Physiological Effects of Sugar-Free Mint Chewing Gum on Typing Performance

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Key Terms: Chewing gum, typing speed, typing proficiency, blood pressure (BP), heart rate (HR), respiratory rate (RR), habits, focus, concentration, task completion

Word Count: 4,323

Abstract

Chewing sugar-free mint gum has been shown in a large body of research to have a stimulating effect on humans, manifesting as improved performance in completing tasks with cognitive demands. Leveraging prior research, we hypothesized that participants chewing gum during a read-and-copy typing test will perform better than those who do not and will express different physiological measurements. Participants (n=50) were evenly and randomly divided into the experimental group that would be given the sugar-free mint gum and the control that would not. All participants were given a questionnaire that assessed their self-perceived typing proficiency and gum chewing habits. Before and after the typing test, we collected measurements of heart rate (HR), respiratory rate (RR), and blood pressure (BP). We used ANOVA to analyze our data and found no statistically significant relationship between chewing sugar-free mint gum and performance on a read-and-copy typing test (p=0.674). We conclude that chewing sugar-free mint gum does not have any effect on typing performance, HR, RR, or BP. Though our hypothesis proved faulty, we believe that further inquiry and revision of our design might produce significant results.

Introduction

In prior studies, chewing sugar-free mint gum has been implicated in alterations of cognitive and physiological factors in subjects. Specifically, chewing gum has been shown to increase alertness and performance in both physiological and self-reported measurements (Allen et al. 2011). Because chewing gum is known to promote cognitive functions as detailed in Smith et al. (2010), our research group elected to investigate the effects of chewing gum in performance on a keyboard typing test. In designing our study methodology, we deemed a typing test to be a sufficient cognitive activity for evaluation of the impact of chewing gum on the autonomic nervous system. Additionally, a typing test assesses processing speed, a cognitive parameter that constitutes the amount of time to complete a mental task. In reviewing the body of literature concerning the effects of chewing gum on various task performances, there is an established precedent of using a battery of measurement methods, most predominantly featuring heart rate (HR) and blood pressure (BP). As Hasegawa et al. observed in a 2009 study, the majority of subjects exhibited increases in these physiological measurements. Modeling our own research after this prior work, we too investigated HR and BP before and after the typing test performance.

Despite a body of evidence that suggests a causal relationship, there is a lack of consensus in the physiological research community regarding the effects of gum-chewing on improving performance. As demonstrated by Tucha et al. in a 2010 study, it was found that chewing gum was associated with improvements in sustained attention only, bearing no effect on performance. We are attempting to address this question through our experiment to see if the act of chewing gum has any impact on cognitive function as it pertains to the typing test, and if there are any possible applications for performance in academics and beyond. There is uncertainty as to if the flavor of the gum causes the physiological effects; however, clarifying these roles is not within the purview of our analysis in this experiment.

We hypothesized that chewing sugar-free mint gum would lead to increases in measures of HR, BP, RR and improved performance on a typing test. By increasing these physiological parameters with chewing gum, we believed there would be a heightened alertness in participants that lead to better typing performance over non-chewing counterparts. In 2002, Onozuka et al. observed a correlation between the chewing of mint gum and increased delivery of oxygenated, glucose-containing blood to the brain. We proposed that through this correlation, there is a link to improved cognitive function and processing. Furthermore, the act of mastication is perceived by the body as a form of exercise and in turn corresponds with suppression of parasympathetic effects (Shiba et al. 2002). Though we cannot directly measure the cognitive effects of chewing sugar-free mint gum on a neurological level, we selected the typing test as an appropriate cognitive task for analysis in conjunction with physiological measurements. We believed that our study would yield results concurring with current literature, which cites chewing gum as having a role in altering, concentration and typing speed and accuracy. Our study collected HR, BP and respiratory rates (RR) before and after the typing test. The subject pool (n=50) recruited for our study was divided evenly into two groups: the experimental group that chewed mint gum, and the control group that did not chew gum.

Materials

Five variables were examined in this experiment to determine the effects of chewing gum on keyboard typing by testing various physiological parameters. The five variables observed were HR, RR, BP, typing speed in words per minute (WPM), and typing error count. RR was measured using a Biopac Respiratory Transducer SS5LB (Serial number: 1602007558; Manufacturer: BIOPAC Systems, Inc.,Goleta, CA). BP and HR were measured using an Omron 10 Series+ BP monitor BP791IT (Serial number: 20150310128LG; Manufacturer: Omron Healthcare, Inc., Lake Forest, IL). RR was measured and analyzed using BIOPAC Student Lab System (BSL 4 Software, MP36). The BIOPAC Systems, Inc. Student Manual (ISO 9001:2008, BIOPAC Systems, Inc.) was used as a guide for direction in analyzing breaths per minute. Typing speed and accuracy were measured using a 1-minute read-and-copy typing test of

"Aesop's fables" on www.typingtest.com, which is measured in number words typed per minute and number of typing errors. The participants completed their participation in a study room in the UW-Madison Medical Sciences Center. The study room had three computers; one for monitoring all Biopac data from the respiratory belt (standard desktop Dell computer), one for entering data into a spreadsheet (Dell laptop), and the third (Apple Macbook Air laptop) for administering the typing test. Wrigley's Extra Polar Ice Chewing Gum was used for this study. The room also had three research facilitators to record physiological measurements and to administer a questionnaire.

Methods

Screening and Consent

Participants were recruited on a voluntary basis from the University of Wisconsin-Madison Physiology 435 course. Each participant was required to fill out a consent form prior to their participation in the study that addressed possible allergic reactions to Wrigley's Extra Polar Ice sugar-free gum, confidentiality, and the testing time commitment of 10 minutes. Before the experiment, the participant sat in a chair in the room and then reviewed and signed the consent form. Participants (n=50) were randomly assigned to either chew sugar-free mint gum during their typing test (n=25), or to not chew sugar-free mint gum while doing the typing test (n=25). Each participant only took the typing test once in order to avoid previous knowledge affecting performance.

Procedure

Participants were first asked to read and sign the consent form. If they consented to participate, they were then given the pre-test questionnaire to complete. After completing the questionnaire, a team member assisted the participant in attaching the necessary equipment and an initial set of recordings were taken. The participant then began the typing test, chewing gum if indicated. A final set of recordings were taken immediately upon completion of the typing test. The procedure of this experiment from start to finish is not expected to exceed 5 minutes. This procedure is summarized in figure 1.

Participant Check-In

One team member escorted the participant to the study room. The room was quiet and free of unnecessary distractions. A team member assisted the participants in using the BP cuff and RR monitor. Female participants were asked to adjust their RR monitors to their own comfort. If a participant was in the experimental group, the team member then administered the sugar-free mint gum to the participant.

