previous studies have shown that the duration of olfactory dysfunction has a negative impact on olfactory training treatment effect [7]. To assess this effect in our samples, we calculated the Spearman's rank order correlation between olfactory improvement and time since onset of olfactory dysfunction in our sample. We found no significant association between the duration of dysfunction and improvement of neither objective olfactory function, r(97) = -.12, p = .22, nor subjective olfactory function, r(97) = .03, p = .77.

Dropout and treatment adherence

We then assessed whether there were any potential differences in dropout rates and adherence to training between the two groups using the Chi-square test of independence. When assessing dropout rates, we found significantly fewer dropouts in the NI group compared to the SC group, χ^2 (1, N = 99) = 5.09, p = .02. The total number of individuals classified as dropouts were 4 in the NI group (6.7%) and 13 in the SC group (23.2%).

Turning our focus to treatment adherence, we wanted to know whether there was a difference between the two training groups in their responses to the adherence questionnaire. By separa-

Table 2. Objective olfactory function scores at the baseline and post-treatment visit reported per olfactory training group.

	Baseline								Post-treatment							
	Threshold		Discrimination		Identification		TDI		Threshold		Discrimination		Identification		TDI	
Group	NI	SC	NI	SC	NI	SC	NI	SC	NI	SC	NI	SC	NI	SC	NI	SC
N	60	56	60	56	60	56	60	56	56	43	56	43	56	43	56	43
Mean	5.10	4.99	10.02	9.82	9.63	10.2	24.9	25.0	6.56	6.08	11.4	10.4	10.3	10.2	28.3	26.7
SD	2.59	2.48	2.08	2.21	2.42	1.91	4.58	4.62	3.14	3.52	2.38	2.16	2.56	2.50	6.01	6.71
Median	5.00	5.13	10.0	10.0	10.0	11.0	25.5	26.3	6.50	5.50	11.5	11.0	11.0	11.0	29.0	27.0

