The Open Access Journal of Science and Technology
Vol. 3 (2015), Article ID 101148, 6 pages
doi:10.11131/2015/101148

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Research Article

# Effects of Mouthpiece Use on Lactate and Cortisol Levels During and After 30 Minutes of Treadmill Running

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Received 29 October 2014; Accepted 4 December 2014

Academic Editor: Mohammad Zandi



**Abstract.** *Background*: Protective mouthpieces have been used in a variety of sports to decrease the risk of orofacial injury. There is limited data to suggest that mouthpiece use during exercise may also provide an ergogenic effect. *Aim*: To investigate the effects of mouthpiece use (the Edge, Bite Tech Corp) on physiological parameters. *Methods*: Twenty-four college-aged recreationally fit subjects ran for 30 minutes on 2 separate trials with a mouthpiece randomly assigned to each trial for all subjects. Lactate and cortisol levels were assessed before, during (lactate only) and after testing. *Results*: This study found that lactate levels were significantly lowered in the mouthpiece condition at 30 minutes of exercise (4.01 mmol/L MP versus 4.92 mmol/L no MP, $P$-value = 0.024). In 22 of the 24 subjects salivary cortisol samples were assessed with no significant difference between mouthpiece and no mouthpiece condition (0.151 ug/dL MP, 0.214 ug/dL No MP, $P = 0.08$). *Conclusions*: The outcomes of this study suggest that use of a mouthpiece may affect lactate post moderate intensity exercise in this population.

**Keywords**: Mouthpiece; mouth guard; lactate; cortisol; moderate intensity running

## 1. Introduction

Dental professionals have advocated the use of mouth guards in a variety of contact sports to reduce the incidence of oral facial injury. Sports include wrestling, American football, field hockey, lacrosse, hockey, and boxing. Studies suggest that mouth guard use in contact sports results in a significant decrease in oral facial injury [1, 2]. In addition to the protective effects that mouth guards provide for athletes, some dentists in the 70s and 80s also cited an improvement in strength and endurance with mouth guard use. Smith [3, 4] found that there was a positive effect on muscular strength with mouth guard use in National Football Players and collegiate football players. Though no numbers were present in the first study Smith cited that 22 of 48 players were stronger, 12 of 48 slightly stronger and 10 of 48 significantly stronger with a wax bite between teeth versus nothing between teeth [3]. The explanation for these improvements was embedded in a controversial dental supposition that the correct positioning of the tempromandibular joint (TMJ) has an effect on whole body physiology [5]. The theory is that in re-positioning the TMJ, there is reduced stress throughout the body which would lead to performance enhancements [3]. However, this theory is not without its critics and likely due to the controversy of the TMJ and effects on performance parameters, research in this area was only recently revived.

Since the 70s and 80s there have been several studies seeking to elucidate effects on both anaerobic and aerobic performance [6–11]. Arent and colleagues cited that with the use of a custom fit upper mouth guard, using tempromandibular realignment techniques, resulted in improvements in anaerobic parameters versus a no mouth guard condition in college athletes [6]. Specifically they cited significant improvements in the following areas: 3.5% improved vertical jump, 4.9% improved average peak power for WAnt and intervals, 4.5% improved 30 s WAnt peak power, and 3.4% improved average mean power for WAnt and intervals. Though there were no differences in bench press and 30 s WAnt mean power, they suggested that the use of such a mouth guard would give athletes an advantage during muscular endurance and anaerobic power measures.

In addition to muscular endurance and anaerobic power measures, other studies have sought to determine the effect of mouthpiece use during aerobic exercise. This is based on previous subjective research by Garabee who cited an improvement in endurance parameters such an increased ability to recover after endurance runs and improvement in fatigue factors [12]. Specifically the subjective data in that study cited runners felt increased endurance and improved recovery with a mouthpiece. To explain effects on endurance exercise with mouth guard use, Francis and Basher found in 17 individuals improved ventilation with mouth guards during 20 minutes of high intensity cycling, despite testing bulky appliances [11]. In their paper they stated that the expectation of decreased ventilation was not cited, rather the improved ventilation could be due to a type of breathing called purse-lip breathing that may explain the improvements in ventilation for these subjects.