Participant Questionnaire

The participant was provided a study questionnaire to complete. The participant read their answers aloud to a team member who recorded the responses into a Google Sheet for data organization and analysis. A copy of the questionnaire can be found in the appendix 1.

Typing Test & Participant Exit

After collection of the questionnaire, a team member set up the typing test for the participant on the computer. The participant then completed the typing test. Upon completion of the test, final physiological measurements and typing performance were immediately recorded. This concluded the participant’s role in the study.

Data Analysis

To analyze our data and findings, we first investigated the function of typing performance (as defined by WPM and error count) with gum-chewing status as the independent variable. We expected to conclude that the participants chewing gum would perform better on the typing test than participants who do not. This relationship between gum-chewing and performance on a cognitively-demanding task was also examined through the responses collected from pre-test questionnaires. Self-reported confidence in typing abilities was also compared to typing performance. We performed an ANOVA test to analyze our data.

Positive Controls

To ensure the practicality of this experiment's procedure and methods, three members of our research team completed the questionnaire. Initial HR, RR, and BP were taken using the respiratory belt, Biopac system software, and automatic BP cuff. Two of the individuals were then given one piece of sugar-free mint gum. All three individuals then completed the typing test. Upon completion of the test, words per minute and typing errors were recorded in addition to the subject's post-test HR, RR, and BP. The data for the two individuals who completed the test while chewing gum were averaged and summarized in figures 2-7. The data for the individual who completed the test without chewing gum can also be found in figures 2-7. In comparison of these two groups, individuals who completed the typing test while chewing gum exhibited a slightly higher post-test HR by 2 bpm and a much higher RR by 8.9 respirations per minute. These differences warrant further investigation of the theory that gum may alter an individual's physiological response. The typing data for both groups, however, was quite similar. This similarity could be due to the small sample size and individual variability in physiological metrics and typing proficiency.

Negative Controls

To ensure the reliability of our physiological measurement equipment, two members of the research team tested the respiratory belt and BP cuff. Without taking the questionnaire, the typing test, or chewing gum, the two team members collected their baseline data using the respiratory belt and the Biopac system to record RR and the automatic BP monitor to record HR and BP. An additional set of measurements were taken at a five-minute interval (the approximate time required to complete entirety of the experiment) and compared those measurements to baselines. The similarity in physiological values between time intervals confirmed the equipment was functioning correctly prior to beginning full experimentation.

Results

A p-value of 0.05 or less was set as the criterion of a significant result for all the parameters measured in this experiment. Although there were correlations, there was no significant difference between participants who chewed gum and those who did not.

Typing Proficiency, Words Per Minute, and Errors

There were no significant differences between participants who chewed gum and those who did not. Figure 8 shows a summary of typing proficiency from the typing test between participants who chewed gum and those who did not. The two-tailed p-value for typing proficiency was 0.674 assuming normal, unpaired distribution. The average typing proficiency for participants chewing gum was 2.08±0.571. The average typing proficiency for participants not chewing gum was 2.020±0.420. We used a scale for self-reported typing proficiency: 1 corresponding to self-assessed below average proficiency, 2 corresponding to self-assessed average proficiency, 3 corresponding to self-assessed above average proficiency.

Figure 9 shows a summary of typing test words per minute between participants who chewed gum and those who did not. The words per minute for participants chewing gum mean was 61.36±15.358. The words per minute for participants not chewing gum mean was

59.120±12.551. Although the participants who chewed gum had a higher mean words per minute count, the p-value of 0.578 reveals no significant difference.

Figure 10 shows a summary of typing errors during the typing test between participants who chewed gum and those who did not. The number of errors for participants chewing gum was 4.200±3.202. The number of errors for participants not chewing gum was 6.240±6.016. The p-value of 0.141 indicates no significant difference.

Physiological Effects

There were no significant differences in physiological measurements between participants who chewed gum and those who did not. Cumulative results for each physiological measurement are illustrated in figures 11-14. Figure 11 shows a summary of physiological HR between participants who chewed gum and those who did not before and after completing the typing test. Figure 12 shows a summary of physiological RR between participants who chewed gum and those who did not before and after completing the typing test. Figure 13 shows a summary of physiological systolic BP between participants who chewed gum and those who did not before and after completing the typing test. The systolic measurements taken before the typing test had the largest p-value of 0.938 and was the farthest away from being a significant measurement. Figure 14 shows a summary of physiological diastolic BP between participants who chewed gum and those who did not before and after completing the typing test. The diastolic measurements after the typing test had the smallest p-value of 0.092 and was closest to being a significant measurement.

Chewing Behavior

For the first five participants chewing continuity was not recorded during the typing test. For the remaining forty-five participants cessation of chewing was recorded. A total of 85% of participants given gum ceased chewing during the typing test.

Discussion

Though our data was largely insignificant, we believe that there is scientific merit in our investigation of the effects of chewing sugar-free mint gum on performance, specifically in typing tests. As previously noted in our results, there were correlations between gum-chewing status and performance that were lacking in statistical significance ($p>.05$). Chewing gum is utilized as a focus and alertness aid in academics and is a common practice among undergraduate students. Thus, there may already exist a perception amongst participants in our study (all of whom are Physiology 435 students, TAs and PLVs) that chewing gum leads to improved performance. To address this potential confounding factor, we surveyed participants on their self-perceived typing proficiency and gum chewing habits. In doing so, we discerned that this was a sufficient method of mitigating any pre-conceptions participants may have held upon entering our study. Additionally, those who chewed gum were, on average, more confident in their self-assessed typing abilities as revealed by the questionnaire. Of interest in this finding is that participants were not aware of their study condition regarding gum-chewing before their completion of the questionnaire. Administration of gum took place after the questionnaire. Participants knew only that they would be assessed for physiological measurements and the typing test regardless of whether they were administered gum or not.

Confounding Variables

Because gum-chewers were administered gum after completing the questionnaire, we cannot attribute increased average confidence to their habits and attitudes surrounding gum-chewing and typing. However, there may have been a priming effect at play in increased confidence. Perhaps it was the case in our study that people who received gum were coincidentally better typists and more confident in their typing abilities than those who did not receive gum. Another potential explanation for this observation is that the effect of expectation of the “reward” of gum before measurements was either fulfilled or denied - those who did not receive gum might have experienced decreased performance due to their disappointment that they did not receive gum. While it is unlikely that any participants intentionally performed poorly after not receiving anticipated gum, our study and its subsequent analysis cannot fully account for the potential priming effects of reward fulfillment/denial and the participant’s assessment of their own habits and attitudes before the gum administration.