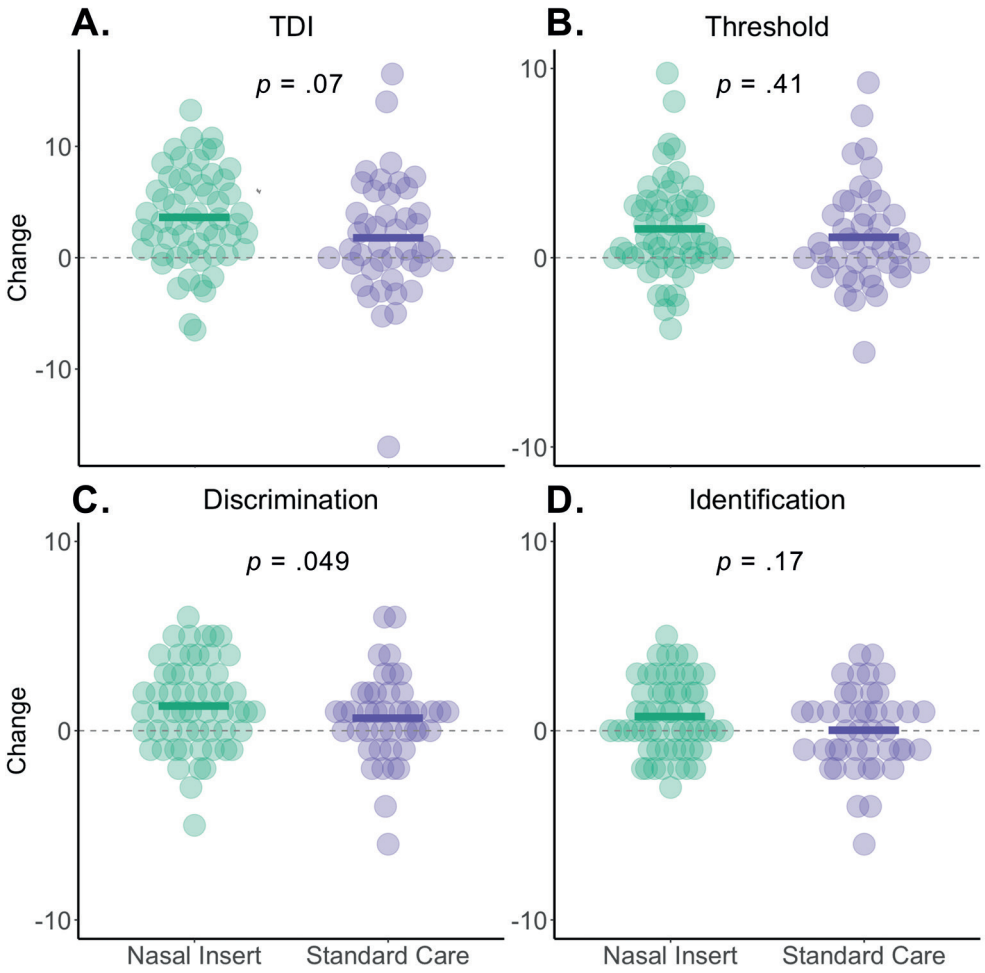

Figure 3. Change in objective olfactory function from baseline to post-treatment per olfactory test score and olfactory training group. A. Combined TDI scores. B. Odor detection threshold scores. C. Odor quality discrimination scores. D. Odor identification scores. In all panels, dots represent individual values (scores slightly jittered for visualization purposes) and solid bars depict group means. Dashed lines indicate 0. Note the difference in scale between panels A and B-D. Note that p-values in figure originates from ANCOVAs with baseline score as covariate.

tely comparing the answers to the adherence questionnaire between the two groups, we found a significant difference in answers to the questions "*Did you consistently perform olfactory training?*", χ^2 (1, N = 99) = 7.8, p = .005, and "*Did you feel that performing olfactory training twice a day was too often?*", χ^2 (1, N = 99) = 32.07, p <.001, but not to the questions "*Did you stop performing olfactory training on your own accord, because you felt that your sense of smell did NOT improve?*", χ^2 (1, N = 99) = .018, p = 0.89, and "*Did you stop performing olfactory training on your own accord because you felt that your sense of smell DID improve?*", χ^2 (1, N = 99) < .001, p = 1 (Figure 4). Critically, in response to the question "*How often did you forget to perform smell training?*", significantly fewer individuals in the NI group reported forgetting to train, χ^2 (4, N = 99) = 26.51, p < .001. This indicates that participants in the nasal insert group were more consistent with their olfactory training.

Discussion

In this study, we aimed to investigate how a modified version of olfactory training using scented nasal inserts compares to standard olfactory training in treatment effect and compliance rate. Using a technique where odors are administered using scented intranasal plugs, we could demonstrate a significantly higher adherence to treatment protocol with more consistent training and fewer forgotten training session while maintaining treatment effects, compared to standard care treatment. Critically, training with nasal inserts reduced dropout rates to a mere 6.7% compared to 23.2% in the standard care group.
Individuals in the nasal insert training group demonstrated an overall greater adherence to treatment and higher satisfaction. Of those completing the study, nearly 98% of the nasal insert training group reported that they consistently performed their training compared to 79% in the standard care group and a full 86.6% reported that they seldom or never forgot a session, com-

