

**THE IMPACT OF BODY SURFACE AREA EXPOSURE TO  
MENTHOL ON HUMAN TEMPERATURE REGULATION  
AND PERCEPTION**

**Honors Thesis**

**Presented in Partial Fulfillment of the Requirements  
For the Degree of Bachelor of Science in Sport and Movement Science**

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By

Nakiya Douglas

Supervisor:

Dr. Jason Gillis

Sports and Movement Science Department

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### **ABSTRACT** **iv**

*The abstract is a summary of the essentials of the entirety of the report. All aspects covered include the reports purpose, the experiment, reference to the methodology, key findings and results, major significances and conclusion.*

### **I. INTRODUCTION/BACKGROUND** **#1**

*Inclusion of background will be formulated into final submission of the actual Lab report for my thesis. Title inclusion is to speculate what the format will consist of and receive feedback of the layout. This will be a general overview that highlights what menthol and its uses are. Drafted information from former annotated bibliographies will also be included to solidify to basis of the study in particular and identify the common effect of menthol through multiple research.*

### **II. METHODOLOGY** **#2**

*Methods will consist of specifics regarding the general approach to the hypothesis being analyzed, a description of the testing facility and lab, a report of the participants involved and their inclusion and exclusion to participate in the study. A breakdown of the actual procedure and the application of the placebo and menthol interventions. This will be set to walk the reader through a typical testing day and what scheduling might look like and my role involved in all of this.*

### **III. RESULTS** **#4**

*Results will include thorough statement of all overall findings of the study, included with graphs to outline these findings and a provided explanation of each. Accurate measures and analysis of data in correlation to those lab findings will also be necessary to talk about the relationship between the independent and dependent variables.*

### **IV. DISCUSSION** **#7**

*Restatement of hypothesis and findings from the study. Inclusion of anything that went wrong in the study with both participants and technical issues. Possible*

*sources of error will also be indicated. Thoughts on the experience itself, what can be done better or things that could be done different. Discussion of what this experiment may provide on scientific and clinical levels. Discussion of changes in variables and participants. Discussion of protocol effectiveness, strengths and weaknesses of the interventions, and limitations*

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**VI. REFERENCES #9**

*Listed annotated bibliography which will in detail will describe prior studies and their findings.*

## **ACKNOWLEDGEMENTS**

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## **ABSTRACT**

Menthol is an active ingredient derived from mint commonly used in sports medicine practices to treat injuries. Although known for its capacity to cause cool sensations without actually cooling the skin temperature, menthol's effect on skin blood flow has not been clearly classified. Some research has shown menthol to increase skin blood flow (vasodilation), while others show decreases (vasoconstriction). It is hypothesized that body surface area (BSA) exposed to menthol influences blood flow. The purpose of this study was to test if large BSA exposures induce vasoconstriction while smaller exposures induce vasodilation. Twelve participants were placed into a controlled environment with a specific amount of their BSA (left middle finger, left arm, left upper/lower body) exposed to a menthol or placebo gel for 30 minutes. Thermal sensation, skin temperature, and skin blood flow were measured throughout testing. Vasodilation was not observed for small BSA. Participants exposed to large BSA experienced enhanced vasoconstriction and felt significantly cooler without change in skin temperature; partly supporting the hypothesis. Research supports menthol activation of cold receptors in the skin and causing cold sensations. Data also provides support that BSA exposure to menthol influences skin blood flow.

## **I. INTRODUCTION/BACKGROUND**

Menthol is considered a terpene alcohol that is either produced synthetically or derived from mint (Eccles, 1994). Menthol is an active ingredient found in many topical pain relievers (analgesics) in addition to producing a cooling sensation (Peier et Al, 2002). Menthol's chemical makeup has allowed it to be used to relieve muscle soreness and is a key ingredient in many commercial products. Menthol can be found in many active forms. The L isomer that plays a major role in the effect of menthol is what allows for the cooling sensations felt when applied to the skin all while being nontoxic to humans (Eccles et al., 1988). Menthol influences skin blood flow by eliciting a cold sensation by acting on transient receptor potential melastin 8 cold sensing channels (TRPM8) (Peier et al., 2002). Both menthol and temperatures below 28 °C activate TRPM8 stimulated by transition of ion channels, which are embedded in terminals of primary afferent nerve endings (McKemy Neuhausser & Julius, 2002; Piere et Al., 2002). These thermo-sensitive neurons are thought to project to the somatosensory cortex, where temperature is perceived (Craig, 2002) and towards the hypothalamus, where body temperature is regulated (Morrison & Nakamura, 2011). In this way, menthol has been shown to influence both human temperature perception and body temperature regulation (Gillis, House & Tipton, 2010; Gillis et al., 2015). Prior research has indicated menthol to induce cutaneous vasodilation (Craighead et al., 2016). Research has also indicated for menthol to driven by a stimulus of skin receptors/ sensory nerves that may vasoconstriction (Gillis et al., 2015). This is driven by activation of peripheral nerves- skin receptors leading to heat storage response due to repeated exposure. Effects are suggested to be based upon body surface area