In our analysis of our study design, we identified a number of aspects that may have influenced the trajectory of our results. Of primary concern as a potentially confounding variable that could be improved was the number of participants (n=50). If our study were to be replicated and revised, we would recruit from a larger and more diverse population of students. Another aspect of our study design that could be improved is instructing participants to chew the gum for a longer amount of time before beginning the typing test and continuing to chew for the duration of the experiment. In practice, participants were only given ten to fifteen seconds (the time required by the study team to explain the typing test) to chew the gum before the typing test commenced at the participants’ first keystroke. The majority of participants stopped chewing for at least a few seconds during the typing test, contributing to our reasoning for a revised protocol in which participants spend more time chewing gum during the experiment. We believe that the short timeframes for chewing may have led to the full effect of introducing gum to performance in the typing test and physiological measures. Another factor to consider was the continuous ambient noise in the study room we conducted our experiments in, there was a noticeable buzzing/hissing from the ventilation system. The ambient noise may have been distracting to participants. Similarly, the presence of the entire study team in the study room may have also had a distracting or intimidating effect on performance. The participant's emotions, stress, amount of sleep, and amount of caffeine consumption may have also played a role in performance on the typing test, regardless of if they chewed gum or not.

Future Improvements and Conclusion

In future studies of whether chewing gum has an effect on typing test performance, it would be beneficial to conduct a study with a larger, more diverse group of participants. To ensure that the physiological effects are fully realized, participants should chew gum for 5 (or more) minutes before beginning the typing test. An ECG test could also be employed to monitor participant HR continuously from the beginning to the end of the experiment, rather than once at the beginning and once at the end. Other avenues of investigation might include experiments exploring the impact of administering different flavors of sugar-free chewing gum. For example, testing whether differences exist between mint flavors opposed to fruit flavors. Extending into other forms of mastication beyond sugar-free chewing gum, the impact of eating and mastication of food could potentially yield more significant results as to the role of chewing and performance. The data collected in our questionnaire could also be analyzed in future experiments. These tests could include comparing how the participants' gender, previous gum chewing habits, and recent use of caffeine and other stimulants may have influenced their typing performance.

We concluded from our study that chewing sugar-free mint gum does not have a significant effect on typing performance, RR, BP, or HR. This finding contradicts our hypothesis and is incongruent with established scientific literature on the relationship between chewing gum and cognitive performance. Our study provides an example of the iterative nature of scientific inquiry.

The data we collected can be used for future Physiology 435 students to advance further research on the physiological effects of chewing gum. We want others to learn from our research and expand upon it to enhance future scientific inquiry. Our research paper will greatly contribute to the science community and Physiology 435 by providing baseline data. Although our results are insignificant, we hope that our research will spark interest in civilians and scientists alike to further the investigation of the physiological effects of chewing gum in other cognitive tasks.

Figures and Tables

Experimental Procedure Timeline

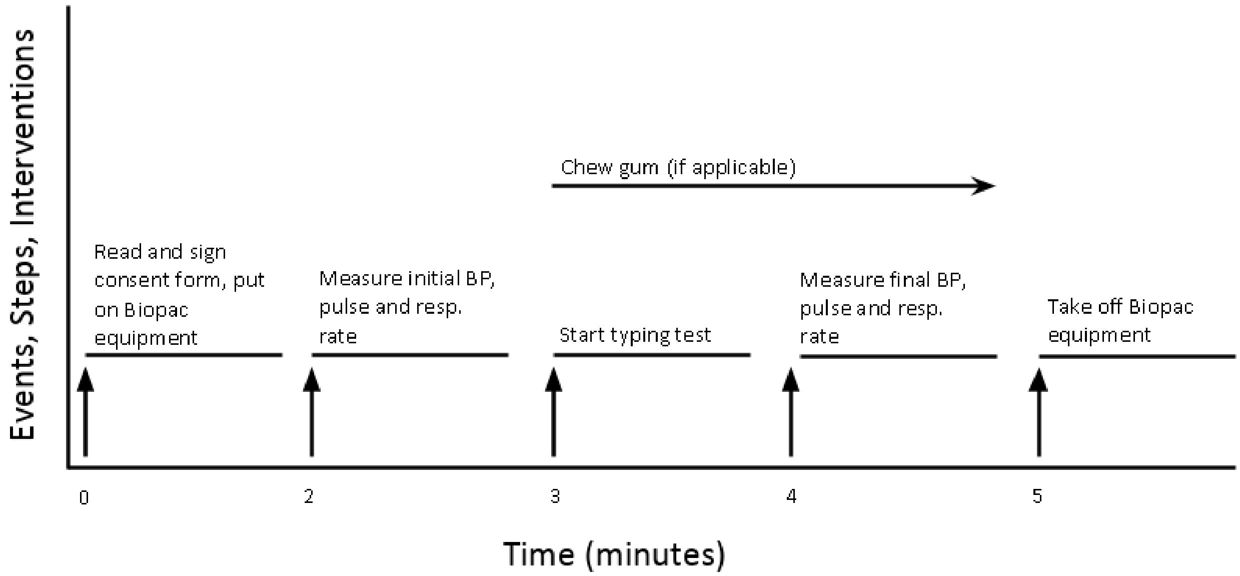

Figure 1: Timeline representing when experimental interventions were applied.

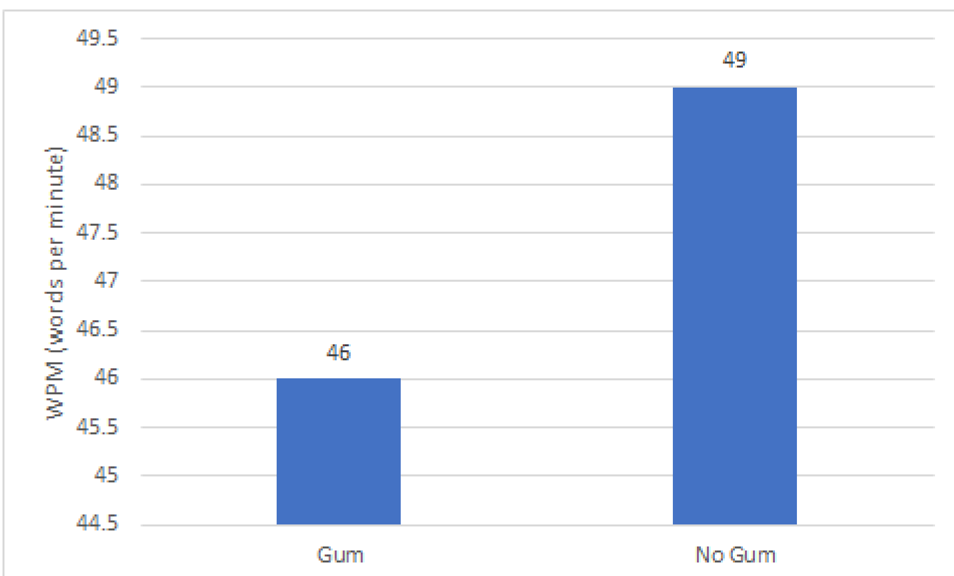

Figure 2: Summary of positive control typing test words per minute data between participants who chewed gum (n=2) and those who did not (n=1).

