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Aromatherapy in practice; effects of an eight-week intervention on self-reported stress and hair cortisol levels

Abstract

Stress and its consequences for health and wellbeing is an ongoing problem in the modern era. The potential for aromatherapy to offer a safe, effective and widely available treatment has been considered but the scientific evaluation has often fallen short. In this study we investigated the potential for the aroma of a blend of essential oils to impact on self-reported stress and cortisol levels as a biomarker of chronic stress. Sixty-six clients of clinical aromatherapists were recruited along with a control group of 33 healthy but stressed individuals. Aromatherapy clients followed an eight-week intervention programme that employed either a traditionally extracted or carbon dioxide extracted blend of essential oils. Control participants received no intervention. All participants completed self-report questionnaires at the start and end of the intervention period and provided two hair samples for the evaluation of cortisol levels in the preceding month. Data analysis revealed that the aromatherapy interventions produced significant reductions in self-reported stress, anxiety and mood disturbance with medium sized effects. Hair cortisol levels also significantly declined from pre- to post- treatment with a medium sized effect for both aromatherapy groups. No changes were seen in the control group for any variables. These findings clearly support the effectiveness of clinical aromatherapy practice for the treatment of chronic stress and suggests that method of extraction of the essential oils is not a critical factor. The potential for aromatherapy to contribute more widely to the democratisation of health care as self-care warrants further investigation.

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Introduction

The twenty-first century has seen a worrying increase in the number of people who experience chronic stress and the associated impact on physical and mental health, with 31% of a survey of the worldwide adult population viewing stress as the biggest health problem in their country from 2018 to 2024.[1] Complementary and alternative medicine (CAM) has become an increasingly important feature of healthcare for such conditions with 12% of a large English sample consulting a practitioner in the preceding 12 months with aromatherapy being the second most popular modality.[2] Research that has evaluated the potential for clinical aromatherapy to beneficially impact on stress has been limited in both scope and approach, however. A large number of the studies performed have involved volunteers who are healthy and report no significant stress at the start of the study.[3–7] The general consensus from such work is that inhalation of the aromas of essential oils, especially lavender can reduce self-reports of stress and impact beneficially on physiological markers such as blood pressure and cortisol. A body of work has also investigated the specific area of occupational stress amongst health workers[8–11] and patient groups in hospital settings.[12–16] As with healthy participants, self-reported stress, anxiety, depression and additionally, pain generally show improvements from aromatherapy interventions, although in some cases no beneficial effects were recorded.[12] There are limited reports of the impact of aromatherapy on physiological markers in patient populations but evidence exists indicating reductions in heart rate and cortisol levels[17,18] and salivary alpha amylase.[19] However, the impact of clinical aromatherapy practice on clients from the general population seeking treatment for feelings of chronic stress and associated symptoms lacks rigorous investigation. The current study aimed to address this deficit by evaluating the impact of aromatherapist led treatment on self-reports and an objective measure of chronic stress.

The hormone cortisol is secreted continuously and follows a regular diurnal pattern in healthy adults as well as being increased in concentration in response to acute stress.[20] Diurnal rhythmicity and acute reactivity of cortisol are typically measured in saliva; however, concentrations are subject to high situational variability. A viable option is the measurement of cortisol in hair; sampling is non-invasive and it has been proposed to be a better evaluation of stress-related secretion over periods of weeks or months.[21] Hair grows at a rate of approximately one centimetre per month[22] and so successive segments can be used to compare cortisol levels before and after a stressful period, or in the case of the current study, before and after a treatment intervention. Previous research has demonstrated increased hair cortisol concentrations in samples experiencing prolonged stress such as dementia caregivers,[68] the unemployed[23] and those with chronic pain[24] when compared to healthy controls. There are limited studies reporting the impact of treatment on hair cortisol levels, although[25] found beneficial effects of cognitive behavioural therapy on both self-reported stress and hair cortisol levels amongst pregnant women.