exposure. Prior research has shown menthol to have an effect on both perceptual and physiological functions, but the influence of the body surface area exposed to menthol on body temperature regulation and perception has not been investigated. The purpose of this study is to navigate this relationship with particular emphasis on menthol's influence on skin blood flow.

## **II. METHODOLOGY**

### **Procedure:**

In a single-blinded study, participants were exposed to menthol application on the left side of three different body surface areas (left middle finger, left arm, and left upper and lower body) and one exposure to a placebo condition. Twelve subjects were to rest in an environmentally controlled tent for 30 minutes pre and post intervention for a total of 60 minutes. Perceptual measures taken included thermal sensation. Thermoregulatory measures of skin temperature and skin blood flow were monitored and recorded throughout testing. Skin blood flow was measured via laser Doppler flowmetry on the middle finger. On both the right and left side of the participants skin temperature was recorded (chest, forearm, thigh, and calf).

### **Description of the testing sessions:**

For four days with a 24hour non-testing period between them. Shorts were necessary to perform the tasks of this study as well as removal of the shirt in order to easily access the body for randomized application of the menthol. Subjects were weighed, measured for height and questioned for caffeine intake and exercise prior to testing sessions (which is an

exclusion of the study). Participants were also asked background questions which included age and history of exercise lifestyle. Upon entering the temperature controlled tent, participants they would then be instrumented with a laser Doppler probe on the left side and skin temperature thermistors. Participants rested in a supine position for 30 minutes pre and post intervention. Thermal sensation was assessed every 5 minutes and recorded. Rectal temperature were also recorded every minute. Blow flow perfusion, skin temperature, and time were monitored from the computer screens. Once the full 60 minutes was up, the test was finished.

**Data Analysis:**

Data were collected over 60 minutes of testing, but only the data over the last 30 minutes of testing were analyzed. Specifically, the area under the curve (AUC) from minutes 30 to 60 was calculated by summing all of the data points together (i.e. min 35 + min 40 + min 45 + min 50 + min 55 + min 60 = AUC). This produced four different numbers for each condition. These four different numbers where then compared using data obtained from 12 participants, using a 1-way Repeated Measures Analysis of Variance, with an alpha level of 0.05.

### III. RESULTS

Thermal sensation, skin temperature, and skin blood flow were measured throughout testing. Vasodilation was not observed for small BSA. Participants exposed to large BSA experienced enhanced vasoconstriction and felt significantly cooler without change in skin temperature; partly supporting the hypothesis.