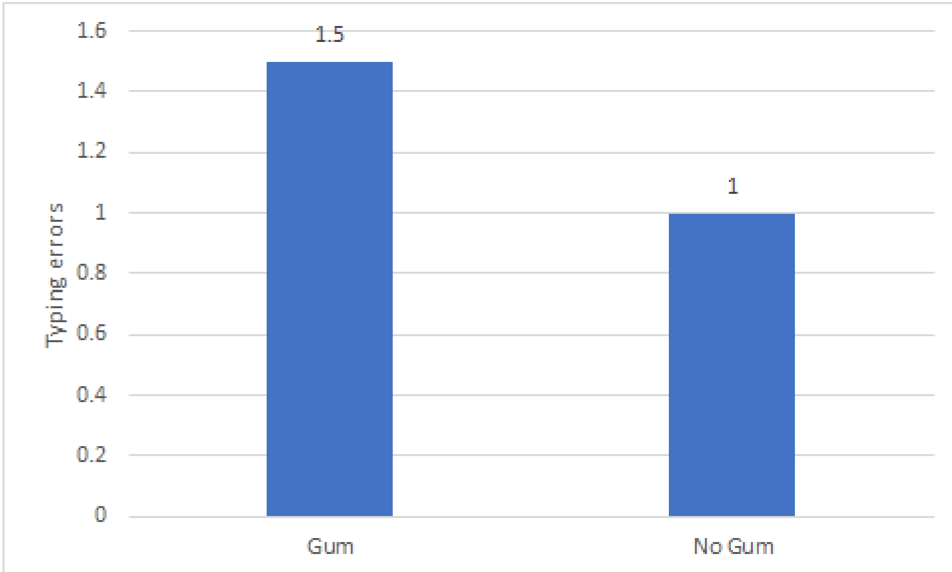

Figure 3: Summary of positive control typing test errors between participants who chewed gum (n=2) and those who did not (n=1).

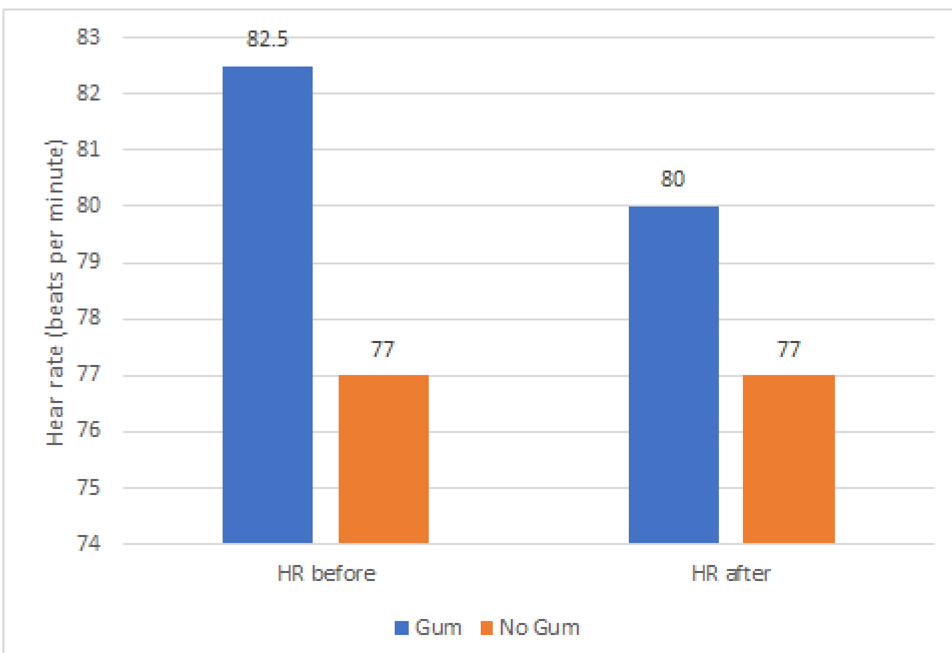

Figure 4: Summary of positive control heart rate data between participants who chewed gum (n=2) and those who did not (n=1) before and after completing the typing test.

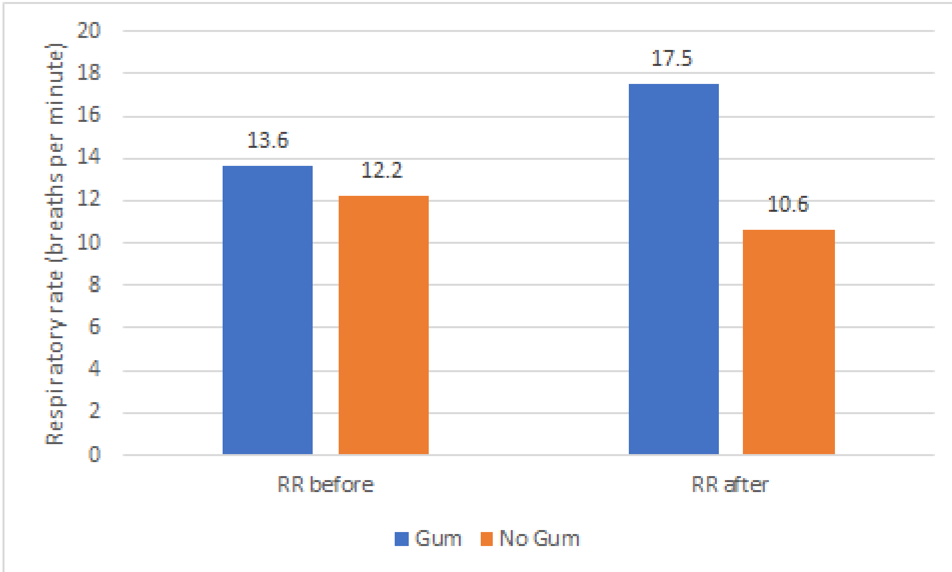

Figure 5: Summary of positive control respiratory rate data between participants who chewed gum (n=2) and those who did not (n=1) before and after completing the typing test.