A current issue in the aromatherapy field relates to the extraction of the essential oils. The process of extraction is aimed at the concentration of active compounds ie monoterpenes and sesquiterpenes, and their oxygenated derivatives such as alcohols, aldehydes, ketones, acids, phenols, ethers, and esters from the bulk plant.[26] Traditional extraction techniques are based on the use of various solvents, heating and mixing, and in recent years have faced criticism due to the cost of the solvents, some of which may be lost through evaporation, the duration of the extraction times and low selectivity.[27] Alternative 'green' extraction methods using supercritical fluid extraction with carbon dioxide (CO_2) have been on the increase due to being quick, easy and selective.[28] These methods are also solvent-free and viewed as environmentally friendly.[29] The properties of extracted essential oils are dependent upon the number and type of molecules that constitute them and the stereochemical structure of the molecules, all of which can be influenced by the extraction process employed.[26] Given that essential oils may vary dependent on extraction method, one of the key questions that remains to be answered is whether the essential oils derived using the different techniques differ in their therapeutic value. The current study will make a direct comparison of equivalent essential oils extracted either through traditional or CO_2 methodologies. Finally, the global aromatherapy market was estimated at USD 8.6 billion in 2023 and is predicted to grow at a capital annual growth rate of 7.9% from 2024 to 2030.[30] As such, the need for evaluations of the kind made in this study is self-evident. The aim of this study is therefore to assess the impact of traditional versus CO_2 extracted essential oil blends employed as clinical aromatherapy interventions on clients seeking to alleviate stress and associated symptoms.

Methods

The design and proposed analysis are available at Open Science Framework (https://osf.io/c5ugb)

Role of the international federation of aromatherapists (IFA)

The IFA recruited therapists from its membership who were interested in taking part in this study. The participants from whom data was collected were all new clients of the therapists and were seeking treatment for stress. The treatment duration of eight weeks was agreed in advance with the IFA and the therapists. The essential oil blend 'Stress-less' is a commercial blend created and supplied by the IFA. The use of traditional or carbon dioxide extracted oil blends was based on individual preference and each therapist only used one type of extracted oils blend.

Design

A 3(condition) x 2(timepoint) mixed design was employed. The between groups factor was the essential oil condition with three levels; traditionally extracted essential oil blend, Carbon Dioxide extracted essential oil blend, and control (no essential oils). The repeated measures factor was timepoint with two levels representing the collection of subjective measures and hair samples before and after the eight week aromatherapy intervention period. The subjective dependent variables were scores on self-report scales of mood, stress and other negative feelings. Cortisol levels were extracted from hair samples taken at the start and end of the study and represent an objective measure of chronic stress in the previous month.

Participants

All client participants in the aromatherapy conditions were recruited by the therapists after being approached by the individuals to be treated for feelings of stress. All these participants were asked if they were interested in contributing data to the study prior to the start of their eight-week treatment block. The traditional extraction group consisted of 30 females (M_{Age} = 54.20, SD = 11.31) and 6 males (M_{Age} = 61.67, SD = 15.23). The carbon dioxide extraction group consisted of 36 females (M_{Age} = 55.46, SD = 13.63) and 6 males (M_{Age} = 41.17, SD = 17.42). Participants in the control condition were recruited from the general population by the department of psychology at Northumbria University and consisted of 24 females (M_{Age} = 46.42, SD = 14.81) and 9 males (M_{Age} = 42.33, SD = 16.82). All control participants expressed feeling daily stress but not to the extent of seeking or receiving any form of medical treatment or complimentary intervention. All participants in all conditions were paid £20 for completing the study to cover their time and inconvenience in completing the questionnaires and providing hair samples.

Material and measures

The following scales were completed at the start and end of the study; Perceived Stress Scale,[31] Profile of Mood States,[32] State-Trait Anxiety,[33] Stress Reactivity,[34] Depression, Anxiety and Stress,[35] and Loneliness.[36]

Hair cortisol

Hair samples were collected from all participants at the start (week -1) and the end (week 9) of the study in accordance with accepted instructions from the lab where the analyses were conducted: https://www.aru.ac.uk/science-and-engineering/business-and-commercial/biomarkers/client-area. Comparisons were made of cortisol levels pg/mg in 1cm segments cut closest to the scalp at the two timepoints indicated above, where these samples represent cortisol secretion in the month prior to each sample.

