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The Effects of Essential Oils on Perception of Exertion and Task Pleasantness

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ABSTRACT

Purpose: The current study explored the effects of essential oils on perception of exertion and exercise task pleasantness. **Method**: Thirty college students (24 women, 6 men) were recruited to perform a handgrip task. Participants were randomly assigned to placebo, bergamot odor, and peppermint odor groups. Adhesive strips were placed under the noses of all participants, with participants in the latter two groups having strips containing essential oils. The placebo group had a strip with no odor. After establishing a maximal voluntary contraction level, participants performed at 30% of their maximum for as long as they could tolerate, during which they provided ratings of perceived exertion (RPE) at 30 second intervals. Task-specific self-efficacy and pleasantness were evaluated post-task. **Results:** Nonparametric analysis using Kruskal Wallis with Bonferroni adjustments failed to reveal significant differences among the groups on total grip time, session RPE, and grip time up to and after participants reported a RPE of 13. Statistical differences were found between placebo and essential oil groups regarding task pleasantness ($p=0.01$). The placebo group reported higher pleasantness scores than essential oil groups. **Conclusion:** Although nonsignificant, findings suggest that bergamot essential oil may provide a more pleasant exercise experience than peppermint essential oil. This work expands the knowledge on the relationships between essential oils.

Keywords: enjoyment, environment, exercise, performance, self-efficacy

1. INTRODUCTION

Essential oils have become more popular for their many aromatherapy benefits as they are used in alternative medicine, recovery products, and additives in many body products (e.g., lotion; NIH: National Cancer Institute n.d.; Navarra et al., 2015). Essential oils are known to be beneficial due to their chemical compounds, which have antibacterial, antiviral, antifungal, anti-inflammatory, and other medicinal properties (Bakkali, 2008; Navarra et al., 2015). Olfaction or smelling is the safest way to reap the benefits of these oils. To that end, olfaction can be defined as the body's sense of smell. There are however imbalances in olfaction research, with more research papers on visual attention as opposed to olfactory attention (Keller, 2011). This is surprising, considering how closely olfaction and cognitive processes are linked (Marchand & Arsenaukt, 2002; Soudry et al., 2011). There is some evidence that smelling certain types of essential oils during bouts of exercise may affect task-related attentional focus, task pleasantness, and rate of perceived exertion (RPE; Basevitch et al., 2011; Millot et al., 2002; Syränen et al., 2019). However, it would be helpful to identify the essential oils that provide favorable results during exercise (Basevitch, 2011; Razon et al., 2014).

Exercise adherence remains a challenge for a sizable portion of the population, as around 50% discontinue participation in an exercise program before the first six months (Robinson & Rogers, 1994). Research that focuses on essential oil and their ergogenic effects may be helpful in increasing adherence to exercise, especially if their use allows exercise to be more pleasant and/or less exertive to an individual (Basevitch, 2011; Jaradat et al, 2016). As such, exercise dropout rates are a major issue for gyms, personal trainers, and healthcare professionals (Whiteman-Sandland et al., 2018). A limiting factor when it comes to exercise adherence is often the unpleasantness and discomfort experienced during exercise (Ekkekakis et al., 2011; Ekkekakis, 2017).

It is important to understand the cognitive mechanisms behind olfaction. During olfaction, aromatic molecules are inhaled through the nose and travel to the olfactory mucosa. This mucosa contains olfactory receptor neurons. When the molecules attach to these receptor neurons, a sequence of chemical reactions create an electrical signal which eventually reaches the olfactory bulbs. These bulbs are projections of the brain. Olfaction is the only one of the five senses that does not relay information through the Thalamus first. Researchers suggest that strong connections between perception, memory, smell, and emotion occur during olfaction (Holden, 2006).

Of exercise-related perceptions, exertion and reports of exertion ratings indicate how strenuous an individual finds the exercise task to be (Borg, 1982). Both the body and the mind can fatigue during strenuous exercise. Consequently, if a participant perceives less RPE, they can adhere to an exercise task for an extended amount of time (Razon et al., 2014). Specifically, if interventions such as the use of the essential oils have potentials to help individuals not feel as exhausted during exercise, their task adherence and endurance may increase.