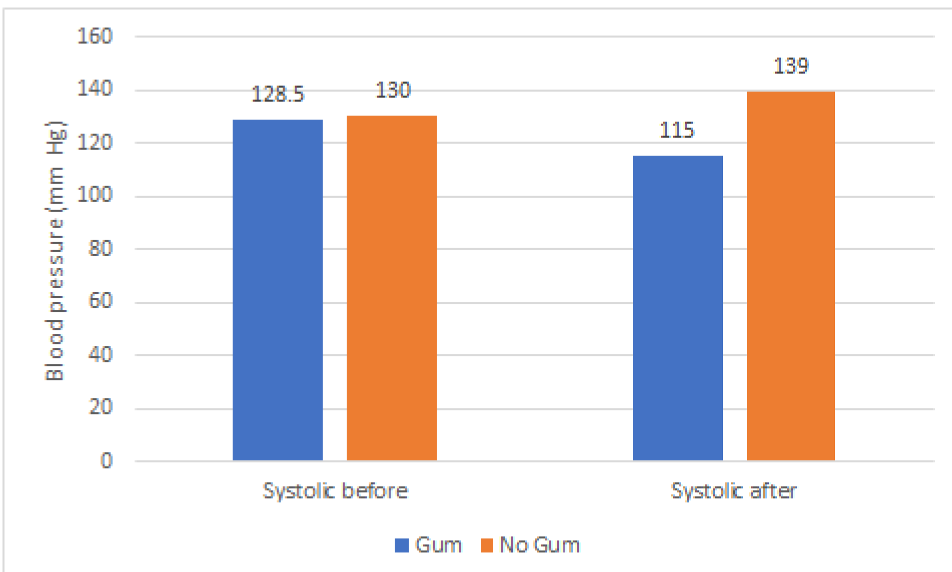

Figure 6: Summary of positive control systolic blood pressure data between participants who chewed gum (n=2) and those who did not (n=1) before and after completing the typing test.

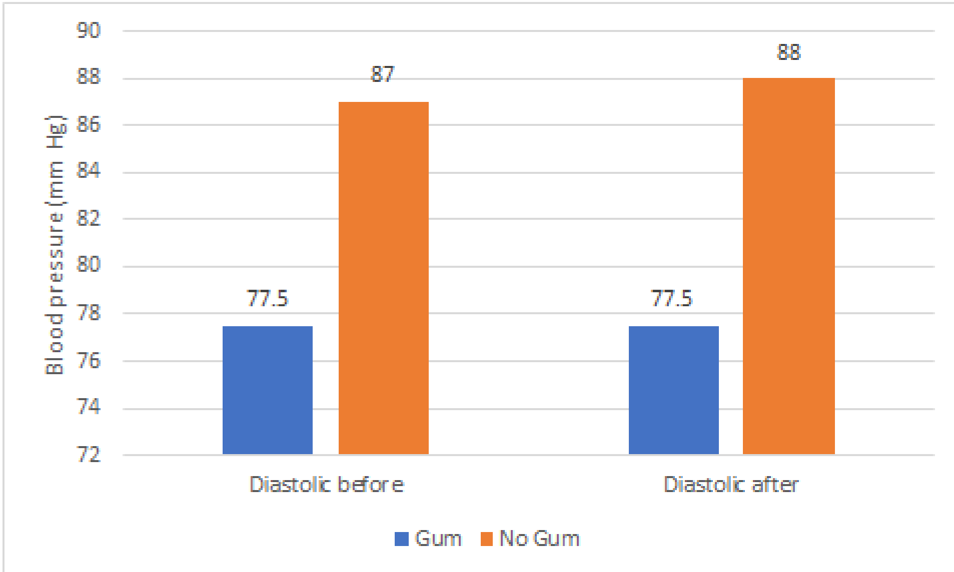

Figure 7: Summary of positive control diastolic blood pressure data between participants who chewed gum (n=2) and those who did not (n=1) before and after completing the typing test.

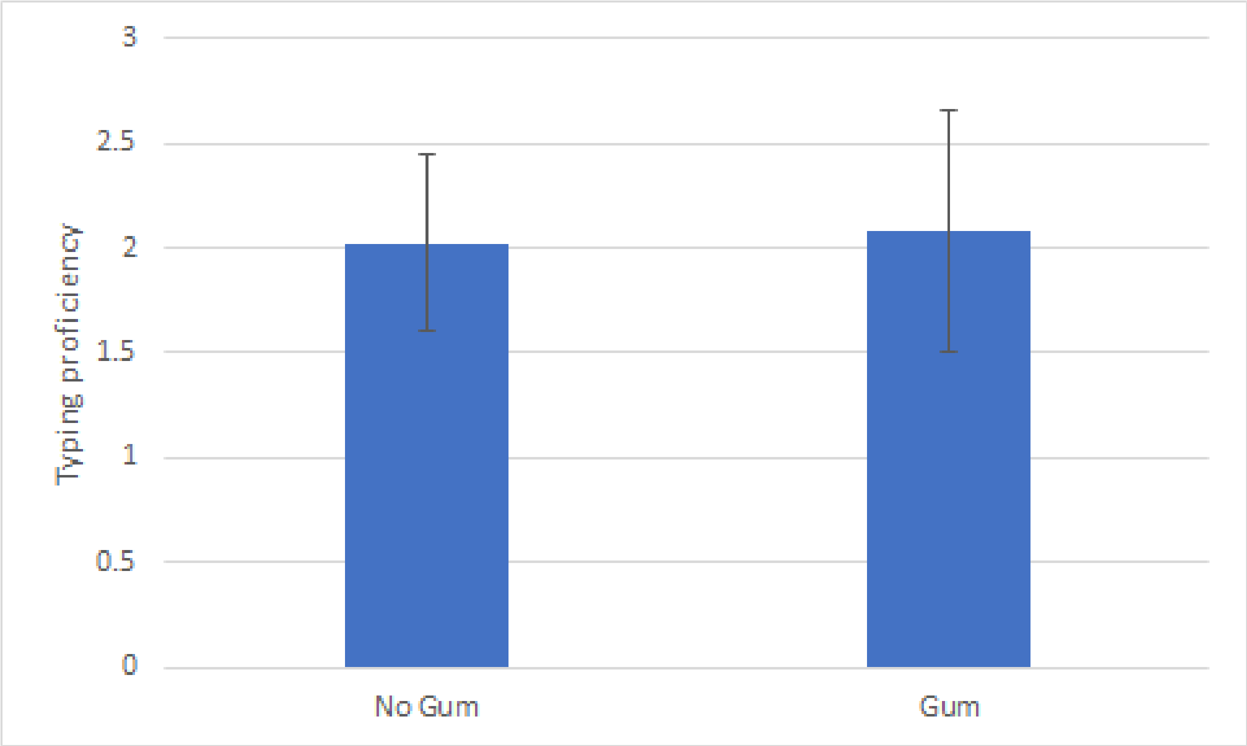

Figure 8: Summary of self-reported typing proficiency from the typing test between participants who chewed gum and those who did not. The sample size includes 25 participants who chewed gum and 25 participants who did not chew gum. The p-value for typing proficiency was 0.674. For the study, reported typing proficiency was determined using numbers 1-3: with number one representing below average typing proficiency, number two representing average typing proficiency and number three representing above average typing proficiency. All responses were self-reported before starting the test. The error bars represent standard deviation from the mean.