Essential oils

The essential oil blends constituted five essential oils. The blend, named 'Stress-less' is a proprietary product of the IFA and was created in the same way but either with traditionally distilled essential oils or Carbon dioxide extracted essential oils. The exact oils and proportions in the blend are the commercial property of the IFA and have not been shared. Each essential oil used was certified with ISO022716 ANS ISO14001, UKAS and EFICI certificates. The product specification sheets identify that the essential oils are in accordance with the requirements of Articles 3 (2) (d) of regulation (EC) 1334/2008 and therefore can be designated as natural and do not contain any solvents or additives.

Procedure

Ethical approval for the study was obtained from the Northumbria University ethics system #46251. On recruitment of the in-therapy participants, informed consent forms were signed and returned to Northumbria University. Upon receipt, participant's questionnaire packs were sent out to the respective therapists. All participants completed baseline questionnaires and initial hair samples were taken at the therapist's clinic, and subsequently engaged with treatment as provided and directed by the therapists. In addition to fortnightly in-clinic treatments each participant received a 10ml bottle of essential oil to take away and inhale from for 5 minutes, three times a day. Following eight weeks of treatment final questionnaires were completed and second hair samples taken during a debrief session when questions were answered and payments were also distributed. Control participants provided initial and final questionnaire data and hair samples by visiting the lab at Northumbria University at an agreed time eight weeks apart. Debrief and payments were made at the second visit.

Data analysis strategy

A mixed two (pre, post treatment) by three (group) factorial multivariate analysis of variance (MANOVA) was applied to all dependent variables in the study. The significance of the interaction effect was employed as a gatekeeper to consideration of the univariate analyses of variance. Any significant interaction effects for the univariate Anovas were then followed up with Bonferroni corrected simple main effects analyses. Pearson correlations were also conducted between pre- and post- treatment hair cortisol levels and any variables significantly affected by the intervention.

Results

The MANOVA revealed a significant main effect of Group, Wilks' lambda = .505, F(44, 176) = 1.613, p = .016, partial eta squared = .290. There was also a significant main effect of pre-post treatment, Wilks' lambda = .560, F(22, 87) = 3.102, p < .001, partial eta squared = .440. Importantly, there was also a significant pre-post treatment by Group interaction effect, Wilks' lambda = .536, F(44, 174) = 1.447, p = .050, partial eta squared = .268. This led to consideration of the univariate tests for which descriptive statistics for the interactions are presented in Table 1, along with uncorrected p values for the interaction effects and the partial eta squared effect sizes. For concision, the Stress Reactivity subscales are not presented because scale total did not approach significance. Similarly, the subscales of the Profile of Mood States scale are not presented as none of the interaction effects for the individual subscales reached significance.

Table 1 Mean (SD) for Pre and Post scales from the Depression, Anxiety and Stress scale (DASS), Perceived Stress Scale (PSS), State-Trait Anxiety absent and present (STA), Profile of Mood States total mood disturbance (POMS TMD), the Loneliness scale, Stress Reactivity (SRS total) and hair cortisol levels (pg/mg). Uncorrected p values for the Condition*Pre_Post interaction effect and partial eta squared effect sizes