Besides anaerobic and respiratory benefits with mouth guard use, there has been some research to suggest that a mouth guard may also improve hormonal aspects during and post exercise. Research in this area has cited effects on cortisol with mouthpiece use as it relates to anaerobic exercise [9, 13]. Specifically research has cited improvements in cortisol with lower custom fit mouthpiece use after 60 minutes of intensive resistance exercise in division I football players ($N = 28$) [9]. There was a mean reduction of cortisol of 51% in mouthpiece condition versus no mouthpiece condition 10 minutes post exercise. This is similar to the research by Hori and colleagues which found a reduction in corticotrophin releasing hormones in physically restrained and stressed rats when they bit down on a wooden stick versus no stick [14]. In the Hori et al study with rats which had been restrained 30 minutes, there was a reduction of the average number of corticotrophin releasing factor (CRF) positive neurons from 199.0 in rats that did not bite down on a wooden spoon to 118.0 for rats that bit down on a wooden spoon. The authors cited that the potential explanation for this may be due to the complex interaction of the hypothalamus with the cerebral cortex and limbic system, specifically via the locus coeruleus. They cited that biting down may cause a suppression of the transmission of neurotransmitters (specifically norepinephrine/noradrenaline) mediated by the locus coeruleus and would therefore affect expression of the corticotrophin releasing hormone [14].

Interestingly, in addition to changes in corticotrophin releasing factor that occurred with biting down, Hasegawa and colleagues cited increased jaw movement and muscle contraction that correlated to increased cerebral blood flow as measured by transcranial Doppler ultrasound [15]. Hasegawa found in three different trials (clenching high muscle activity) chewing (moderate muscle activity), and teeth tapping (low muscle activity) differences in velocity of middle cerebral blood flow. For clenching there was a 6 percent difference in pre to on task in the clenching trial, 6 percent difference in pre and on task for the chewing trial, and 1 percent difference in pre and on task for the tapping trial. Interesting, the peak velocity of the cerebral artery blood flow occurred in 20 seconds with clenching, versus 145 seconds in chewing and 82–100 seconds in tapping. Thus, both Hori et al and Hasegawa et al research outcomes suggest changes occurring with clenching and biting that could lead to physiological outcomes during stress. However, a limited number of studies have examined the interaction of the mouthpiece on physiological outcomes during exercise. Thus, the goal of this study is to assess changes, if any, in cortisol (HPA axis) and lactate (two very common physiological markers occurring during exercise stress) with use of a mouthpiece before, during and post moderate intensity exercise with college-aged recreationally fit individuals.

## 2. Methods

*2.1. Experimental Approach.* The focus of this study was to determine if the use of a mouthpiece during moderate to higher intensity exercise affected lactate and cortisol before, during and after the exercise. Thus, a within subjects design was utilized in which each subject was randomly assigned the use of mouthpiece during one of two identical bouts of exercise that were separated by a minimum of one week and maximum of two weeks. Each subject was fit with the mouthpiece and then underwent familiarization sessions with the use of the treadmill, as well as the wearing of the mouthpiece.

*2.2. Subjects.* Subject characteristics are found in Table 1. There were 24 subjects who participated in our study (21 males and 3 females). All subjects participated in university-mandated physical exercise, which consisted of a minimum of two cardiovascular and two resistance exercise sessions

Table 1: Subject descriptions.

| | |
|---|---|
| Males | 21 |
| Females | 3 |
| Age | 20.84 (1.62 SD) |
| Height | 171.88 cm (3.27 SD) |
| Weight | 69.91 kg (21.87 SD) |

per week. All subjects were free of injury or sickness on testing days and were told not to participate in physical activity on the day of testing. Each subject was asked orally if they had adhered to these guidelines, and if had not, they were asked to return to the laboratory when they were either free of injury/sickness or had not participated in physical activity on the day of testing. The institution's Institutional Review Board approved the study. Before participation in the study, each subject read and signed an informed consent form detailing the study and stating that they could withdraw at any time from the study without consequences.

