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Title: Aerobic capacity is not improved following 10-day supplementation with peppermint essential oil

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Abstract

This study examined the effects of peppermint essential oil (PEP) on aerobic capacity. Seven healthy participants performed a graded maximal exercise test following 10-days of ingesting either PEP or a control in a randomised cross-over design. There was no significant difference between control and PEP trials for expired gas variables ($\dot{V}O_2$ peak 3.54 vs. 3.52 L/min) or performance measures (time to exhaustion 583.33 vs. 587.04 seconds). Similarly, resting cardio-pulmonary measures were also unchanged between visits.

Key words: Nutrition, $\dot{V}O_2$ peak, performance, ergogenic aids

Introduction

The ingestion of peppermint has typically been reserved and advocated for use in treating digestive complaints due to its pain-killing and anti-inflammatory properties (Della Loggia et al. 1990, Mimica-Dukić et al. 2003). However there is also evidence that peppermint ingestion may have a benefit for sporting performance, as oral administration of peppermint essential oil has been shown to reduce blood lactate concentrations following a 400 m run (Sönmez et al. 2010) and cause increments in isometric hand-grip strength (36.1%) and standing vertical jump (7.0%) performances, withn 60 minutes post-consumption (Meamarbashi 2014). Further research from Meamarbashi and Rajabi (2013) investigated the effects of 10-day peppermint essential oil supplementation (0.05 ml/day) on cardiorespiratory exercise performance. Respiratory gas analysis, collected during a graded maximal exercise test revealed mean increases in maximal oxygen uptake ($\dot{V}O_2$ max) (10.5%), in addition to a 24.9% increase in time to exhaustion. Forced vital capacity increased by 4.8%, whilst peppermint ingestion also resulted in statistically significant reductions in resting heart rate (-4.8%) and systolic blood pressure (-6.2%). Some of the possible mechanisms for the improvements in exercise capacity could include an increased pain threshold (Mauskop 2001), relaxation of bronchial smooth muscle tonicity (Meamarbashi and Rajabi 2013), enhanced clearing of blood lactate (Sönmez et al. 2010) or a stimulating effect on the brain (Meamarbashi 2014). However, the authors were unable to explain reductions in resting heart rate and systolic blood pressure.

If peppermint was to emerge as a potent ergogenic aid, it could offer a natural alternative to sport supplements for high-level and recreational athletes. However, although it appears feasible that the previously observed physiological changes induced by peppermint could

have possible ergogenic benefits, some of the reported effects have been considerable. Such increases warrant further investigation, particularly when considering other authors have reported much less substantial improvements in cardio-respiratory parameters following a period of intense exercise training (Helgerud et al. 2007, Aagaard et al. 2011). The effects observed by Meamarbashi and Rajabi (2013) may be the result of a serious flaw in their design, as all participants were tested pre and post supplementation, with no evidence of randomisation. Therefore, a learning effect may have occurred. The aim of this study was to investigate the effects of 10-day supplementation with peppermint essential oil on cardiorespiratory and exercise performance during a graded maximal exercise test.

Methods

Participants

Seven (4 male and 3 female) physically active participants (3-4 hours of exercise per week) volunteered to take part in the study, (age 24.57 ± 3.95 years, body mass 74.81 ± 15.16 kg, height 175.46 ± 7.48 cm). The study was cleared by the institution's ethics committee, and all volunteers provided written informed consent.

Experimental Design

The experimental approach to the research employed a single blind (researcher), randomised, cross-over design. The study was single blinded due to difficulties in masking the peppermint.

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Participants completed a total of 4 laboratory sessions, comprising of (i) a familiaristaion/screening session, (ii) baseline measurements and (iii/iv) testing under control (CONT) and experimental (PEP) conditions in a randomised order (with a seven-day washout period in between). Peppermint and menthol are typically metabolised and excreted within 24-hours (Somerville et al. 1984, Kohlert et al. 2000). All participants were familiarised with the laboratory setting and the measurement techniques prior to the onset of data collection, in an attempt to reduce measurement error. Resting measurements for anthropometric data and cardio-pulmonary parameters were performed first. This was followed by the same maximal exercise protocol, in which further assessments for pulmonary gas exchange and exercise performance were monitored continuously.