	Control		**Traditional**		**CO_2**		**Interaction Sig**	**η2p**
Variable	Pre	Post	Pre	Post	Pre	Post		
DASS Depression	4.61 (4.99)	4.79 (5.31)	5.06 (3.64)	3.63 (4.33)	4.88 (5.57)	3.57 (4.20)	0.324	0.02
DASS Anxiety	3.79 (3.45)	4.21 (4.90)	4.17 (4.04)	2.14 (2.81)	5.86 (4.94)	2.91 (3.75)	0.012	0.079
DASS Stress	6.00 (3.24)	6.76 (4.62)	8.44 (3.97)	5.46 (4.59)	7.83 (4.26)	6.17 (4.28)	0.027	0.065
PSS	19.42 (6.05)	18.67 (6.11)	19.75 (6.47)	12.99 (6.34)	17.48 (8.26)	14.85 (6.75)	0.038	0.059
STA Absent	8.79 (2.29)	8.36 (2.73)	8.56 (2.26)	8.86 (2.27)	8.07 (2.25)	8.34 (2.51)	0.438	0.015
STA Present	4.67 (2.15)	5.15 (2.54)	5.75 (2.47)	4.46 (1.97)	5.06 (2.27)	5.08 (2.00)	0.008	0.085
POMS TMD	-3.91 (23.48)	-.067 (27.86)	2.28 (25.39)	-10.67 (21.40)	0.71 (23.51)	-8.02 (22.31)	0.034	0.06
Loneliness	12.27 (4.50)	12.61 (4.62)	13.17 (3.53)	11.45 (4.06)	13.19 (3.85)	12.56 (4.04)	0.099	0.042
SRS Total	1.03 (0.39)	1.01 (0.42)	1.04 (0.38)	0.88 (0.36)	1.11 (0.36)	0.96 (0.4)	0.228	0.027
Cortisol	18.27 (9.53)	19.03 (7.71)	19.31 (8.38)	17.09 (5.66)	20.29 (13.13_	16.45 (11.13)	0.029	0.063

DASS anxiety

The pre-post*Group interaction was significant, F(2, 108) = 4.653, p = .012, η^2_p = .079. Analysis of simple main effects indicated that for the traditional essential oil group the decrease in anxiety from pre (4.17) to post (2.14) treatment was significant, p = .014, Cohen's d = .484, 95% CI [.135, .826], a medium effect size. For the CO_2 group the decrease from pre (5.86) to post (2.91) was significant, p < .001, Cohen's d = .490, 95% CI [.167, .808], a medium effect size. The control group elicited no significant difference p = .616, Cohen's d = -.115, 95% CI [-.457, .228]. See Figure 1a.

DASS stress

The pre-post*Group interaction was significant, F (2, 108) = 3.745, p = .027, η^2_p = .065. Analysis of simple main effects indicated that for the traditional essential oil group the decrease from pre (8.44) to post (5.46) treatment was significant, p = .002, Cohen's d = .517, 95% CI [.166, .862], a medium effect size. For the CO_2 group the decrease from 7.83 to 6.17 approached but did not reach statistical significance, p = .063, Cohen's d = .285, 95% CI [-.026, .591], a small effect size. The control group elicited no significant difference p = .450, Cohen's d = -.136, 95% CI [-.478, .208]. See Figure 1b.

State trait anxiety present

The pre-post*Group interaction was significant, F (2, 108) = 4.993, p = .008, η^2_p = .085. Analysis of simple main effects indicated that for the traditional essential oil group the decrease from pre (5.75) to post (4.46) treatment was significant, p = .002, Cohen's d = .504, 95% CI [.154, .848], a medium effect size. For the CO_2 group the small increase from pre (5.06) to post (5.08) treatment was not significant, p = .947, Cohen's d = -.009, 95% CI [-.312, .293]. The control group also displayed an increase in this variable that was not significant, p = .259, Cohen's d = -.250, 95% CI [-.595, .098]. See Figure 1c.

Perceived stress scale

The pre-post*Group interaction was significant, F (2, 108) = 3.382, p = .038, η^2_p = .059. Analysis of simple main effects indicated that for the traditional essential oil group the decrease from pre (19.75) to post (12.99) treatment was significant, p < .001, Cohen's d = .700, 95% CI [.331, 1.062], a medium to large effect size. For the CO_2 group the decrease from 17.48 to 14.85 approached but did not reach statistical significance, p = .088, Cohen's d = .231, 95% CI [-.076, .537], a small effect size. The control group elicited no significant difference p = .661, Cohen's d = .096, 95% CI [-.247, .437]. See Figure 1d.

POMS total mood disturbance

The pre-post*Group interaction was significant, F (2, 108) = 5.964, p = .016, η^2_p = .052. Analysis of simple main effects indicated that for the traditional essential oil group the decrease in mood disturbance from pre (2.28) to post (-10.67) treatment was significant, p = .004, Cohen's d = .432, 95% CI [.088, .771], a small to medium effect size. For the CO_2 group the decrease from pre (0.71) to post (-8.02) was significant, p = .034, Cohen's d = .315, 95% CI [.003, .623], a small effect size. The control group elicited no significant difference p = .482, Cohen's d = -.165, 95% CI [-.508, .180]. See Figure 1e.