*2.3. Procedures.* Subjects were asked to complete two runs for 30 minutes on a treadmill (Treadmaster TMX 425 C by Full Vision Inc., Newton, KS) on two separate days. Treadmills speed was set based on 75-85% age predicted heart rate maximum. Subjects were tested first on what speed to set the treadmill based on the 75-85% heart rate range as measured with a heart rate monitor (Polar Heart rate monitor, Polar Electro Inc., Lake Success, NY). This speed was kept constant for each subject for both testing conditions. In addition, subjects were randomly assigned the use of mouthpiece on one of two days of testing, with testing taking place at approximately the same time each afternoon. Laboratory temperatures and humidity were also held consistent during all testing. Lactates (Accutrend Lactate Analyzer, Sports Resource Group, Inc., Hawthorne, NY) were taken at pre, 15 and 30 minutes of exercise and 10 minutes post exercise. In addition to lactates subjects provided a salivary sample for assessment of cortisol levels before exercise and immediately at the completion of the run by placing a straw in their mouths and allowing their saliva to slide down the straw into a cryovial. Each sample was labeled and placed into a freezer until all samples are collected and ready for assay to detect differences in cortisol levels. When all samples had been collected they were shipped to Salimetrics, according to company instructions, to obtain cortisol assay results (Salimetrics LLC, State College, PA).

Prior to the start of the study, subjects were fitted with an upper (maxilla) boil and bite mouthpiece (Bite Tech, Inc., Minneapolis, MN). Mouthpieces were fitted by dropping them in boiling water for 1 minute and then placing onto subject's maxilla. These mouthpieces were designed with two bite pads that separate the maxilla and mandible of an individual, having two cm distal width and a one cm proximal width. See Figure 1 for views of mouthpiece used for this study.

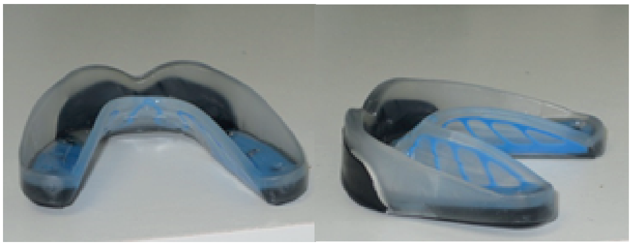
*2.4. Statistical Analysis.* The primary goal of this study was to determine the effect of mouthpiece use on individuals during and after an endurance exercise. Specifically we wanted to determine, if after randomly assigning the mouthpiece on one of two days resulted in lactate and/or cortisol effects in the individual, thus we utilized a within-subjects design to test the effect. All data was entered into Microsoft Excel for management and exported to SPSS 17.0 (IBM Corporation, Armonk, New York) for statistical analysis. Comparison of lactate and cortisol at individual time points between groups was done using a paired t-test. Percent change scores between group means were calculated using the following formula: ($\mu$2-$\mu$1/$\mu$1) x 100. Statistical significance was set at $P \leq 0.05$. All data are presented as mean $\pm$ SD.

## 3. Results

All subjects ($N = 24$) completed the study, with lactate collected for all subjects. However, only 22 subjects were able to provide readable salivary samples. The results of the study showed lactates were not statistically significant at minute 15 ($P = 1.00$, 4.55 mmol/L mouthpiece versus 4.55 mmol/L no mouthpiece). However, there was a statistically significant difference in lactates at 30 minutes of exercise ($P = 0.02$, 4.01 mmol/L mouthpiece versus 4.92 mmol/L no mouthpiece) with a trend towards lowered lactates at 10 minutes post ($P = 0.07$, 2.75 mmol/L mouthpiece versus 3.10 mmol/L no mouthpiece). There were no differences in cortisol levels between with and without mouthpiece condition with the pre time point ($P = 0.315$, 0.111 (ug/dL) MP and 0.120 (ug/dL) No MP). However, there was a trend to lowered cortisol levels in the post condition with $P = 0.08$, 0.151 (ug/dL) MP versus 0.214 (ug/dL) No MP). See Table 2 for data results.