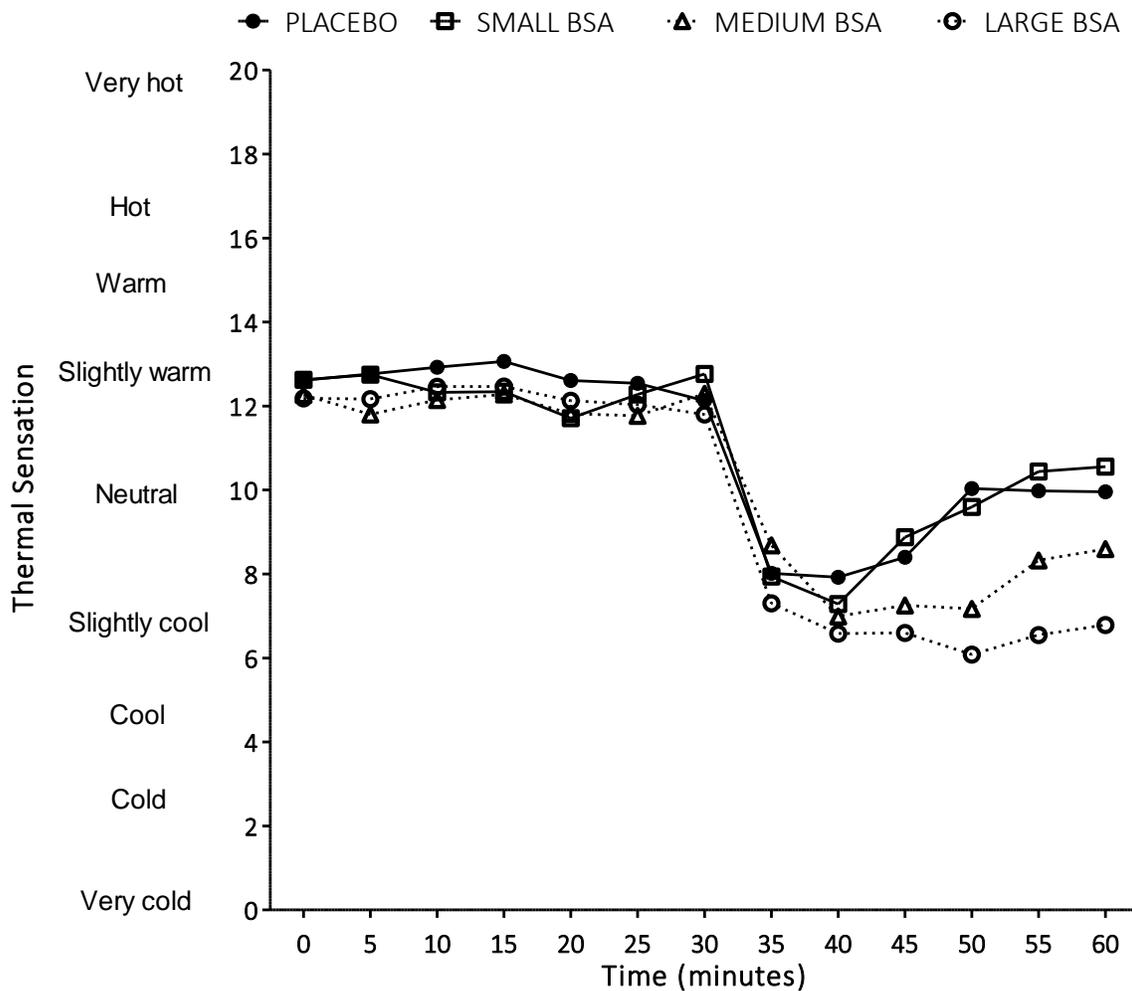


Fig 1: Thermal Sensation following the application of three different menthol exposures (Small, Medium, and Large Body Surface Area exposures), compared to a Placebo Condition at minute 30 in twelve participants. An analysis of the area under the curve from minute 30 to 60 found a significant difference (1-way ANOVA,  $p < 0.05$ ) between conditions. These data indicate that participants exposed to the largest body surface area of menthol felt the coolest.