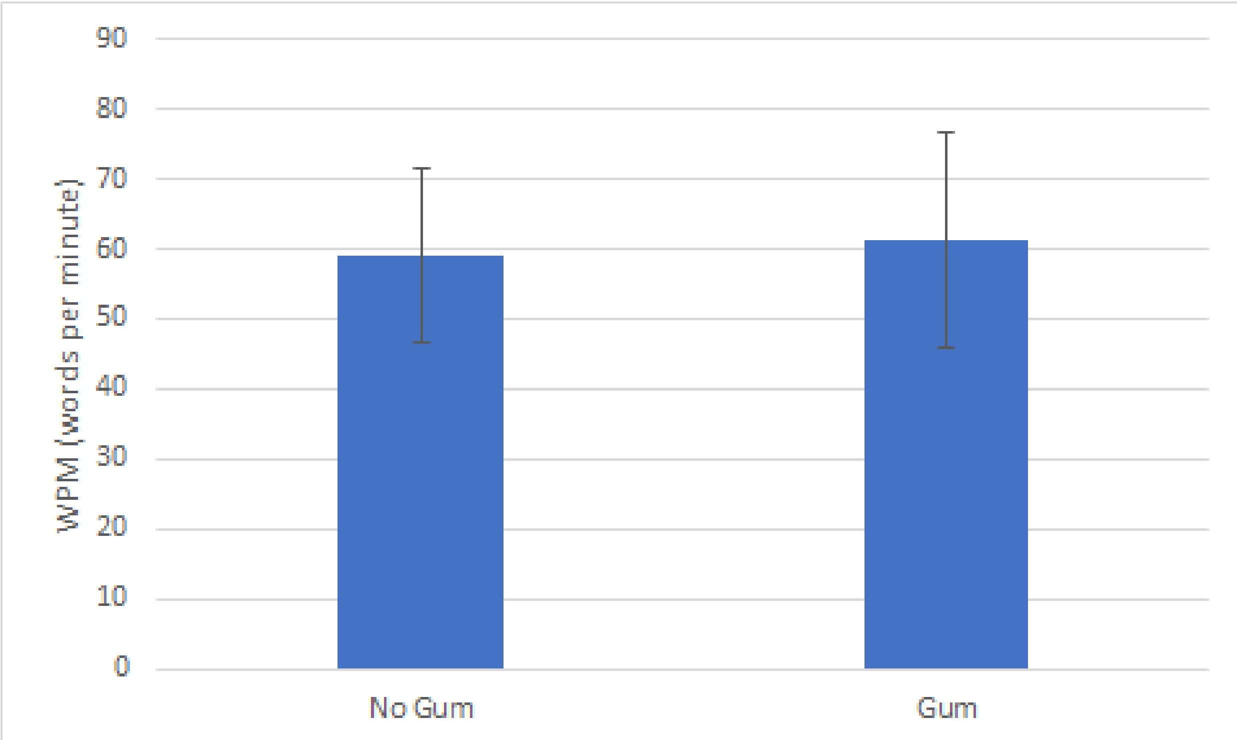

Figure 9: Summary of typing test words per minute between participants who chewed gum and those who did not. The sample size includes 25 participants who chewed gum and 25 participants who did not chew gum. The p-value for words per minute was 0.578. The error bars represent standard deviation from the mean.

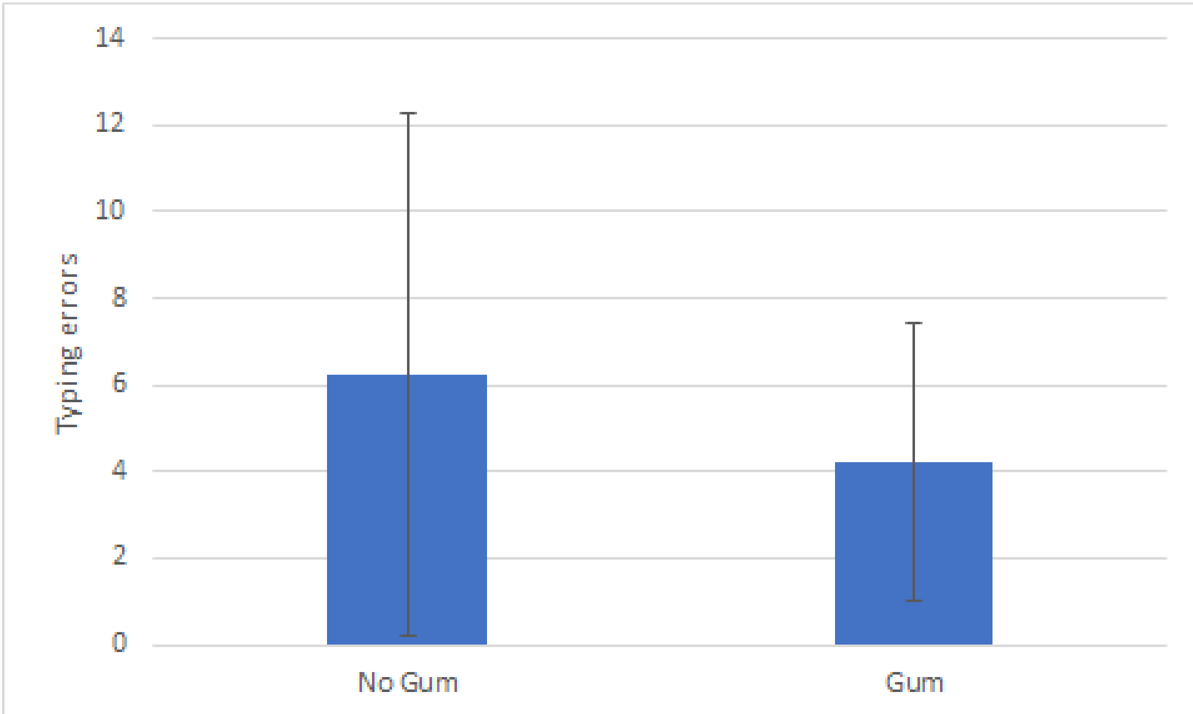

Figure 10: Summary of typing errors during the typing test between participants who chewed gum and those who did not. The sample size includes 25 participants who chewed gum and 25 participants who did not chew gum. The p-value for typing errors was 0.141. The error bars represent standard deviation from the mean.

