Effects of Mouthpiece Use on Auditory and Visual Reaction Time in College Males and Females

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Abstract: Studies in exercise science have suggested that the use of a mouthpiece can improve performance, and these improvements may be linked to an enhancement in temporomandibular joint (TMJ) positioning. Studies have suggested that by improving TMJ positioning, there is improved blood flow in the area of the TMJ. Changes in TMJ positioning may be improved with an oral device. The purpose of this study was to determine if there were improvements in auditory and visual reaction time with the use of a boil and bite mouthpiece. Using a BIOPAC system, study participants (N = 34) were asked to respond to an auditory signal during 40 trials. In the visual reaction time test, participants (N = 13) were assessed on how quickly they responded to a computer cue for a total of 30 trials. Auditory results showed a significant improvement with the use of a mouthpiece (241.44 ms) vs without a mouthpiece (249.94 ms). Visual results showed that participants performed slightly better with the mouthpiece (285.55 ms) vs without the mouthpiece (287.55 ms). These findings suggest that the use of mouthpiece positively affects visual and auditory reaction time, which is a vital aspect to optimal sport and exercise performance. Future studies should continue to shed light on possible reasons for the improvements in auditory and visual reaction time with the use of a mouthpeice. In addition, future studies should further illuminate what, if any, connection these improvements have with enhanced TMJ positioning.

Reaction time is the period that occurs between a stimulus and the initiation of muscle response[1] and can be assessed as simple reaction time, choice reaction time, and discriminate reaction time.[1] Signals to any sensory system in a variety of populations can be ascertained in any of the above situations. For example, Borysiuk[2] evaluated reaction and movement time with tactile, acoustic, and visual stimuli in advanced and novice fencers. He found that the advanced fencers had a significantly improved reaction time with the visual ($P < .057$) and the tactile ($P < .029$) stimuli, with no significant differences in the acoustic stimuli between novice and advanced fencers. However, the mean reaction and movement times with all three stimuli were lower in experienced fencers vs the beginners. Borysiuk found fencing training improved reaction times in people with advanced fencing skills, thereby explaining improved performance.[2]

Many studies in exercise science have suggested that the use of a mouthpiece can improve performance, which may be related to an enhancement in temporomandibular joint positioning. Without proper temporomandibular joint positioning, nerves and arteries within the joint may become occluded, resulting in strain in nearby tissues, thereby reducing blood flow.[3-7] By neutralizing the temporomandibular joint with a mouthpiece, patients have reported to their dentists reduced pain in the jaw, head, and neck areas, along with increased physical strength. This improvement in strength may be linked to improved blood flow and oxygen kinetics associated with reduced stress in the temporomandibular joint, thereby producing improved blood flow to the exercising skeletal muscles.[8-10]

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Several studies have shown that mouthpieces result in improved strength and endurance.[11-14] Specifically, Fuchs[7] found the isometric strength of the upper and lower body in 40 females was improved when participants wore a wax bite between the upper and lower teeth, resulting in a 3-mm vertical dimension. The greatest improvement with the wax bite was in isometric strength, with an increase of 8% in the left arm, 4.5% in the right arm, 6.3% in the left foot, and 11% in the left foot. Alexander[15] confirmed this finding when she tested the EDGE mouthpiece (Bite Tech Inc, Minneapolis, MN) in 61 male and female participants and found 74% had improved grip strength when using the mouthpiece.

BY NEUTRALIZING THE TEMPOROMANDIBULAR JOINT WITH A MOUTHPIECE, PATIENTS HAVE REPORTED TO THEIR DENTISTS REDUCED PAIN IN THE JAW, HEAD, AND NECK AREAS, ALONG WITH INCREASED PHYSICAL STRENGTH.

The authors found that muscular endurance improved significantly with the use of the mouthpiece vs not using one. Specifically, they determined mean bench press repetitions increased 11% while preacher curl repetitions increased 17% when participants used the mouthpiece compared with non-use (P = .03 bench press; P = .004 preacher curl). Thus, based on the indicative data that a mouthpiece improves exercise outcomes, this study's goal was to further elucidate the possible benefits of wearing a mouthpiece in regard to athletic performance, specifically improved reaction time.