## 4. Discussion

With the increased promotion of mouthpiece use in sport and exercise, the purpose of this study was to determine physiological mechanisms that could explain potential improvements cited in endurance exercise with mouthpiece use. Thus the goal of this study was to utilize an objective indicator of fatigue (lactate levels) to understand any effects of mouthpiece use on this measure. In earlier research Garabee cited that runners felt better with mouth guard use; specifically citing this improvement was due to the detrimental effects of clenching which would thereby drain the body of needed energy leading to quicker fatigue [12]. The mouth guard, he reasoned, improved malocclusion issues associated with clenching and would thereby explain improved endurance capacity with mouth guard use during endurance exercise [12]. However, the idea of clenching and



Back view Side view

**Figure** 1: Design of upper mouthpiece.

Table 2: Effects of mouthpiece use on lactate and cortisol at 30 minutes and 10 minutes post moderate intensity activity.

| | 30 min MP | 30 min No MP | % **change** | 10 min post MP | 10 min post No MP | % **change** |
|---|---|---|---|---|---|---|
| Lactates (mmol/L) | 4.01± 0.24 | 4.92 ± 0.43 | **22.9%** | 2.76 ± 0.17 | 3.10 ± 0.19 | **12.3%** |
| Cortisol (ug/dL) | 0.151±0.106 | 0.214 ± 0.170 | **42%** | N/A | N/A | N/A |

the negative effects of malocclusion are difficult to interpret and study as it relates to fatigue during endurance exercise [5]. Therefore, we have sought to identify objective measures of improvements during endurance exercise by assessing lactate and cortisol with mouthpiece use.

In this present study we assessed effects of mouthpiece use on lactates and cortisol during and after exercise. In order to understand individual effect, we utilized participants as their own subjects to determine individual effects of mouthpiece use versus comparing with a control group. It was important to establish the individual effects to determine if outcomes as cited in mouth guard/mouthpiece advertising by mouth guard/mouthpiece companies held true for the individual consumer. Although there is literature to suggest that mouth guards have a physiological effect on the individual during both strength and endurance exercise, it was unknown if this was due to some type of psychological effect in which the subject felt the mouthpiece would improve performance resulting in a noted improvements. Therefore, before we fit the participants with mouthpieces, we did not lead them to believe that the mouthpiece would or would not help them in any way during the protocol. Since the literature is relatively new in this area and few people utilize mouthpieces for performance enhancement, it was not difficult to convince participants of this statement as we, the researchers, were also unaware of any positive or negative physiological effect.

Our study found a significant improvement in lactate (decreased 23% at 30 minutes of exercise with mouthpiece use) with no significant improvement in cortisol, though the trend suggests improvements in cortisol. The question remains as to how a mouthpiece elicits an effect on lactate and cortisol, which are activated via the sympathetic adrenal medullary axis (SAM) axis and hypothalamic pituitary axis (HPA) axis, respectively. The complex nature of the stress response (with exercise serving as the physical stress) involves both the SAM axis and HPA axis to regulate homeostasis. As Hori and colleagues indicated in their study, there is a potential norepinephrine response which could explain outcomes when rats bit down on a wooden stick [14]. Norepinephrine serves as a neurotransmitter but also plays a key role as a hormone in regulating glycolysis during exercise. Thus, one variable that can be assessed during exercise is lactate which is a by-product of glycolysis and is affected by both epinephrine and norepinephrine during physical stress of exercise. In the current study we did find lowered lactate levels which may be a result of improvements in norepinephrine. However, future studies should assess if there are differences in norepinephrine with mouthpiece use.