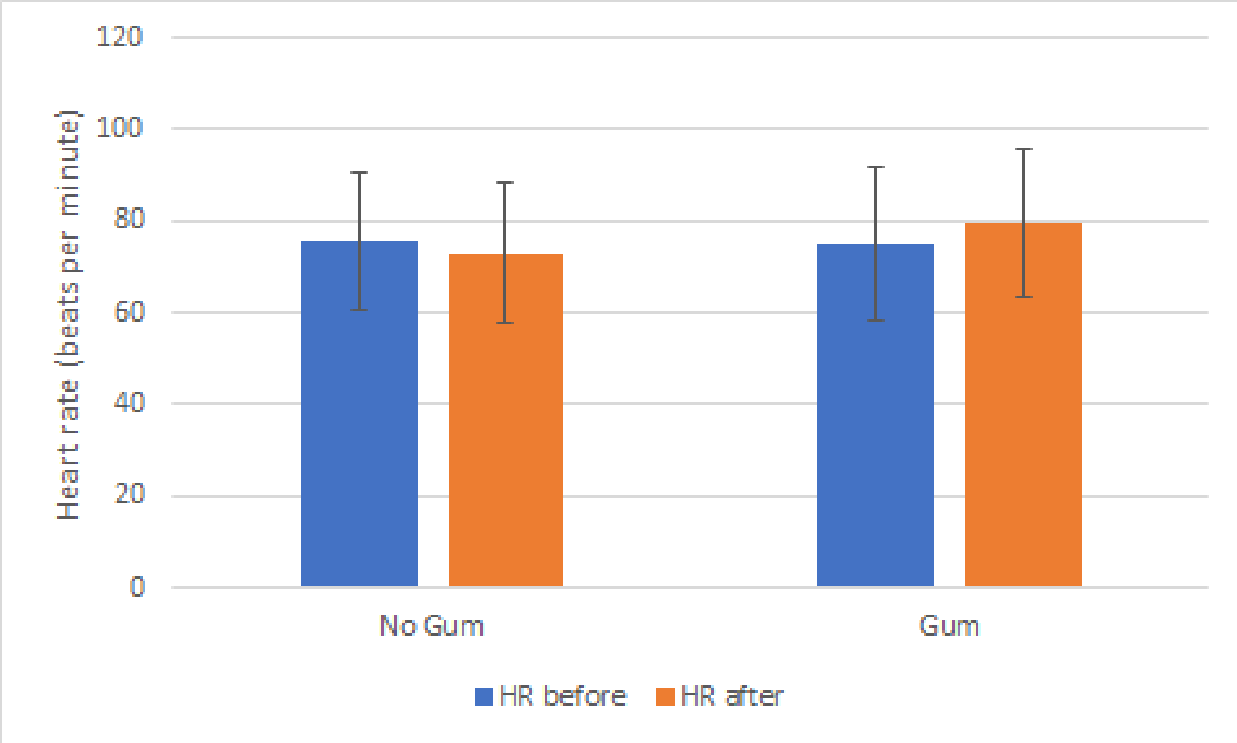

Figure 11: Summary of physiological heart rate between participants who chewed gum and those who did not before and after completing the typing test. The sample size includes 25 participants who chewed gum and 25 participants who did not chew gum. The p-value for heart rate before was 0.916 and the p-value for heart rate after was 0.145. The error bars represent standard deviation from the mean.

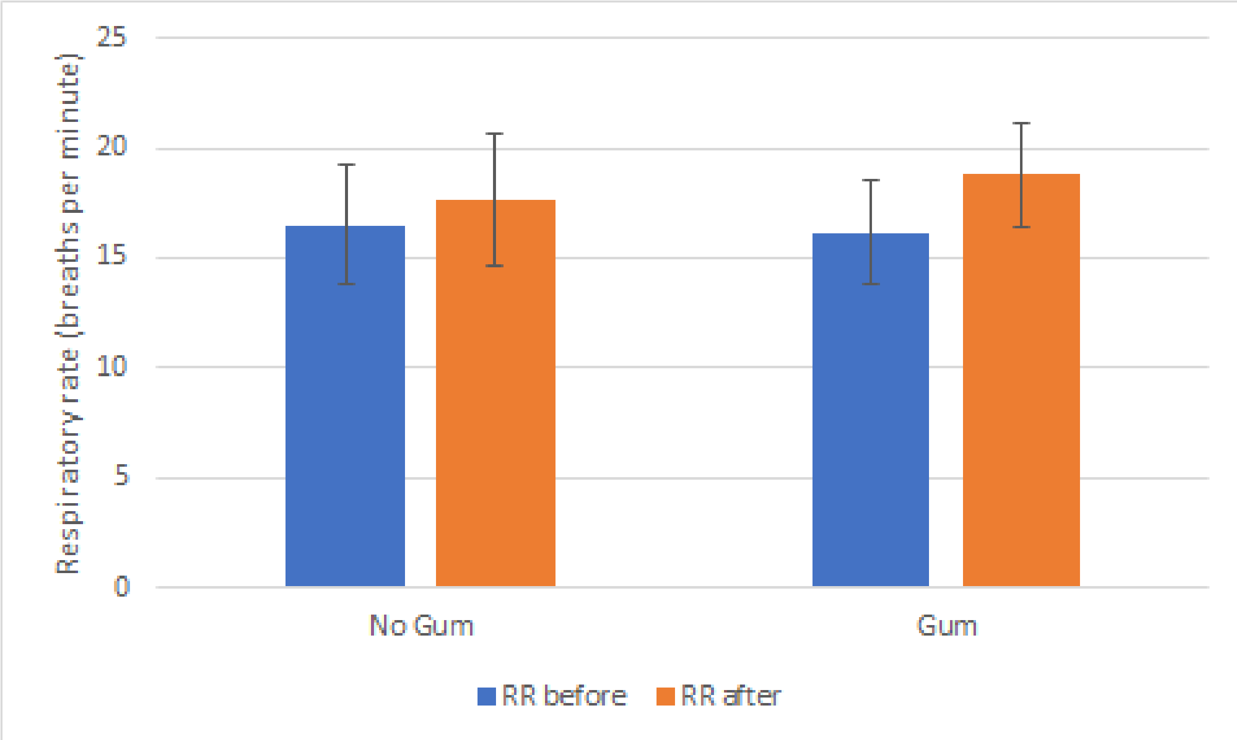

Figure 12: Summary of physiological respiratory rate between participants who chewed gum and those who did not before and after completing the typing test. The sample size includes 25 participants who chewed gum and 25 participants who did not chew gum. The p-value for respiratory rate before was 0.581 and the p-value for respiratory rate after was 0.133. The error bars represent standard deviation from the mean.