In fact, there is some evidence that suggests lowering RPE via olfaction may render exercise less tiring and more pleasant for individuals (Kim et al., 2018). Specifically, recent findings have shown that in isotonic exercises, individuals exposed to an aroma oil mixture odorant (i.e., lavender, rosemary, and peppermint) have significantly reduced their RPE relative to a control group (Kim et al., 2018). Furthermore, participants in this study suffered from patellofemoral pain syndrome, which means they experienced intense pain in their legs during effort expenditure. Despite their discomfort, exposure to the oil mixture was still associated with lowered RPE in these participants (Kim et al., 2018).

To reiterate the link between emotions and exercise adherence, the threshold for exercise tolerance can also be lowered because of the aversive affective responses to exercise (Ekkekakis et al., 2011; Ekkekakis, 2013). Evidence also suggests that pleasant odors can help create more positive emotions and affective responses in individuals as compared to neutral odors (Han et al., 2017; Kim et al., 2018). Early findings have indicated that for participants who held their hand in a hot, circulating bath for three minutes, physical discomfort was found to be decreased when pleasant odors were present, which created positive mood states as well (Marchand & Arsenault, 2002). Regarding types of oils used in studies, there is limited research on essential oils and their ergogenic effects, which have focused on popular scents including peppermint and lavender (Jaradat et al., 2016; Torabi et al., 2017). Peppermint oil is known to have pain reducing effects (Kim et al., 2018). To our knowledge, bergamot essential oil has yet to be investigated in exercise settings to reduce pain. The effects of bergamot oil on affect have been studied in other settings (e.g., mental health waiting rooms; Han et al., 2017). Han and colleagues (2017) found that aromatherapy of bergamot oil dispersed into the waiting room increased positive affect (i.e., feeling proud and active; p=0.07) and decreased negative affect (i.e., nervousness; p=0.06) for those in the treatment group (n=45) compared to the controlled group (n=12). Further, Navarra and colleagues (2015) provide evidence from ten clinical studies that bergamot essential oil reduces stress and anxiety symptoms.

Consequently, researchers have called for additional investigations of the efficacy of alternative odorants within different effort settings (Basevitch, 2011; Jaradat et al., 2016). Of interest to the present study are the effects of essential oils on RPE and task pleasantness during exercise. The rationale behind this research relates to the notion that a pleasant olfactory stimulus may potentially help reduce aversive sensations associated with effort, hence facilitating exercise related enjoyment and adherence. Of interest herein, is to further explore the effects of bergamot oil and other scents within strength-endurance settings where individuals need to relax and push their effort depending on task requirements.

Therefore, the purpose of this study is to test the ergogenic potentials of peppermint and bergamot essential oils during a strength-endurance task within a non-clinical sample. Specifically, this study will explore whether peppermint and bergamot essential oils relative to a placebo condition can influence RPE and task pleasantness during a handgrip squeezing task within a heathy college aged sample (Leitzelar et al., 2017). Consequently, we hypothesized that individuals exposed to peppermint and bergamot oil relative to others in the placebo group will score significantly lower on RPE and higher on task-pleasantness while also tolerating the task longer. Our findings explore the claims associated with the use of peppermint and bergamot essential oils. From a practical standpoint, if enough evidence exists for the use of these odorants, individuals may gain an efficient and cost-effective tool to optimize exercise-related affects and exercise tolerance.

2. METHODS

2.1 Participants

Necessary sample size was determined using G*Power 3.1 software assuming a moderate effect size, and to achieve sufficient power (0.95) a sample size greater than 90 (three groups of 30) was required. A convenience sample of participants was recruited for this exploratory study and study participation fell short (three groups of ten). Important to note, the Covid-19 pandemic had a negative effect on participation in the current investigation, which impacted the statistical power of the results of the present study (Stoto et al., 2022). Lee (2020) reviewed (n=523) published articles involving clinical trials on Covid-19 during the Covid-19 pandemic. Many in-person clinical trials faced challenges with power and sample size during this time. They were also found to conclude inaccurate results without mentioning the *a priori* power and sample size required. The authors of the current study make a note of the required sample size and suggest replication of this study, in the future, with increased sample sizes in each group (Lee, 2020). As this study is exploratory in nature, the current sample size was adequate and reflects the sample sizes of previous research (Han et al., 2017; n=57; Jaradat et al., 2016; n=20; Kim et al., 2018; n=7).

