Pleasant odors attenuate the blood pressure increase during rhythmic handgrip in humans

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Abstract

We have investigated the effects of inhaling odors of preference on physiological responses to physical exercise in college students. Rhythmic handgrip, maintaining a mercurial pressure by repetitive compression, increased blood pressure. In the participants exercised with inhaling odors of their choice, such as rose, jasmine and lavender, the increase in diastolic blood pressure during exercise was reduced by 24%. In contrast, the blood pressure increase during static handgrip, maintaining the power 30–40% of maximum, was not affected by the existence of favorite odors. Since the blood pressure increase during static handgrip is a lower brainstem reflex, the present result shows that the inhalation of favorite odors suppresses the muscle sympathetic vasoconstrictor activity and attenuates the blood pressure increase by affecting the central nervous system higher than the midbrain.

Keywords: Exercise; Blood pressure; Odorants

The presence of odors reveals a variety of psychophysiological actions. For example, the electroencephalograph (EEG) and task performance such as a response time [8] as well as mood and autonomic nervous functions [1] have been shown to be influenced by inhaling odors. We have previously reported that odors chosen by participants based on their preference reduce tension, anxiety and confusion of the participants and allow them to feel pleasant [15]. Pleasant odor and unpleasant odor have been shown to cause different effects on heart rate as well as EEG activities in humans at rest [3]. In the present experiments, we first evaluated the effect of inhaling pleasant odors on the cardiovascular changes during muscle exercise. Generally, an exercise increases blood pressure. However, rhythmic exercise and static exercise employ different mechanisms in increasing blood pressure. A dynamic exercise like rhythmic handgrip increases blood pressure, causing arterial vasoconstriction except in the working muscles. On the other hand, the muscle chemoreflex [11] plays an additional role in increasing blood pressure during a static exercise like sustained handgrip: an accumulation of muscle metabolites stimulates the sensory nerve endings in the working muscles and causes the increase in blood pressure employing the sympathetic nervous system as an efferent pathway of the reflex. Therefore, we have examined the effects of pleasant odors on cardiovascular changes, especially blood pressure, during both rhythmic handgrip and static one.

Participants were 26 undergraduates from the Tsuru Municipal University, Fujiyoshida School of Nursing, Yamanashi Eiwa College and Yamanashi University (six males and 20 females, aged between 18 and 24). All experimental procedures were performed in accordance with the Ethic Committee of Yamanashi Institute of Environmental Sciences. Essential oils of jasmine and lavender were gifts from Takasago International Corporation (Tokyo, Japan). Essential oils of rose, sweat orange, lemon and peppermint were purchased from PRANAROM (Enghien, Belgium). Participants who were subjected to the experiment with the presence of odors were asked to choose one of these six odors based on their preference. For examination of the preference, essential oils were diluted 10 000-fold by distilled water at 40°C.

Blood pressure was periodically measured on the left upper arm with an automatic blood pressure monitor by...
oscillometry (UA731, A & D, Tokyo, Japan). Respiratory movement, electrocardiogram, pulse wave of the left middle finger, and skin temperatures of the forehead and the left forefinger were continuously monitored with a polygraph system (type 365-12, GE Marquette Systems Japan, Tokyo, Japan), and computerized. Measurements were carried out individually in an artificial climatic chamber (TBR-4.5SA2GX, TABAI ESPEC Corp., Tokyo Japan). The air temperature and relative humidity of the climatic chamber were adjusted at the request of the participants: air temperatures varied between 24 and 25.5°C and the relative humidity between 40 and 50%. The capacity of the chamber was 19.8 m³. The ventilation rate was 60 m³/h normally but reduced to 30 m³/h when odors were present.

The rhythmic handgrip exercise was performed by the use of a mercurial sphygmomanometer. The occluding cuff of the manometer, 14 cm wide and 23 cm length, was wound around a glass bottle with a diameter of 7.6 cm, which was sufficiently hard not to alter shape during compression. A compression bladder of the manometer was artificially loosened so that cuff pressure fell from 200 to 100 mmHg in 2 min unless additional compression was done. Participants equipped with sensors and electrodes were seated in an armchair and asked to relax for at least 20 min before the exercise. Meanwhile, data were sampled 2–3 times, and the data 2 min before the exercise were taken as the control. Participants were then asked to maintain cuff pressure at 200 mmHg by compressing the bladder in their right hand for as long as possible. Duration of the repetitive compression varied from 1.5 to 3 min among the participants. Immediately after the participants reported a breakdown, the blood pressure was measured and registered with the other parameters. Values at this point were referred to as those during exercise. Statistical significance between the data was examined by analysis of variance (ANOVA) and further by Duncan’s multistage test.