After the completion of all baseline measurements in visit two, participants were randomly assigned into two groups, using an online random number generator. Group one received 10-days of peppermint essential oil supplementation, followed by 10- days of control supplementation after a 7-day washout period. Group two received the same supplements, but in an alternate fashion (control – peppermint). Exercise testing took place at the end of each respective 10-day supplementation period. Peppermint supplements were prepared by adding 0.05 ml to 500 ml of still natural mineral water (Meamarbashi and Rajabi 2013). During the control period participants consumed 500 ml of still natural mineral water. It is acknowledged that this may not be as appropriate as a taste matched placebo, but this could not be achieved as the odour of the peppermint may be as ergogenic as the ingestion (Zoladz and Raudenbush 2005). The peppermint essential oil was commercially available (Holland and Barrett Retail Limited, Warwickshire, UK). Nutritional properties of the oil were 100% pure Japanese oil of peppermint.

Reliability Analysis of Physiological Measurements

Data from familiarisation and baseline trials were subjected to reliability analysis, with the results indicated throughout the methods section. Firstly, the coefficient of variation (CV), used to calculate within-subject variation scores and relative variability across measures employed within the study, was expressed to the nearest 0.01 percent (%), whereby individual variation scores were calculated using the formula seen in equation 1. The mean of all individual CV scores were reported as each measures overall CV%. Secondly, the technical error of measurement (TEM) was used to indicate the precision of each associated measurement, in regards to investigator and instrument error. Absolute TEM was calculated using a previously established formula (Hopkins 2000) shown in equation 2. Reported TEM scores were expressed in the same units as the measured variable, to the nearest 0.01.

$$\text{Individual CV \%} = \left(\frac{\text{SD (Fam*:t1*)}}{\text{Mean (Fam*:t1*)}} \right) \times 100$$

Equation 1. Individual CV formula to calculate the variation between measures. The mean of all individual data was then calculated as the overall CV% for each measure. *Fam refers to the mean recorded result for one independent measure from familiarisation trials in the study. *t1 is the mean result recorded from testing day 1 for 1 independent measurement within the study.

$$\text{Absolute TEM} = \sqrt{\sum *d^2 / 2n*}$$

Equation 2. TEM formula sampled from Hopkins (2000). Each variable assessed in experimental trials was subject to TEM investigations. *d refers to difference in mean scores from the familiarisation and baseline trial. *n refers to the amount of trials subject to TEM assessment.

Cardio-Pulmonary Tests

Resting heart rate (RHR) (CV=9.62%; TEM= 10.53 bpm) was measured telemetrically using a Polar s610i HR monitor and transmitter (Polar Electro, Oy, Kempele, Finland). Systolic (SBP) (CV=4.56%; TEM=6.46mmHg) and diastolic (DBP) (CV=3.64%; TEM=2.94mmHg) blood pressure measurements were acquired using an OMORON Pro-Logic PL100 (OMORON Healthcare UK Ltd., Milton Keynes, UK) oscillometric device and monitor. Resting pulmonary function tests were performed using a Micro DL handheld electric turbine spirometer (Carefusion UK 236 Ltd, Basingstoke, England) for measurements of; forced vital capacity (FVC) (CV=3.98%; TEM =0.26 L), forced expiratory volume in one second (FEV^{-1}) (CV=4.43%; TEM=0.21 L), and FEV^{-1}/FVC % (CV=1.60%; TEM=1.77%). Chest circumferences at maximum inhalation (CV=0.98%; TEM=1.31cm) and maximum exhalation (CV=1.82%; TEM=2.87cm) were acquired using a Seca 201 ergonomic circumference measuring tape (Seca, Hamburg, Germany).

Maximal Exercise Test

All exercise tests were conducted on a Velotron Pro cycle ergometer (Racermate Inc, USA). Participants completed a ramp style exercise protocol which started at 0 W, and increased by 30 W every 60 seconds (1 W every 2 secs) until volitional exhaustion (Larson et al. 2015). Participants self-selected their cadence throughout each test, however a minimum cadence threshold of 60 rpm was enforced. Exercise tolerance/volitional exhaustion was defined as the point in each test at which the cadence had been below the predetermined requirement for test cadence, minus 3 rpm for more than 5 consecutive seconds. Expired air was averaged over 15-second periods, and analysed continuously using a cardiopulmonary exercise system, on a breath by breath basis using an online metabolic cart (Cortex Metalysyer 3B, Biophysik, Germany). Expirate was analysed for maximal $\dot{V}O_2$ (L/min^{-1}), ventilation (VE), and

respiratory exchange ratio (RER). Data for work done (KJ), peak power output (PPO; W) and time to exhaustion was extracted from the cycle ergometer.