Another possible explanation for improvements in lactate may be related to improvement acid/base balance within the blood. During exercise, the process of transporting carbon dioxide through the blood to the lungs involves the binding of hydrogen. Wasserman and colleagues suggest that as much as 94% of hydrogen ions produced during exercise will be immediately buffered by bicarbonate buffering [16]. Hydrogen at the level of the lungs will bind with bicarbonate ion which then dissociates into carbon dioxide and water. In comparing mouthpiece use to pursed lip breathing (as the tongue lays down and subjects are asked to breathe through their mouths), the literature has shown that such breathing (pursed lips breathing) increases carbon dioxide output and decreases pH levels (lower hydrogen ions in the blood) [17, 18]. To support this theory, Garner and colleagues assessed the effect of a mouthpiece while measuring oxygen/carbon dioxide kinetics during running and found that with mouthpiece use there was increased carbon dioxide exhalation and oxygen intake versus no mouthpiece use. In addition, there were significant improvements in respiratory rate, with the mouthpiece condition having lowered respiratory rates versus no mouthpiece condition [10]. The authors also cited improved airway opening with mouthpiece use specifically in the oropharynx [10]. These findings are similar to the ventilation and respiratory outcomes occurring with pursed lips breathing research [17, 18]. In both Mueller et al and Tiep et al studies, there were significant decreases in respiratory rate with pursed lip breathing in both rest and exercise conditions and significant increases in carbon dioxide production in rest condition. In the Garner et al study they cited that this improvement in airway dynamics was explained by the type of mouthpiece utilized which resulted in forward mandibular placement of the mandible. In addition, to the anatomical effect of the mouthpiece on the airway there may be a neuromuscular effect in which the genioglossus is being contracted and thereby with the contraction leads to the dilation of the pharyngeal area. Sleep apneic research cites this phenomenon in both healthy and sleep apneic patients in which, if the genioglossus is contracted (tongue is pushed down and forward), there is a subsequent relaxation of the pharyngeal area in the back of the throat [19–21]. Thus, the type of breathing with a mouthpiece may be associated with pursed lips breathing as in both cases the tongue is contracting leading to the subsequent outcomes cited in previous studies. However, further studies are needed to assess the impact of mouthpiece use on the neuromuscular and anatomic effects in the mouth.

Finally, there were no significant differences in cortisol levels as compared to findings by a previous study, though a trend was noted. As cited earlier, Garner and colleagues found significant improvements (improvement 51%) in cortisol with mouthpiece use after one hour of intensive resistance exercise [9]. In that study subjects wore a custom fit lower mouthpiece. Although the mouthpiece was different than in the present study, both mouthpieces had the same bite pads which had a greater height in the proximal area (1 cm) versus the distal area (2 cm). In this present study, cortisol was collected immediately after the exercise to determine if there is a potential association with mouthpiece use and cortisol during shorter term endurance exercise. There was a trend for lowered cortisol in the mouthpiece condition post exercise, but was not significant between groups. This may be due to the type of exercise utilized as well as the timing for which the samples were taken. In the present study, samples were taken immediately after exercise. In addition, research suggests that cortisol increases after 45 minutes to an hour of intense aerobic exercise [22]. The current protocol was only 30 minutes. Clearly the present strenuousness of the exercise could not achieve the desired changes in cortisol as would a longer and more intensive protocol. Finally this is made evident in comparing our study to that of Garner and colleagues who utilized intensive resistance exercise which lasted an hour [9]. However, due to the unknowns of aerobic exercise and the use of the mouthpiece, we elected for a shorter protocol to determine if differences in cortisol would be apparent. Interestingly the percent change in this current study was 42% as compared to the resistance training protocol study at 51%. The trend is evident from the current study, thus future studies with aerobic exercise with a mouthpiece and assessment of cortisol would utilize a longer and potentially more intense aerobic protocol.

It is apparent that many questions remained to be answered with this supposed mouthpiece effect on human performance. The current study illustrates an improvement in lactate levels in mouthpiece use during endurance exercise. In addition, it found trends towards improvement in cortisol levels. Improvements in lactate and cortisol in endurance exercise with mouthpiece use may suggest improvements in fatigability and recovery capabilities, which in turn may affect future exercise sessions. Further studies need to assess the impact of these parameters on recovery with mouthpiece use as well as any effect with mouthpiece use on overtraining syndrome. Future studies should continue to elucidate the effects of mouthpiece use on performance parameters to include aerobic and anaerobic exercise and the interaction of HPA axis and SAM axis.

The purpose is to educate dental practitioners on how to properly educate interested patients on mouthpiece use in exercise and performance. In the current study, there were no negative acute outcomes for wearing a mouthpiece during exercise, with no subjects complaining of pain or discomfort. In fact many of the subjects commented that they felt the mouthpiece improved outcomes in performance, that is, they felt less tired and could therefore complete the protocol with greater ease. This is similar to the study with Garabee who reported similar outcomes in runners who wore mouthpieces [12]. However, this study sought to quantify purported feelings of improvements. However, it is clear that more studies are needed in this area to further elucidate any positive or negative physiological outcomes with mouthpiece use during exercise and how these are linked to physiological outcomes.