The static handgrip was performed by the use of a power grip hand exerciser (A846-1, Smith & Nephews Inc., Germantown, WI). Participants were asked to maintain the power 30–40% of maximal voluntary contraction previously measured by a grip dynamometer (Grip D, Takei, Tokyo, Japan). Samplings of the data during sustained handgrip were performed by the same protocol as for the rhythmic handgrip.

The participants who had chosen odors beforehand, were exposed to odors 1 min before the exercise began by placing a glass bottle containing 100 ml of the odor solution, in which the essential oil had been diluted by 1000 times with distilled water, on the table in front of the participants. The temperature of the odor solution was kept at 40°C during the experiment by the use of a heating pad. After the experiment, the participants reported that they were continuously aware of the existence of the odor of intermediate strength.

Rhythmic handgrip significantly increased systolic blood pressure from 103 ± 3.4 to 126.8 ± 4.2 mmHg (mean ± SEM, n = 10) and diastolic blood pressure from 70.6 ± 2.4 to 91.7 ± 3.1 mmHg (F(1,18) = 19.07, P = 0.0004; 28.53, P = 0.0001, respectively). Respiratory rate also significantly increased from 15.5 ± 1.2 to 22.0 ± 1.7 cpm (F(1,18) = 9.49, P = 0.0064). The amplitude of the finger pulse wave significantly decreased to 54.0 ± 5.3% (F(1,18) = 73.97, P = 0.0001), indicating the cutaneous vasoconstriction. These changes were also found to be significant by Duncan’s test (P < 0.05). These results show that rhythmic handgrip affects the blood pressure, respiratory rate, and finger pulse wave no matter whether odors are present or not. However, as shown in Fig. 1, the diastolic blood pressure during rhythmic handgrip was significantly lower in the six participants inhaling their favorite odors than that in the other four participants without odor-inhalation (F(1,18) = 9.93, P = 0.0136 by ANOVA; P < 0.05 by Duncan’s test).

Static handgrip at 30–40% of maximal voluntary contraction also increased blood pressure and decreased the amplitude of finger pulse wave. However, there were no differences in blood pressure and in the other parameters between odor-inhaling group (n = 8) and non-inhaling group (n = 8) before and during exercise.

In general, blood pressure increases during exercise. The
increase in blood pressure is considered to compensate, although not completely, blood flow supplying the working muscle in which muscle contraction compresses blood vessels concomitantly with an increasing demand of oxygen [11]. The increase in blood pressure is attained by an activation of the sympathetic vasoconstrictor neurons. For example, muscular vasoconstriction outside working muscles occurs as a result of sympathetic activation during exercise [2]. An increase in sympathetic nervous activity is also reported in working muscles [6,14]. On the other hand, the activity of muscle sympathetic neurons during exercise is influenced by the mode of exercise: the muscle sympathetic nervous activity during static handgrip is decreased when the exercise is performed voluntarily but increased when the exercise is performed involuntarily [9]. This fact suggests that the muscle sympathetic nervous activity is sensitive to central command. Static handgrip increases blood pressure by muscle chemoreflex whose reflex center is located in the lower brainstem, because the reflex is still observed in cats decerebrated at the intercollicular level [5]. The present result (Fig. 1), therefore, shows that the inhalation of pleasant odors alters the central command without affecting chemoreflex and suppresses the blood pressure increase by acting on the central nervous system higher than the midbrain.

Smaller increase in blood pressure is probably due to a smaller activation of the sympathetic vasoconstrictor neurons innervating the resistant vessels outside the working muscles. Another possibility that a greater vasodilation in the working muscles via $\beta$-adrenoceptors [7,10] and muscarinic receptors [12,13] attenuates the blood pressure increase can be neglected, because the activation of these $\beta$-adrenoceptors and muscarinic receptors actually increases blood flow to working muscles but causes no changes in blood pressure [4].