A total of 30 participants (women=24, men=6; *M*age=20.6, *SD*=1.58) were recruited via advertisements, flyers, information sheets, and internet postings from a college in the Northeastern U.S. to participate in the study. Participants were randomly assigned to three conditions: (a) peppermint (n=10), (b) placebo (n=10), and (c) bergamot (n=10). Before the study, participants signed a university-approved informed consent form in accordance with the Declaration of Helsinki, in addition to a health history questionnaire. This ensured that participants could safely participate in the study. Only healthy participants who did not indicate any allergies related to the olfactory system and/or counter indication to exercise-testing were included in the study. The university's institutional review board approved this study, and no data collected occurred prior to this approval.

2.2 Procedure

Data collection took place in the Human Performance Laboratory of the university. A detailed explanation of the study was given to the participants, who then signed the informed consent form. Next, the participants completed the health history questionnaire, TSSE scale, and the first question of the Pleasantness Rating. Prior to assigning groups, participants were asked if they were sensitive to essential oils. Participants were partially randomly assigned to one of three groups: (1) Peppermint, (2), Bergamot, or (3) Placebo (no oil exposure: water). Participants, who were not sure whether they were sensitive to essential oils were unknowingly assigned to the Placebo condition. For standardization purposes, each participant performed three trials using the handgrip dynamometer. Consistent with previously validated protocols (Basevitch et al., 2011), each participant was instructed to squeeze the handgrip dynamometer with maximal effort in one movement. They completed three maximal efforts trials while holding an upright position. The highest value in kg was recorded as the participant's maximum strength and 30% of this value was computed for use during the task performance. Three drops of essential oil or control oil, approximately 150 mL, was then applied to an adhesive bandage with a cotton ball attached. The adhesive bandage was applied under the participants' nose and above their upper lip. The purpose of the cotton ball was to create a barrier between the oil and the skin to avoid possible irritation. Next, for the purpose of the testing protocol, participants were instructed to squeeze the dynamometer at their 30% max strength for as long as they could or until volitional fatigue. RPE was recorded 30 seconds into the testing period and then continuously recorded every 30 seconds. It was also noted by the researcher on the data sheet the time when the participant reached an RPE of 13 and the total grip time after 13 RPE to exhaustion. An RPE of 13 is rated as "Somewhat Hard" and when fatigue began for the participant. The test administrator also monitored the dynamometer to ensure the participant was squeezing at the pre-determined 30% maximum squeezing value. If the participant failed to squeeze at the proper weight once, the administrator will ask them to squeeze more or less to return to the 30% value. If the participant failed again, the test was terminated. When the participant stopped squeezing, the stopwatch was paused. At the completion of the test, the adhesive bandage was removed. Time on task was recorded. The participant then completed the rest of the Pleasantness Rating questions and the Commitment Check. The participant was also asked to rate the entire exercise task as one number using the same RPE scale, which was recorded as session RPE.

For the purposes of the present study, peppermint essential oil *(Mentha piperita)* was chosen because it represents a stimulating odor, based on previous research (Raudenbush et al., 2009). Bergamot essential oil *(Citrus bergamia)* was chosen to explore utilizing this oil in exercise settings. In a previous study, one drop or approximately 50 mL of oil was placed on the adhesive strip under the nose. However, researchers have suggested the dose amount of 50 mL is not sufficient to induce any sort of effect (Basevitch et al., 2011). A specific recommendation was not given. Drawing upon the results of Basevitch and colleagues' pilot study, three drops or approximately 150 mL of an oil will be sufficient for each participant.

2.3 Health History Questionnaire

This pre-screening form was used to verify the participant was able to participate in the study with minimal to no risk of injury. It was also used to keep track of demographic data.

2.4 Rate of Perceived Exertion (RPE; Borg, 1982)

This scale was used to measure the participants' perceived exertion during the squeezing of the dynamometer. RPE is a 20-point category-ratio scale that begins with 6 (no exertion at all) to 20 (maximal exertion). The usage of this scale is common in laboratory testing and has been found to be a reliable measure (e.g., Mathiassen et al., 2014; McGorry et al., 2010; Spielholz, 2006).

2.5 Commitment Check

This form was used to measure how committed to the exercise task each participant was. Three questions were answered by means of a rating scale from 0 (none/not at all) to 5 (very much/very well).

2.6 Task-specific self-efficacy (TSSE, Bandura, 1986; 1997)

This scale helped determine to what capacity the participants believe in their ability to successfully complete the task. The results from the scale were used to ensure that participants do not differ from each other in their self-efficacy beliefs regarding the squeezing task.