Hair cortisol

The pre-post*Group interaction was significant, F (2, 108) = 3.657, p = .029, η^2_p = .063. Analysis of simple main effects indicated that for the traditional essential oil group the decrease in hair cortisol levels from pre (19.31) to post (17.09) treatment approached but did not reach significance, p = .057, Cohen's d = .299, 95% CI [-.037, .631], a small effect size. For the CO_2 group the decrease from pre (20.29) to post (16.45) was significant, p < .001, Cohen's d = .522, 95% CI [.197, .842], a medium effect size. The control group elicited no significant difference p = .528, Cohen's d = -.118, 95% CI [-.459, .226]. See Figure 1f.

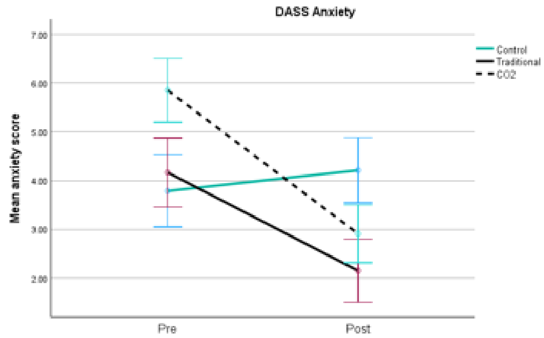

Figure 1a

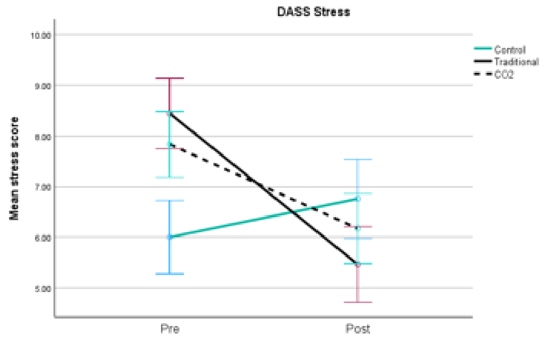

Figure 1b

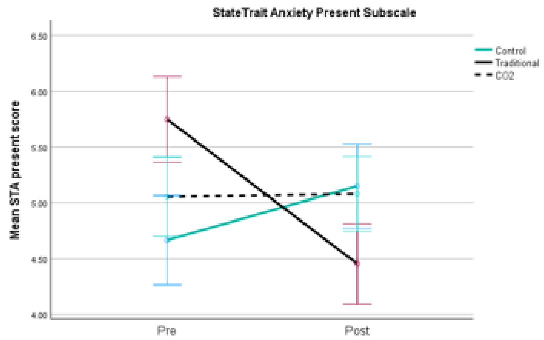

Figure 1c

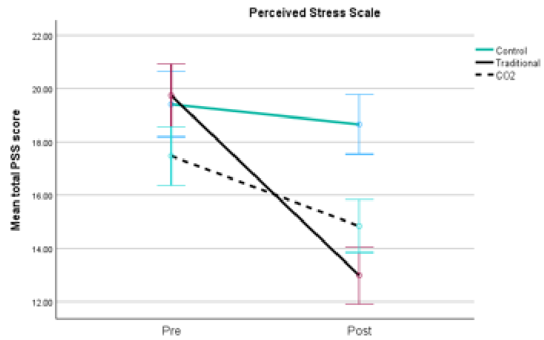

Figure 1d

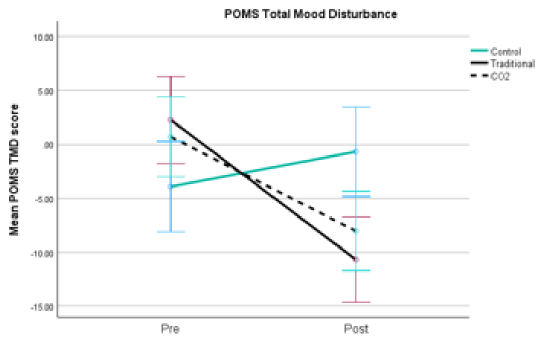

Figure 1e

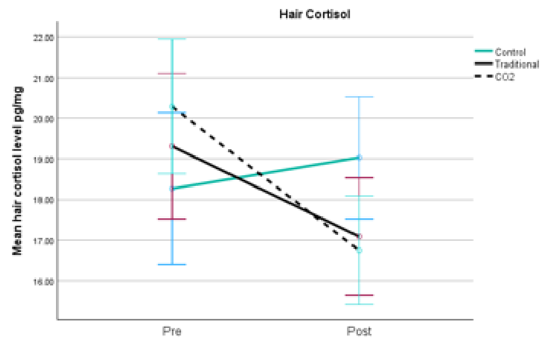

Figure 1f

Figure 1 Interaction plots for the dependent variables that reached significance. Error bars depict standard errors.

Correlations

Pearson correlations were conducted between cortisol levels and scores on the above scales at both pre- and post-treatment time points (Table 2). Prior to treatment there were: a significant positive correlation with a medium effect size between the DASS Stress variable and hair cortisol $r(109) = .330$, $p < .001$, and a significant positive correlation approaching a medium effect size between the Perceived Stress Scale and hair cortisol, $r(109) = .248$, $p = .009$. A small to medium sized significant negative correlation was observed between DASS anxiety and hair cortisol $r(109) = -.210$, $p = .027$. No other correlations approached significance.

Table 2 Pearson correlations between hair cortisol levels pg/mg and scale scores for those scales affected by the intervention. DASS = Depression Anxiety and Stress Scale; STA = State Trait Anxiety Scale; PSS = Perceived Stress Scale; POMS TMD = Profile of Mood States Total Mood Disturbance. * denotes p<.05, ** denotes p<.01. N = 111

	DASS Stress	DASS Anxiety	STA Present	PSS	POMS TMD
Cortisol (pre)	.330**	-.210*	.007	.248**	-.088
Cortisol (post)	-.110	-.090	-.025	.007	-.026

Discussion