METHODS

The research involved assessments of visual and auditory reaction times. There were 34 participants for the auditory arm and 13 for the visual. Ages ranged from 18 years to 21 years, with participants recruited from The Citadel's student body. The study was approved by the school's internal review board, and all participants signed consent forms.

BIOPAC Systems (BIOPAC Systems Inc, Goleta, CA) equipment was used to gauge auditory reaction time. The BSL-SS10L push button hand switch (BIOPAC Systems Inc), BSL-OUT1 headphones (BIOPAC Systems Inc), and Windows 95/98/NT 4.0/2000 (Microsoft® Corp, Redmond, WA) were employed. Each participant sat in a relaxed position with closed eyes and held the hand switch with the dominant hand, with the thumb in position to press the button. They were instructed to press this button when the headphones emitted a sound. Everyone underwent four segments, with 10 trials each. Segments one and two included a stimulus at pseudo-random intervals (1 to 10 seconds) while segments three and four used a stimulus at fixed intervals (every 4 seconds).

The visual test used a MS-DOS-based Motor Learning Activity Software System developed at Texas A&M University. This system uses Hick's Law, which states that reaction time increases as a function of a binary logarithm (log2 n), in which "n" is the number of equally likely possibilities. Specifically, the participant was asked to place his or her fingers on letters on a computer keyboard that corresponded to the same letters that were displayed on the computer screen. Above each letter on the computer screen were four large circles. The program proceeded through three sets of 10 trials. During the first trial, a line would appear over one circle with the letter beneath it. After a pseudo-random amount of time (1-10 seconds), the circle became white, at which point participants were to respond as quickly as possible by striking the corresponding letter on the keyboard. During the second set of 10 trials, the line would appear over two circles,

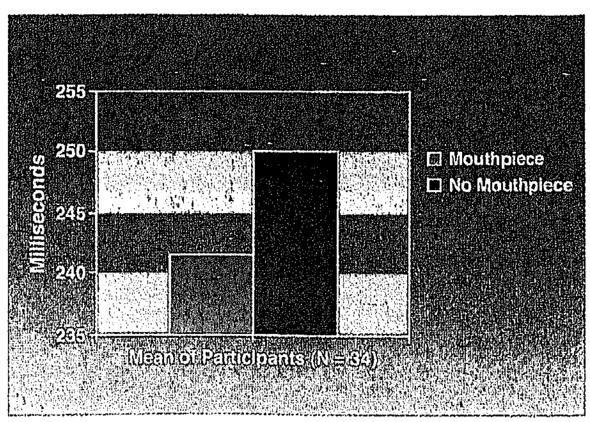

Figure 1 Mean values of auditory reaction time with and without mouthpiece.

but only one circle became white, and participants were to strike as quickly as possible the corresponding letter on the keyboard. For the final set of 10 trials, a line appeared over all four circles, one circle turned white after a pseudorandom amount of time, and participants were to respond as quickly as possible by striking the corresponding key on the keyboard. Participants completed two sets of the outlined Hick's Law test for a total of 60 trials.

For both arms of the study, participants completed the trials with and without a mouthpiece (the EDGE boil and bite). This mouthpiece was designed specifically to create a greater bite opening distal vs proximal in the mouth. Assignment of the mouthpiece was random, and participants were not told if any effect, either positive or negative, would result from its use.

RESULTS

Results of the auditory test showed participants (N = 34) performed significantly better with the mouthpiece than without (P = .004). The mean values with the mouthpiece were 241.44 ms vs 249.94 ms without the mouthpiece (Figure 1). Sixty percent were more successful with the mouthpiece. For the visual test, participants (N = 13) performed slightly better with the mouthpiece (P = .681). The mean values with the mouthpiece were 285.55 ms vs 287.55 ms without the mouthpiece. Sixty-two percent of participants were more successful with the mouthpiece (Figure 2).

DISCUSSION

This study indicates the use of a mouthpiece results in improvements in auditory and visual reaction times. The significance found in the auditory assessment suggests that the outcomes were not coincidental. The lack of significance in the visual test may be because of the small number of participants. If more participants were recruited, a trend of a lowered visual reaction time with the mouthpiece may be established.