2.7 Pleasantness rating

This scale was used to evaluate the participants' experience with the essential oils as well as the exercise task overall. The first question was answered before participants began the test, and three remaining questions were answered at task completion. The question "How would you rank your mood?" was asked pre-test (first question) and post-test (fourth question). Questions two and three were also asked post-test. Test subjects answered all four questions using a scale from 1-5. One indicated negative/unpleasant feelings, three indicated neutral/indifference, and 5 indicated positive/pleasant feelings.

2.8 Apparatus and Handgrip Test

A calibrated handgrip dynamometer was used to measure handgrip strength (Takei Physical Fitness Test Grip-A Grip Strength Dynamometer, Tokyo, Japan). The handgrip test is an effective method of inducing exertional symptoms (e.g., muscular fatigue/discomfort), while exposing participants to minimal risks (Leitzelar et al., 2017). While handgrip squeezing is not a common activity otherwise, it is an appropriate task in testing the hypotheses of the current study. This method is consistent with previous work which also implemented a handgrip test to volitional fatigue (Basevitch et al., 2011; Razon et al., 2009). A stopwatch was used to record time.

2.9 Statistical Analyses

A placebo-control design was used for this exploratory study. A nonparametric Kruskal Wallis test with Bonferroni correction was used to compare total grip time, session RPE, and grip time up to and after 13 RPE across the three experimental conditions. Descriptive statistics and Post Hoc tests were also performed on the same variables. Effect sizes were calculated using transformed rank cases of each variable through a comparison of means. A Chi-Square test was used to analyze exercise task pleasantness. All data analyses were completed using SPSS 27 for Mac with an alpha level set at 0.05 to determine significance. Bonferroni adjusted *p* values were reported.

3. RESULTS

Due to small sample size (n_{total}=30, $n_{peppermint}$=10, $n_{Bergamont}$=10, $n_{placebo}$=10) the distribution of each of these groups were skewed. Considering the median value is better suited for skewed distributions to derive at central tendency, since median is a more robust and sensible value to rely on for skewed distributions. Looking at the median value of each group (see Figure 1), participants with bergamot held longer contractions than participants in the peppermint and placebo groups. The placebo group may appear to have held longer based on the visual inspection of the plot, but that is due to the number of outliers the placebo group included. Hence the use of the median value instead of mean, which is sensitive to outliers, is used (see Table 1). Interestingly, participants who were in the placebo group performed better than participants with peppermint. This is an unexpected result that does not support our hypothesis.

Table 1

Median Values for Each of the Three Condition Groups

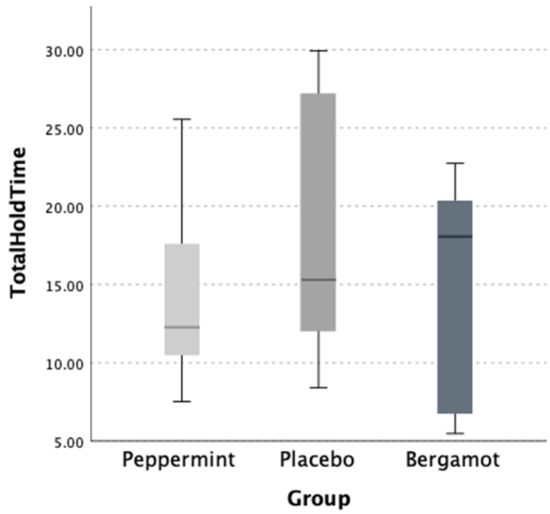
Group (sample size)	Median
Peppermint (*n*=10)	12.27
Bergamot (*n*=10)	18.07
Placebo (*n*=10)	15.31

3.1 Total Grip Time

A nonparametric Kruskal Wallis test with Bonferroni correction analyzing total grip time across the three experimental conditions (peppermint, placebo, bergamot) was performed. There were no significant findings as seen in Figure 1 ($H(2)=1.15$, $p=0.563$, $\eta^2=0.04$).