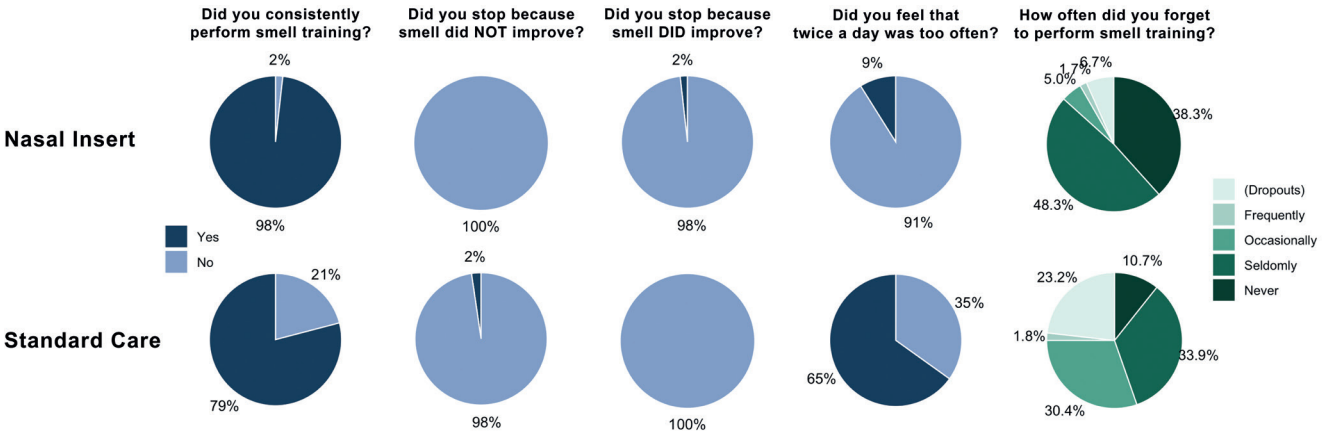

Figure 4. Frequency of answers to the adherence questionnaire separated by olfactory training group.

pared to 64.3% in the standard care group. The exact reasons why the standard care group reported lower adherence to treatment protocol are difficult to determine but 35% of the group reported that training twice a day was too much compared to 9% in the nasal insert group. It can be speculated that the increased adherence in the nasal insert group might be attributed to the enhanced mobility during training that the inserts allowed them. Alternatively, the difference in the number of odors used for training (6 SC vs 10 NI) might have contributed given that a recent study suggests that expanding from 4 to 6 odors increase adherence to treatment protocol [21]. A more simplistic explanation is that the mere act of being provided with some sort of medical system increases the perceived saliency of the training. The exact mediating mechanism notwithstanding, in all medical treatment, adherence to treatment protocol and persistence in maintaining prescribed treatment is a key factor in treatment outcomes on both the individual and group level. Past studies have demonstrated that only half of all medical patients adhere to the medical advice they receive from their attending doctor [22] and close to 50% of patients do not take their prescribed medication as frequently as instructed, or at all [23]. Medical treatment requiring even more time and effort from the patient, such as at home physical therapy regimens, commonly demonstrate a compliance rate as low as 30% [12]. Adherence to olfactory training in the general clinical population is similarly suboptimal where at least 15% of patients do not even start their recommended training regimen and among those who start, only 33% self-report consistent training [13]. Both training groups demonstrated considerably higher adherence frequencies than those normally observed in clinical settings. Notably, the Standard Care group achieved 79% adherence, standing out in comparison to real-life experiences. A deviation from standard care was the contact participants in both treatment groups had with the study staff. In addition, participants who volunteer to participate in research studies are naturally more motivated to perform the assigned intervention. These two factors likely increased adherence frequencies compared to the numbers observed in clinical settings. In addition, one should note that the current recommended standard care in Sweden recommends olfactory training for 20 minutes per session, considerably longer than the 3- to 15- minute durations commonly reported in the literature. A direct comparison of results between the Standard Care group included in this study and the literature should take this into account. Nonetheless, considering both the lower dropout rates and higher adherence to treatment for those following through with the treatment in the nasal insert group, it can be speculated that it potentially is a clinically advantageous method that could increase overall effectiveness of odor training in a clinical population.

There were significantly fewer dropouts in the nasal insert group (6.7% vs 23.2%). While this is potentially positive for treatment outcome, we do not know exactly why someone discontinues a study. Subjective experiences of both presence and lack of olfactory improvement during olfactory training treatment is associated with non-adherence [13]. In other words, individuals stop performing the training on their own accord both if they feel that their sense of smell improves, and if they feel that it does not improve. This is problematic considering that subjective and objective olfactory performance are poorly correlated [24] meaning that the sensation of change of lack thereof is not a reliable signal. Patients that experience a clinically relevant improvement do often notice this change; however, also in this group, only about 60% are consciously aware of the change [19]. It is here worth highlighting that we used a validated adherence to treatment scale that was developed specifically for odor training [13], but the two questions pertaining to why participants chose to discontinue are less informative in the context of this study because only individuals who attended the final visit answered them. Nonetheless, past studies suggest that individuals without any self-perceived improvements are more likely to discontinue olfactory training [13].