The results of this study demonstrate that treatment by aromatherapists using the 'Stress-less' essential oil blends significantly reduced feelings of stress, anxiety and mood disturbance amongst clients seeking a solution for their experiences and impact of long-term stress. The traditional extraction blend produced slightly greater benefits for the subjective variables than the CO_2 extraction blend, although these differences were not large save for the DASS anxiety scale where the CO_2 blend produced no benefit. In contrast, the CO_2 blend produced marginally greater decrease in hair cortisol levels from pre- to post-treatment than the traditional blend. Control participants showed no change in any of the subjective or hair cortisol variables across the course of the study. Some comparison of the effect sizes observed here can be made to previous work in the area. A meta-analysis of five published studies employing healthy participants[37] reported a mean effect size of -0.96 for subjective assessments of stress and -0.62 for salivary or serum cortisol levels. These mean effect sizes are larger than those observed here and although[37] suggest that the mean effects may be overestimated due to the small size of the studies in the analysis, it may also be that healthy participants employed in research self-report greater reductions in stress than do those individuals who are seeking assistance with a clinical problem. Treatment resistance is common in post-traumatic stress disorder[38] and it is possible that the participants in the treatment groups employed here identified lower levels of improvement due to an inherent reluctance to report feeling better. Alternatively, the expectation of the effectiveness of the treatment amongst the clients may be low, especially when they may have found orthodox treatment ineffective,[39] and even when improvements were experienced the ratings of the change may be blunted. The difference in the effect sizes reported for the cortisol measures may reflect the sensitivity of the salivary and serum measurements to acute stressors and healthy participants employed in the studies reviewed, compared to the treatment of chronic stress reported here.

The analysis of cortisol in hair is considered a useful technique for the retrospective assessment of chronic stress.[40] However, the correlations between cortisol levels and self-reported stress presented here show limited evidence of a relationship. The reason for the lack of objective-subjective correlation may lie in the fact that the cortisol levels derived from the hair samples describe the average level for the previous month, whereas the subjective measures were point estimates at the end of the same month. The important observation that both the hair cortisol levels and subjective evaluations of stress reduced over the period of the treatment is not reduced in value by the lack of objective-subjective correspondence for this reason.