The question, however, is how the mouthpiece provides such a benefit. Reaction time, specifically with visual and auditory stimuli, is a complicated series of events that begins with the stimulus and ends with the initiation of the movement. For example, reaction time associated with visual stimuli begins with the primary visual cortex from which two processing streams emerge. The first stream entails recognition of objects, while the second involves guiding actions and originates from the posterior parietal cortex. The oculomotor system involves three loops starting from the frontal cortex. The first loop goes through the brainstem, then the thalamus, returning to the cortex. The second loop travels through the caudate nucleus, substantia nigra, and thalamus, back to the cortex. The final loop proceeds through the superior colliculus and thalamus, returning to the cortex, with all three loops cross-communicating.[16] Auditory reaction time is associated with efficient spiral organ receptors in the middle ear, which transfer sound to the temporal lobes of the cerebral cortex via sensory neurons. It is well known that visual stimulus results in slower reaction times vs auditory stimulus because of the increased number of sensory neurons involved in the visual pathway.[2] Thus, the mechanisms by which a mouthpiece could affect these pathways may be complicated and worthy of further research.

Research claiming a reduction of stress in the temporomandibular joint area with the use of a mouthpiece may be one explanation for the improvement in reaction time.[8-10] If there is improved blood flow and neural transmission with the use of a mouthpiece that properly aligns

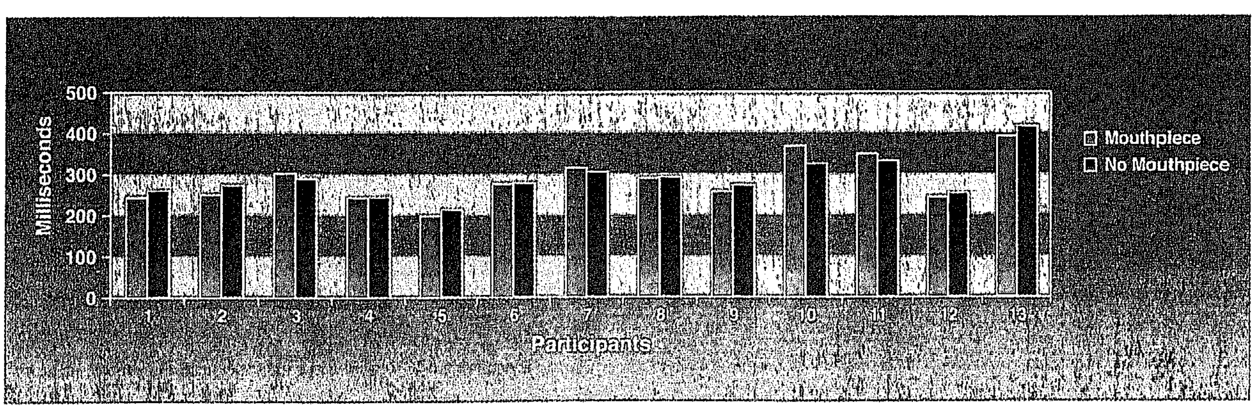

Figure 2 Mean values of visual reaction time with and without mouthpiece.

THUS, THE MECHANISMS BY WHICH A MOUTHPIECE COULD AFFECT THESE PATHWAYS MAY BE COMPLICATED AND WORTHY OF FURTHER RESEARCH. RESEARCH CLAIMING A REDUCTION OF STRESS IN THE TEMPOROMANDIBULAR JOINT AREA WITH THE USE OF A MOUTHPIECE MAY BE ONE EXPLANATION FOR THE IMPROVEMENT IN REACTION TIME.

the temporomandibular joint, then blood flow with increased oxygen unloading could be enhanced in other areas of the head and neck, leading to improvements in such events as reaction time. Reaction time with both the auditory and visual cues is a complicated series of events that may in some way be modulated with improved blood flow. Further studies should ascertain whether the physiologic mechanism within each of these systems is affected by proper temporomandibular alignment that occurs with the use of a mouthpiece.

CONCLUSION

This study explored auditory and visual reaction times with and without the use of a mouthpiece. Many sports engage the use of auditory and visual cues and depend on improved reaction times to obtain positive performance outcomes. If these findings are correct, it can be hypothesized that a number of athletes may be able to enhance performance when using a mouthpiece. Further studies are needed for a greater understanding of how mouthpieces affect performance physiologically.

DISCLOSURE

Dr. Garner has received an honorarium from Bite Tech Inc.

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