A total of 36.7% in the nasal inserts group and 19.6% of par-

ticipants in the standard care group experienced a clinically relevant improvement in their sense of smell after completing the olfactory training regime. Hence, percentagewise, more individuals in the group training with nasal inserts demonstrated a clinically relevant improvement of olfactory functions after training compared to standard care. However, it is important to point out that there was no statistically significant difference between the two groups in TDI score. This discrepancy between actual and statistical outcome is mediated by the fact that two individuals in the standard care group achieved a very large improvement after training due to reasons unknown. Moreover, due to standard care outlines and convenience of obtaining suitable household odors, there was a difference in number of odors used for training. Whether this difference in number of odors impacted the outcome in respective group is not known. A limitation of the present study is that we could not control that the participants in the nasal insert group focused on the odor object, represented by an image on the individual package, as instructed, rather than some other task at hand. Because active mentalization of the odor object in question has been demonstrated to enhance olfactory training outcome (4), this might potentially mask a potential difference in treatment outcome between groups. However, this would mean that the nasal inserts improvement could be potentially larger and therefore do not unduly bias our results. On the other hand, tentative evidence suggests that training with single molecules might be more effective than training using common household odors [10]. It should, however, be noted that this statement is based on evidence obtained in a single study, with comparisons made between five versus seven individuals in each training group. Nonetheless, further studies are needed to determine whether the degree of mentalization or differences between the use of odor mixture versus household odors could have an impact on the obtained results. Moreover, we only included participants with post-viral or idiopathic hyposmia, meaning that we cannot generalize our results to other patient groups with olfactory dysfunction. Finally, it is known that longer periods of training yield better outcomes [25]. It could therefore be speculated that olfactory function in both groups could have increased had the length of training been extended.

Conclusion

Olfactory training with scented nasal inserts leads to a significantly higher adherence to treatment protocol with more consistent training and fewer forgotten training sessions while maintaining treatment effects, when compared to standard care. This combination of significantly lower dropout rates and higher adherence, while maintaining treatment outcomes, makes nasal inserts an interesting method to increase the effectiveness of olfactory training in standard clinical populations.

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Authorship contribution

JNL, ALW, and PSJ contributed to conception and design of the study. ALW together with MS and JM refined the study protocol and collected the data. ALW performed the statistical analysis and wrote the first draft of the manuscript. JNL, SH, ET, and PSJ wrote sections of the manuscript. All authors edited versions of the manuscript, read, and approved the submitted version.

Conflict of interest

JNL receives financial compensation from Sulcus Consulting AB where NosaMed AB, the maker of the NosaPlug, is a client.

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Availability of data and materials

All raw data and analysis scriptsare available at the Open Science Framework (OSF): https://osf.io/g6e53/?view_only=60e7df87bd8647a389630dfa55b6b527.

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Anja L. Winter
Department of Clinical Neuroscience
Karolinska Institutet
Nobels väg 9
171 77 Stockholm
Sweden

Tel: +46852483232
E-mail: anja.winter@ki.se

Johan N. Lundström
Department of Clinical Neuroscience
Karolinska Institutet
Nobels väg 9
171 77 Stockholm
Sweden

Tel: +46852483249
E-mail: johan.lundstrom@ki.se

Anja L. Winter[1], Sofie Henecke[1,4], Evelina Thunell[1], Mattias Swartz[1], Joakim Martinsen[1], Pernilla Sahlstrand Johnson[2,3*], Johan N. Lundström[1,4,5*]

[1] Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden
[2] Skåne University Hospital, Department of Oto-Rhino-Laryngology, Malmö, Sweden
[3] Lund University, Department of Clinical Sciences, Malmö, Sweden
[4] Department of Otorhinolaryngology, Karolinska University Hospital, Stockholm, Sweden
[5] Monell Chemical Senses Center, Philadelphia, PA, United States

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