Given that the results of this study indicate that both subjective and objective markers of stress can be positively impacted by aromatherapy treatment, consideration of possible mechanisms is warranted. The hedonic valence mechanism suggests that the pleasantness of an aroma can influence mood and performance,[41] but can perhaps be rejected here. Although the relationship between aroma pleasantness and hedonic response is undeniable,[42] the likelihood of it being sufficient to address significant reports of continuing stress is low, especially when aromas rated with similar levels of likeability have been reported to impact differentially on aspects of stress.[43,44]

A more intriguing possibility is the engagement of signal pathways in the central nervous system via stimulation of the olfactory bulb. Aroma molecules stimulate the olfactory system which induces cortical responses including the release of neurotransmitters in a chemical-electrical-chemical signal process.[45] Component molecules of a range of essential oils have been demonstrated to possess such neuropharmacological properties in animal models. Linalool, a major constituent of a number of essential oils inhibits glutamate binding and as such may act as a tranquilizer.[46] Carvacrol by comparison, produces anxiolytic effects through involvement with gamma-aminobutyric acid transmission[47] and lemon aroma has been shown to accelerate the turnover of 5-hydroxytrptamine that might be linked to antidepressant effects.[48,49]

The volatile organic compounds that make up the aromas may also enter the blood stream via the lung mucosa when inhaled[50,51] and can pass across the blood brain barrier to deliver direct pharmacological effects. In vitro studies have demonstrated that extracts of rosemary display inhibition of both butyrylcholinesterase and acetylcholinesterase enzymes[52] and direct absorption of active compounds may be related to the cognitive enhancing effects reported for this essential oil.[53] The design of the current study does not permit for evidence in favour of either mechanism, but the positive findings should provoke further investigation.

An important concept in aromatherapy interventions and one that is pertinent here when investigating the effectiveness of blended oils is that of synergy.[54] Synergy suggests that a combination of products produces something with multiple modes of action whereby the whole is greater than the sum of its parts. Given that individual essential oils are made up of many components it is not perhaps surprising that synergy exists within individual oils. For example, lemon grass contains the active antibacterial components neral and citral but their activity is strengthened by the presence of a non-active component, myrcene.[55] Similarly, although demonstrated to be pharmacologically active in vitro,[56] 1-8 cineole has no behavioural effects when isolated,[57] but when present as a major component in rosemary[58] and sage[59] essential oils is linked to cognitive enhancement, effects that are likely to be a consequence of synergy with other minor components. The blending of essential oils as in the production of the 'Stress-less' product employed in the current study is predicated on the basis of synergy. Lema oil® is made from a combination of tea tree and the polar fraction of Manuka. Excellent synergistic bacteriological effects were reported by Christoph, et al.,[60] for this blend when compared to the effects of the individual components, although only additive effects were found when considering respiratory pathogens.[61] As such, synergistic effects are not a definite outcome. Indeed,[62] report combinations that range from synergy to antagonism, whereby active compounds with different mechanisms produce inactivity in the blend. The results of the current study do not inform on the possibility of synergistic effects as the individual components were not tested separately. Such an investigation would be of value. Although there are many papers that report the outcomes of different extraction techniques on essential oil content and quality[63–67] this is the first study to the authors knowledge that makes a direct comparison of blends derived from two of the techniques in a clinical aromatherapy context. The findings suggest that the extraction types differ little, if at all in their effectiveness as a treatment for stress. This may be of great interest to clinical aromatherapists who might be pressured to change their oils due to environmental of economic factors.

Conclusion

This study makes a significant contribution to the field because it considers the effectiveness of an eight-week period of aromatherapy treatment with either CO_2 or traditionally extracted essential oils in clients actively seeking relief from chronic stress. The benefits of

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the treatments are clear in both subjective and objective measures and support the potential value of aromatherapy as an alternative or complimentary approach for the reduction in stress.

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Conflicts of interest

The author declares there is no conflict of interest.

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