Figure 1

Total Grip Time in Minutes for Each of the Three Conditions

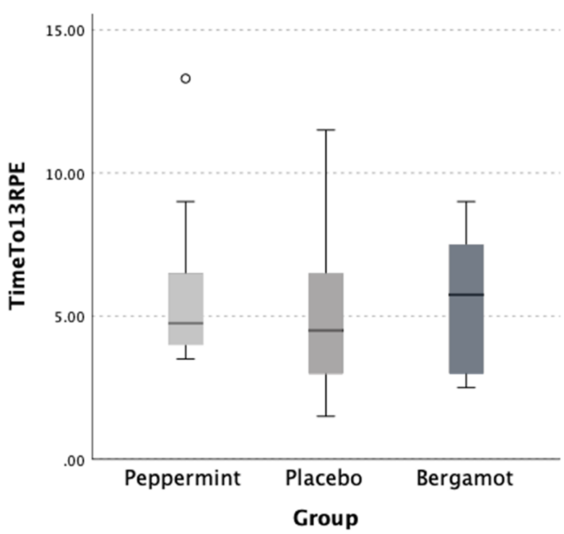


3.2 Session RPE

A nonparametric Kruskal Wallis test with Bonferroni correction was used to compare total session RPE across the three experimental conditions. There were no significant findings ($H(2)=2.51$, $p=0.285$, $\eta^2=0.09$).

Figure 2

Grip Time in Minutes by Condition up to a RPE of 13



3.3 Grip Time up to/after 13

A nonparametric Kruskal Wallis test with Bonferroni correction was used to compare time held until participants reported a RPE score of 13 and time held after reporting a RPE score of 13. There were no significant findings between the three conditions up to ($H(2)=0.35$, $p=0.841$, $\eta^2=.0.01$) or after ($H(2)=1.09$, $p=0.579$, $\eta^2=0.04$) reporting a RPE score of 13. Figures 2 and 3 show the non-significant differences.

Figure 3

Grip Time in Minutes by Condition from Reporting a RPE of 13

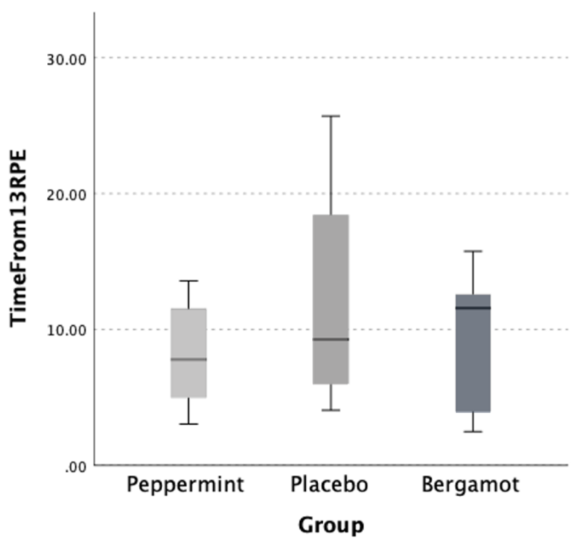


Table 2

*Task Pleasantness * Group Cross Tabulation: Cross Tabulation Analysis of Task Pleasantness for Each of The Three Conditions*

		Group			
	Count	Peppermint	Placebo	Bergamot	Total
Task Pleasantness	2	1	1	3	5
	3	6	2	2	10
	4	2	1	5	8
	5	1	6	0	7
Total		10	10	10	30

Note. Respondents were asked to rate task pleasantness pre and post test on a scale of 1-5.

3.4 Pleasantness

A Chi-Square test was performed to analyze task pleasantness in each of the three conditions. Participants rated the placebo condition to be the most pleasant condition, (*n*=6, Pleasant). Most participants rated Bergamot as Mildly Pleasant, (*n*=5, Mildly Pleasant). Peppermint was the lowest rated condition for the exercise task, (*n*=6, Neutral). When compared to an alpha level of 0.05, the significance level was 0.01, indicating that there was a significant difference between the three conditions as seen in Tables 2 and 3.

Table 3

*Smell Pleasantness * Group Crosstabulation: Crosstabulation Analysis of Smell Pleasantness for Each of The Three Conditions*

		Group			
	Count	Peppermint	Placebo	Bergamot	Total
Smell Pleasantness	3	0	2	0	2
	4	7	3	2	12
	5	3	5	8	16
Total		10	10	10	30

Note. Respondents were asked to rate smell pleasantness pre and post test on a scale of 1-5.

3.5 Gender

After examining each group by age, gender, pre-test mood, task pleasantness, and smell pleasantness using a Chi-Squared test, there was no difference between men and women participants (p=0.266) or across age (p=0.352). However, participants in the peppermint group had lower task and smell pleasantness rates compared to others.