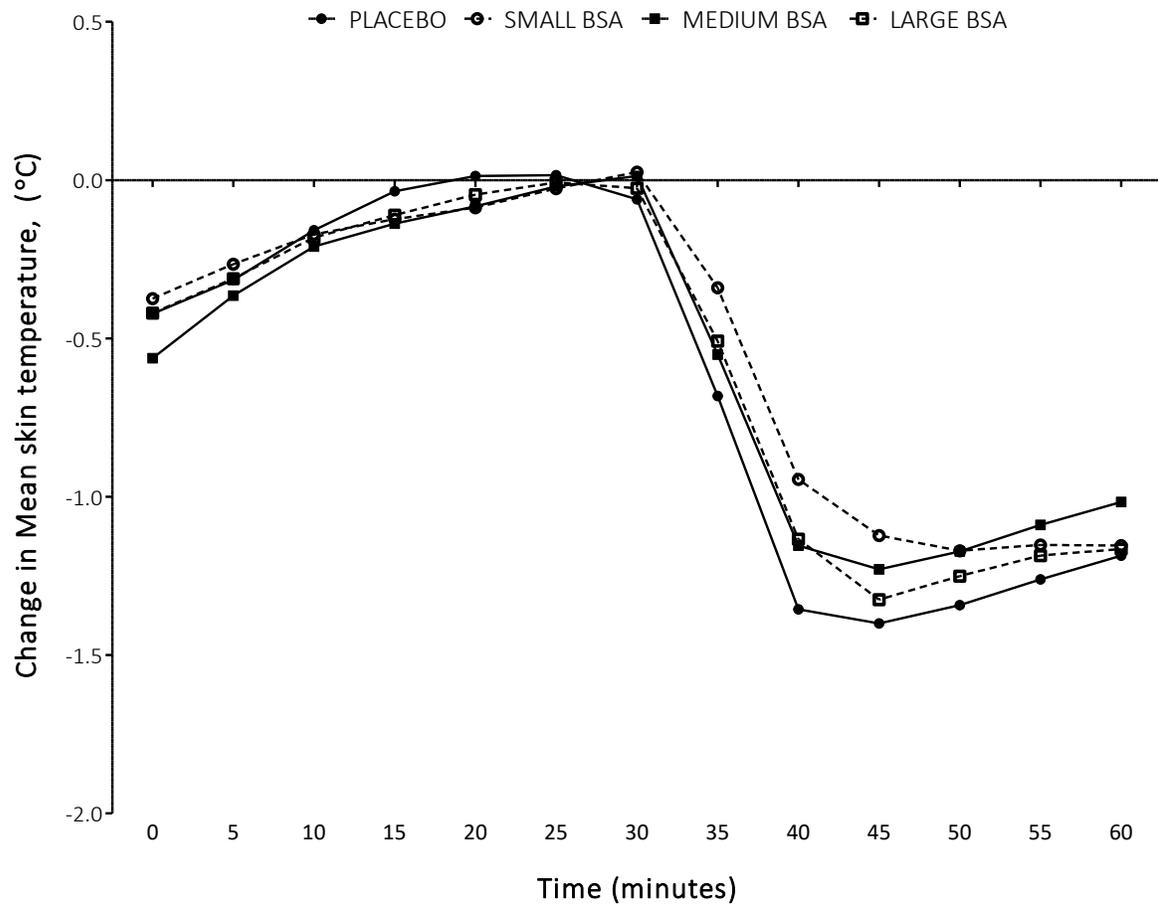


Fig 2: Mean Skin temperature following the application of three different menthol exposures (Small, Medium, and Large Body Surface Area exposures), compared to a Placebo Condition at minute 30 in twelve participants. An analysis of the area under the curve from minute 30 to 60 found no significant difference (1-way ANOVA,  $p > 0.05$ ) between conditions. These data indicate that the increased cool sensations felt by participant in the Large BSA condition in Figure 1 was not due to a lower skin temperature.