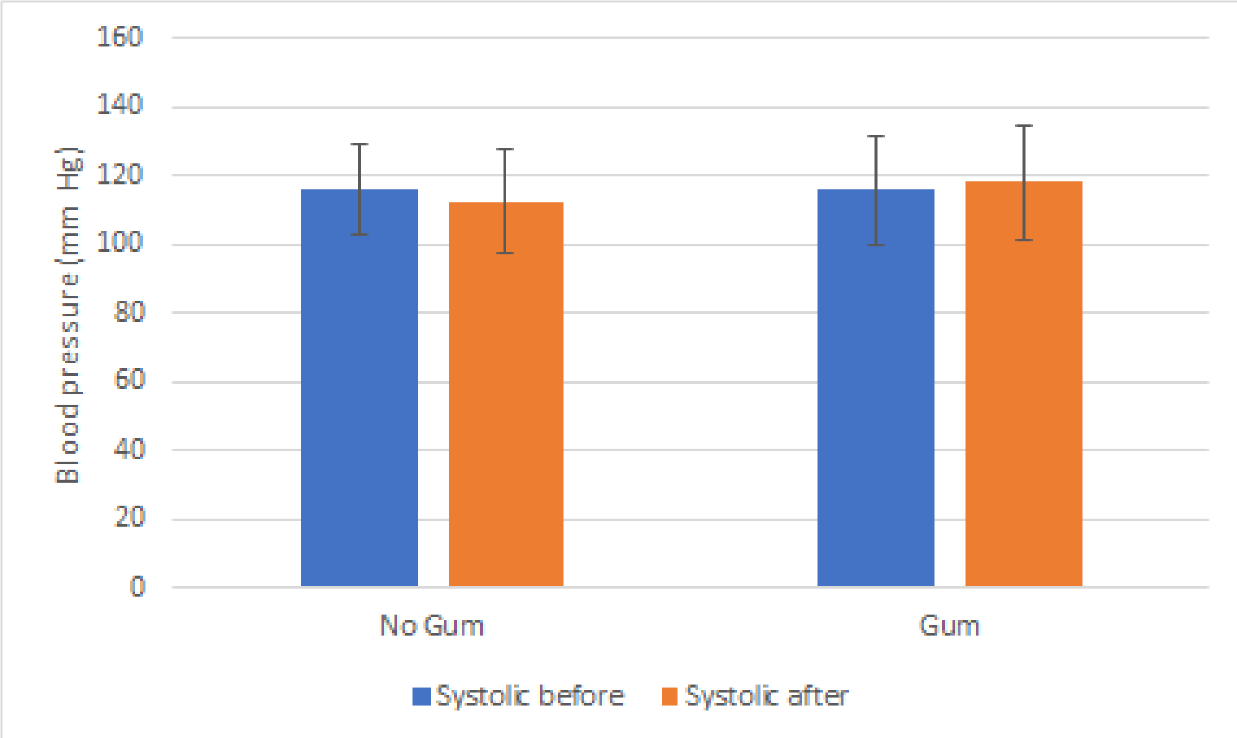

Figure 13: Summary of physiological systolic blood pressure between participants who chewed gum and those who did not before and after completing the typing test. The sample size includes 25 participants who chewed gum and 25 participants who did not chew gum. The p-value for systolic blood pressure before was 0.938 and the p-value for systolic blood pressure after was 0.216. The error bars represent standard deviation from the mean.

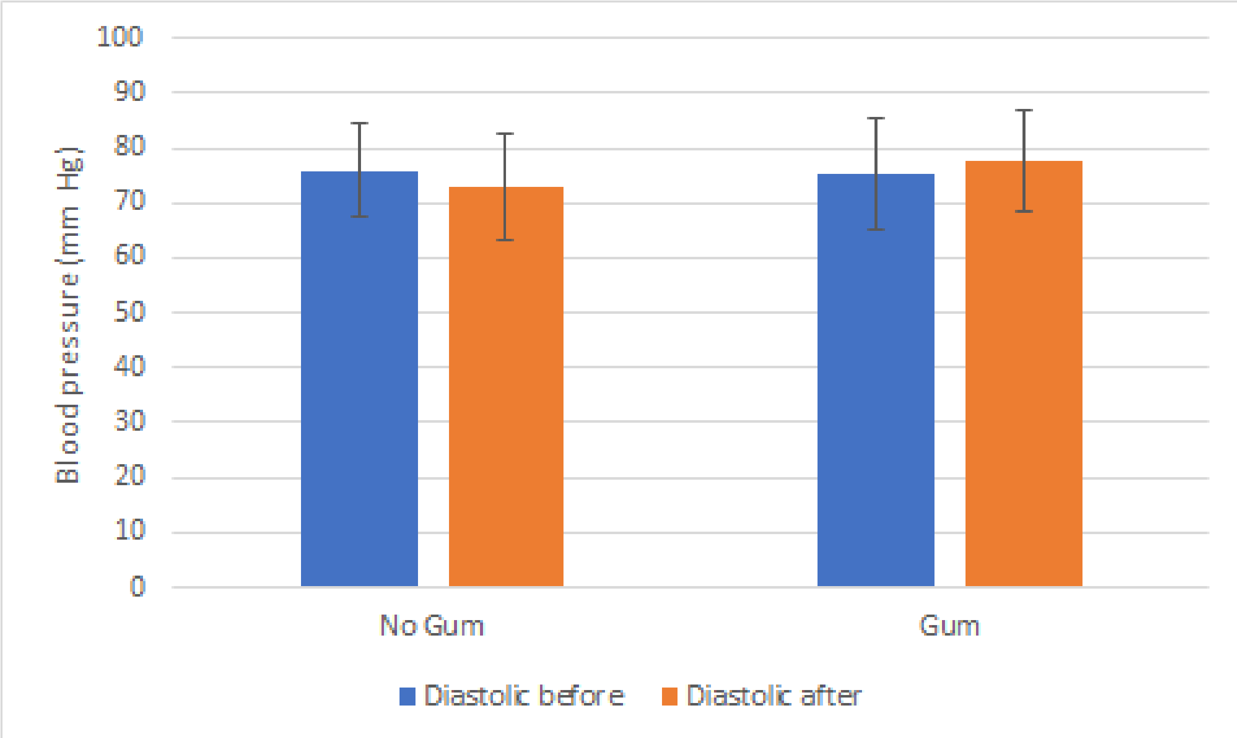

Figure 14: Summary of physiological diastolic blood pressure between participants who chewed gum and those who did not before and after completing the typing test. The sample size includes 25 participants who chewed gum and 25 participants who did not chew gum. The p-value for diastolic blood pressure before was 0.784 and the p-value for diastolic blood pressure after was 0.092. The error bars represent standard deviation from the mean.

Appendix

1. *Participant questionnaire*

You may skip any question that you do not wish to answer. Please indicate any non-answers by marking through the numeral with an X. Thank you for participating in this study!

i. Do you have any allergies or sensitivities to mint gum that might prevent you from participation in this study?

ii. Please indicate your gender:

    | Female | Male | Other | Prefer not to answer |

iii. How would you rate your own typing proficiency? | Below Average | Average | Above Average |

iv. How often do you chew gum? Choose the response that most closely resembles your habits. | Never, I don't chew gum | Occasionally, I sometimes chew gum | Frequent, I usually chew gum

v. Have you ever used chewing gum to help you focus or concentrate on cognitively demanding tasks? (studying, taking a test)

vi. Have you ingested caffeine or any other drugs in the last 12 hours that might affect your performance?

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