Statistical Analyses

All statistical analyses were completed using IBM SPSS Statistics 22 (SPSS Inc., Chicago, IL). Central tendency and dispersion of the sample data are represented as the mean $\pm$ SD. The data was analysed by a non-parametric test due to the difficulty associated with checking smaller sample sizes for normal distribution. Differences between PEP and CONT conditions were therefore analysed using the Wilcoxon signed-rank test, with two-tailed statistical significance accepted at $p < 0.05$. Effect sizes were calculated using the formula; (Mean of PEP – Mean of CONT) $\div$ Pooled standard deviation between trials. Statistics used to check reliability scores have been described in the respective part of the method.

Results

Physiological variables and performance parameters are presented in Table 1. Expired gas analysis during the maximal exercise test ($\dot{V}O_2$, $\dot{V}E$ and RER) was not significantly different between conditions ($p \geq 0.45$), with very small effect sizes (≤ 0.10). Similarly, performance outcomes during the test were comparable between condition ($p \geq 0.50$, ES ≤ 0.02). Resting cardio-pulmonary measures (FVC, FEV^{-1}, $FEV^{-1}/FVC\%$, SBP, DBP, RHR) were not significantly different between conditions ($p \geq 0.07$), however there was a moderate effect size for an increase in $FEV^{-1}/FVC\%$ in the PEP condition (0.43).

Discussion

The purpose of this study was to examine the effects of ingesting PEP for 10-days on exercise capacity during a graded maximal exercise test. A previously published study (Meamarbashi and Rajabi 2013) observed substantial increases in exercise performance, reporting a 10.5% increase in $\dot{V}O_2$ max, 24.9% increase in time to exhaustion and 51.5% increase in work completed following a 10-day supplementation period. Hence it was deemed appropriate to further investigate the efficacy of PEP ingestion as a potent ergogenic aid.

In contrast to this we do not report any performance benefit when participants consumed PEP compared to CONT. Moreover, the size of the effects do not even approach small-moderate levels for the expired gas analysis or performance parameters (Table 1). This is a vast difference to the findings of Meamarbashi and Rajabi (2013). Interestingly $\dot{V}O_2$ max increased by approximately 9% in both PEP and CONT in this study compared to baseline measurements, suggesting that the familiarisation sessions were necessary to remove a learning effect in the experimental conditions. The magnitude of this increase is of note as it is similar to the 10.5% increase witnessed by Meamarbashi and Rajabi (2013), who did not randomise the order of their trials, and therefore the benefits they observed may be due to a learning effect. Performance parameters (peak power, time to exhaustion and work done) improved by only ~1% in PEP and CONT compared to baseline in this study, much less than in Meamarbashi and Rajabi (2013). Therefore, it is unlikely that the increases in similar variables in the previous study is due to learning, but this is difficult to decipher without reproducibility data for the tests employed.

The results of this study also differ to Meamarbashi and Rajabi (2013) when examining resting cardio-pulmonary measurements. FVC was reported to increase significantly by 4.8% following 10-days PEP ingestion, whereas we witnessed an insignificant 0.04% change which was within the pre-determined TEM. This variable was also suggested to increase within 1-hour following PEP ingestion by Meamarbashi (2014), and Jaradat et al (2016) also observed increases in FVC when using another plant from the mentha genus (*M. spicata*), but this was administered a different way (nebuliser). Similarly RHR, SBP, and DBP were reported to significantly decrease following PEP ingestion by Meamarbashi and Rajabi (2013), but any changes in the current study were minimal and within the TEM for the measurement. Nagai et al (2000) have described reduced blood pressure during hand-grip exercise when performed in the presence of the participant's favoured odour, however it is unclear how many of the 26 participants selected peppermint as there was also the option of rose, sweet orange and lemon. The authors were unable to find any another studies examining specifically the effect of peppermint ingestion/inhalation on resting cardio-pulmonary measures. FEV^{-1} was not measured in past work, but has been included in the present study. Neither FEV^{-1} nor $FEV^{-1}/FVC\%$ increased significantly following PEP, however PEP had a moderate effect upon $FEV^{-1}/FVC\%$ (0.43) and the average increase of 2.42 was greater than the TEM (1.77). It should be considered that this study was not powered to determine a difference in $FEV^{-1}/FVC\%$ as it was not the primary outcome measure, therefore future work with a greater number of participants is warranted to further examine the effects of peppermint on this parameter. Chest circumference at maximum exhalation was significantly different between conditions (p = 0.03), however if put into context the average difference was within the pre-determined TEM.