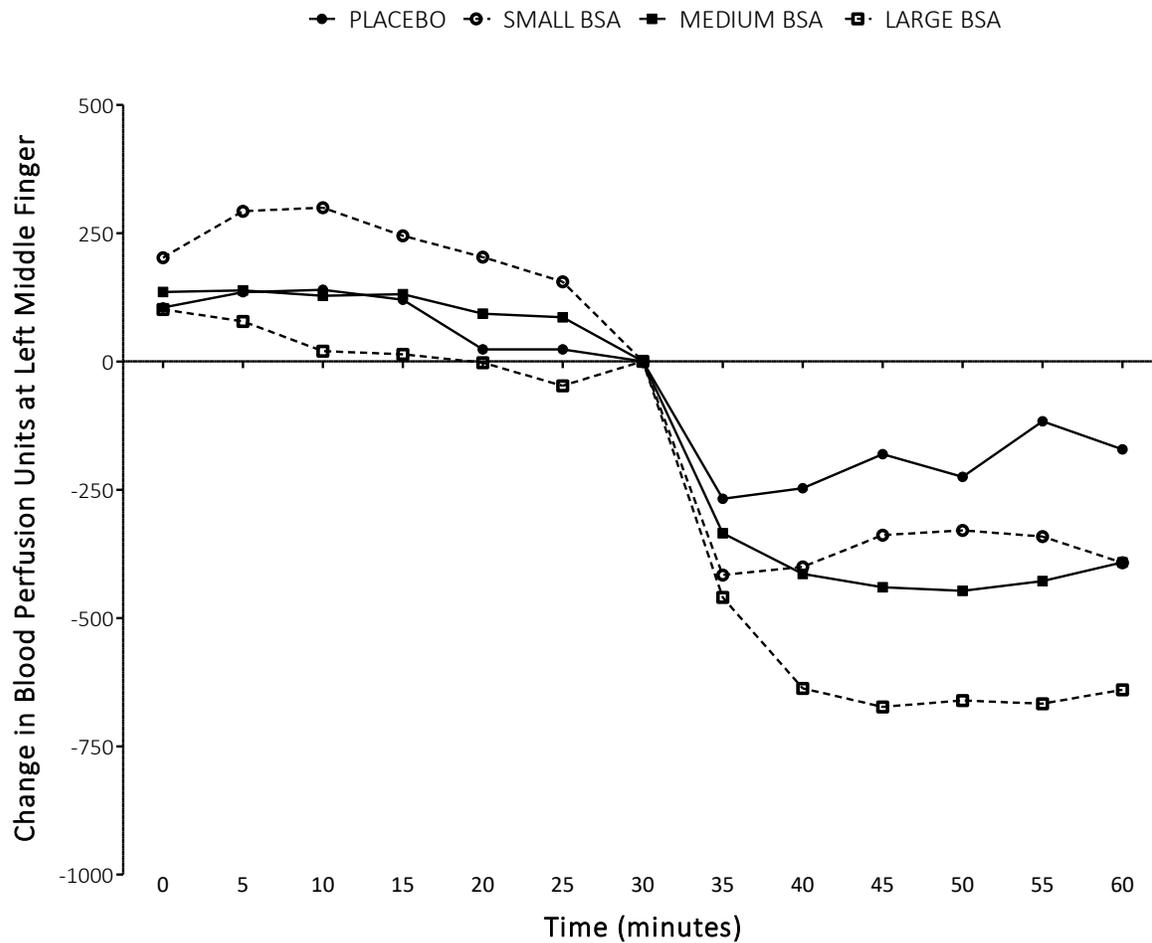


FIG 3. Blood Flow following the application of three different menthol exposures (Small, Medium, and Large Body Surface Area exposures), compared to a Placebo Condition at minute 30 in twelve participants. An analysis of the area under the curve from minute 30 to 60 found a significant difference (1-way ANOVA,  $p < 0.001$ ) between conditions. These data indicate that participants exposed to the largest body surface area of menthol had a significant reduction in skin blood flow.

#### **IV. DISCUSSION**

Menthol has been shown to influence both human temperature perception and body temperature regulation (Gillis, House & Tipton, 2010; Gillis et al., 2015). Prior research has shown menthol to have an effect on both perceptual and physiological functions. This appears to not only be associated with dosage but also, according to the data collected in this experiment, with body surface area exposure. The fundamental purpose of this study was to test if large BSA exposures induce vasoconstriction while smaller exposures induce vasodilation. Results indicate participants that were exposed to large BSA had enhanced vasoconstriction while feeling significantly cooler without change in skin temperature. However in smaller BSA there was no clear indication of vasodilation that was observed, as had been observed by Craighead et al. (2017), partly supporting the experimental hypothesis. Preliminary data did in fact support menthol activation of cold receptors in the skin and causing cold sensations because participants in all menthol conditions felt significantly cooler than the placebo condition, with the exception of the small BSA condition. This is probably because the small BSA exposed to menthol i.e. the fingertip, was not sufficient to bring about significantly afferent inputs to register cool sensations. Data also supported that BSA exposure to menthol influences skin blood flow, with particular emphasis on large BSA exposures leading to vasoconstriction. These data did not support the work of Craighead et al., (2017) who observed increased skin blood flow with menthol. This is perhaps because their experimental set-up was different. They used a heated skin blood flow probe to control skin temperature, and infused menthol at skin temperature. In the present study, we applied menthol in gel form to the skin, which caused a reduction in skin temperature, leading to a reduction in skin

blood flow across all conditions. This reduction in skin temperature was apparently enough to eliminate menthol's vasodilator effects. Limitations of this study were mostly influenced by variability of applications per participant i.e. every participant has a unique thermoregulatory system and may respond differently to menthol, so there is a lot of variability in the data. In addition there was no direct assessment of vasodilation to completely override the conclusion found in the small BSA results.

The practical implications of the present experiment suggest that when menthol is applied in gel form, as it often is in a clinical setting, it will cool the skin and cause enhanced vasoconstriction, rather than vasodilation, and this vasoconstriction seems to be stronger and more prolonged as the BSA exposed to menthol increases.

## **V. CONCLUSION**

Research supports menthol activation of cold receptors in the skin and causing cold sensations. Data also provides support that BSA exposure to menthol influences skin blood flow. The hypothesis is consistent with the literature and research findings in terms of menthols influence on BSA. Gel application caused large BSA applications to feel cold without any real skin reduction in temperature. Menthol has a strong perceptual stance in which skin blood flow is influenced creating the cold sensation in which the participant feels. It seems to be in the smaller body surface area vasodilation was not consistent with the data. In the larger exposures to menthol, the opposite happens.

## **VI. REFERENCES**

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