4. DISCUSSION

The purpose of this study was to investigate how essential oils affect the perception of exercise intensity and pleasantness. First, we hypothesized that participants who were smelling the two essential oils would have an increased grip time. Secondly, we hypothesized that the participant would rate the overall session as a lower RPE than the placebo. Lastly, we hypothesized that the essential oils would have an increased pleasantness rating than the placebo. While previous research has indicated that there may be some link between essential oils and exercise (Razon et al., 2014), our results did not display a strong connection.

Regarding our first hypothesis, there was no significant difference in total grip time between either of the three groups. Similarly, there was not a significant difference between the three conditions and grip time up to and after and RPE of 13. Basevitch et al. (2011) found in their study that smelling essential oils during a grip strength, endurance task did not produce a longer holding time either.

Session RPE was an RPE rating given by the participant, that they felt was an appropriate indicator of how hard the exercise task was on average throughout the entire duration. In this study, there was no significant difference in RPE between the three conditions. However, those in the placebo group indicated lowest amount of effort. This is interesting considering that the placebo group also had the longest holding time after an RPE of 13 was reached. This could mean that the participants in the placebo condition were able to hold longer and feel as though they were not exerting a large amount of effort. Participants exposed to peppermint had a lower session RPE than the participants exposed to bergamot, but this was not statistically significant. Peppermint has been a leading condition in many studies regarding olfaction, and these results add to the strength of those previous findings (Jaradat et al., 2016; Kim et al., 2018). Task pleasantness was rated the highest among the placebo group. Again, we did not anticipate the placebo-conditioned participants to outperform the essential oil-conditioned participants. However, bergamot on average made the task more pleasant than those who were exposed to peppermint. It is interesting to note this data because there is not much research on the bergamot essential oil and exercise, which could aid in increasing exercise adherence if it were to make the task more pleasant (Marchand & Arsenault, 2002).

In this study, the participant group exposed to the placebo held longer during the grip strength task and rated that they were not exerting as much force as the other groups. They were not in contact with either of the essential oil conditions. However, during the experiment, anecdotally, it was noted that some participants remarked that the placebo “smelled good”, even though there was no smell. A placebo effect could have taken place during the data collection of this project. This has been reported in many research studies and clinical trials (Llewellyn et al., 2019), which renders the explanation of these outcomes somewhat difficult.

There are several limitations to note. First, thirty participants with 10 per condition was a small sample size. This was due to social distancing limitations of the Covid-19 pandemic. Stoto and colleagues (2022) posit the importance of designing appropriate studies within the context of Covid-19 or a pandemic going forward, including methods of recruitment and analysis. Additionally, a low number of participants can make it difficult to produce significant findings (Jaradat et al., 2016). There was also a small number of men versus women. It may be of importance to study the relationship between exercise and essential oils, but also analyze the differences in gender in the future. Thus, this study should be replicated with a larger sample size (Han et al., 2017; Lee, 2020). Another limitation that arose during the study was we did not analyze whether each participant had previous experience using essential oils or enjoyed the smell of the chosen essential oils at rest. Using the oils frequently, even to the point of daily use, may influence how accustomed participants are to the smell. This might render the effects of the oils as more or less influential during the tests (Pellegrino et al., 2017).

5. CONCLUSIONS

Exercise adherence remains a challenge for a sizable portion of the population. Exercise attrition can be an obstacle for health clubs, personal trainers, and healthcare professionals. Strategies to lower RPE and increase task-pleasantness can assist with exercise tolerance and long term adherence. While little significant connection was found between exercise and essential oils in this study, it did provide some evidence to support the use of bergamot to assist with exercise adherence. Bergamot provided participants exposed to it a mildly pleasant exercise experience. Further studies are needed to thoroughly investigate bergamot oil, not only in relation to exercise, but in other strenuous or stressful settings as well. Future studies could include other essential oils as well as other aroma delivery methods, like oil diffusers (Han et al., 2017). The implications of this study include using essential oils to increase exercise tolerance for individuals who are struggling to adhere to exercise regimes. Those who experience positive emotions while exercising may ultimately adhere to a consistent exercise routine and subsequently, increase their overall health and wellness.

6. ACKNOWLEDGEMENTS

6.1 Disclosure of Funding Sources

None.

6.2 Conflict of Interest

The authors declare no conflicts of interest.

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