Although this discussion constitutes largely as a comparison to the work of Meamarbashi and Rajabi (2013), it must be acknowledged that theirs is not the only study to demonstrate an ergogenic effect, it is simply the protocol that most closely resembles the current work. We do not discount that peppermint may have the potential to be ergogenic, as authors have suggested some mechanisms as to how this could be achieved such as increased pain threshold (Mauskop 2001), relaxation of bronchial smooth muscle tonicity (Meamarbashi and Rajabi 2013), enhanced clearing of blood lactate (Sönmez et al. 2010) or a stimulating effect on the brain (Meamarbashi 2014). The present study has its own limitations such as the relatively low sample size and single-blind design, and it also cannot be discounted that the peppermint essential oil utilised in this study may not have been as potent as in past work. Moreover the average maximal $\dot{V}O_2$ was approximately 0.8 L/min higher in our participants than in the previous study, so base-line physical capacities may affect the efficacy of peppermint as an ergogenic aid. However, the present data suggest that research in this area needs to be better controlled to truly understand the size of the effect of peppermint, and future work should look to establish an agreed method of delivery (i.e. optimal dosages for ingestion or nebulisers). Moreover, these findings highlight the importance of replication studies, particularly in the field of sport and exercise nutrition which is becoming increasingly commercial. In summary 10-day supplementation with peppermint essential oil had no effect upon aerobic capacity and performance during a graded maximal exercise test compared to a control.

Conflict of interest statement

The authors declare that there are no conflicts of interest

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Table 1. Physiological and performance parameters in the CONT and PEP trials

Parameter	CONT (n = 7)	PEP (n = 7)	% change	P value	Effect size
Physiological Parameters					
$\dot{V}O_2$ peak (L/min)	3.54 ± 1.52	3.52 ± 1.25	-0.52	0.87	-0.01
$\dot{V}$E peak (L/min)	144.33 ± 50.29	143.61 ± 44.13	-0.50	0.61	-0.02
RER	1.36 ± 0.13	1.33 ± 0.08	-2.00	0.45	-0.25
FVC (L)	3.93 ± 0.88	3.93 ± 0.88	0.04	0.75	0.01
FEV^{-1} (L)	3.24 ±0.67	3.33 ± 0.66	2.74	0.13	0.13
FEV^{-1}/FVC (%)	82.29 ± 5.62	84.71 ± 6.10	2.95	0.07	0.43
Resting systolic blood pressure (mmHg)	122.00 ± 13.64	121.43 ± 11.43	-0.47	0.74	-0.04
Resting diastolic blood pressure (mmHg)	69.57 ± 5.26	67.57 ± 4.96	-2.87	0.07	-0.39
Resting heart rate (beats/min)	70.29 ± 7.34	72.00 ± 9.38	2.44	0.60	0.20
Chest circumference at max. inhale	97.47 ± 7.50	98.74 ± 7.90	1.30	0.23	0.17
Chest circumference at max. exhale	92.12 ± 6.64	93.83 ± 7.30	1.86	0.03	0.25
Performance Parameters					
Peak power (W)	291.71 ± 102.16	293.71 ± 98.05	0.69	0.50	0.02
Time to exhaustion (s)	583.33 ± 204.79	587.04 ± 196.53	0.64	0.50	0.02
Work (KJ)	94.08 ± 59.88	94.43 ± 57.27	0.38	0.50	0.01

Data is presented as means ± SD. RER = respiratory exchange ratio; FVC = forced vital capacity; FEV^{-1} = forced expiratory volume in one second.