## Conflicts of Interest

The authors have no professional relationship with the manufacturer of this mouthpiece and will not benefit from the results of this study. In addition, the authors do not endorse the product based on the results of this study. The study was partially funded by Bite Tech, Inc (supplying the mouthpieces) but the company was not involved in any part of the design of the study, data acquisition, analysis or the final written product of this study.

## References

[1] J. C. Hughston, Prevention of dental injuries in sports., *American Journal of Sports Medicine*, **8**, no. 2, 61–62, (1980).

[2] ADA Council on Access, Prevention and Interprofessional Relations: and ADA Council on Scientific Affairs. Using mouthguards to reduce the incidence and severity of sports-related oral injuries, *Journal of American Dental Association*, **137**, no. 12, 1712–1720, (2006).

[3] S. D. Smith, Muscular strength correlated to jaw posture and the temporomandibular joint., *The New York state dental journal*,

**44**, no. 7, 278–285, (1978).

[4] S. D. Smith, Adjusting mouthguards kinesiologically in professional football players., *The New York state dental journal*, **48**, no. 5, 298–301, (1982).

[5] M. Moore, Corrective mouth guards: Performance aids or expensive placebos? *Physician and Sportsmedicine*, **9**, no. 4, 127–132, (1981).

[6] S. M. Arent, J. McKenna, and D. L. Golem, Effects of NeuroMuscular Dentistry-Desgined Mouthguard on Muscular Endurance and Anaerobic Power, *Comp. Ex. Physiol.*, **7**, no. 2, 73–79, (2010).

[7] D. P. Garner and J. Miskimin, Effects of mouthpiece use on auditory and visual reaction time in college males and females., *Compendium of continuing education in dentistry*, **30**, 14–17, (2009).

[8] D. P. Garner and E. McDivitt, Effects of mouthpiece use on airway openings and lactate levels in healthy college males., *Compendium of continuing education in dentistry*, **30**, 9–13, (2009).

[9] D. P. Garner, W. D. Dudgeon, and E. J. McDivitt, The effects of mouthpiece use on cortisol levels during an intense bout of resistance exercise, *Journal of Strength and Conditioning Research*, **25**, no. 10, 2866–2871, (2011).

[10] D. P. Garner, T. P. Scheett, and E. J. McDivitt, The effects of mouthpiece use on gas exchange parameters during steady-state exercise in college-aged men and women, *Journal of the American Dental Association*, **142**, no. 9, 1041–1047, (2011).

[11] K. T. Francis and J. Brasher, Physiological effects of wearing mouthguards, *British Journal of Sports Medicine*, **25**, no. 4, 227–231, (1991).

[12] W. F. Garabee Jr., Craniomandibular orthopedics and athletic performance in the long distance runner: a three year study, *Basal facts*, **4**, no. 3, 77–81, (1981).

[13] D. P. Garner and E. J. McDivitt, The effects of mouthpiece use on salivary cortisol and lactate levels during exercise, *Medicine and Science in Sports and Exercise Supplement*, **41**, no. 5, p. S448, (2009).

[14] N. Hori, N. Yuyama, and K. Tamura, Biting suppresses stress-induced expression of corticotropin-releasing factor (CRF) in the rat hypothalamus, *Journal of Dental Research*, **83**, no. 2, 124–128, (2004).

[15] Y. Hasegawa, T. Ono, K. Hori, and T. Nokubi, Influence of human jaw movement on cerebral blood flow, *Journal of Dental Research*, **86**, no. 1, 64–68, (2007).

[16] K. Wasserman, W. L. Beaver, and B. J. Whipp, Mechanisms and patterns of blood lactate increase during exercise in man, *Medicine and Science in Sports and Exercise*, **18**, no. 3, 344–352, (1986).

[17] B. L. Tiep, M. Burns, D. Kao, R. Madison, and J. Herrera, Pursed lips breathing training using ear oximetry, *Chest*, **90**, no. 2, 218–221, (1986).

[18] R. E. Mueller, T. L. Petty, and G. F. Filley, Ventilation and arterial blood gas changes induced by pursed lips breathing., *Journal of applied physiology*, **28**, no. 6, 784–789, (1970).

[19] M. B. Blumen, A. Perez De La Sota, M. A. Quera-Salva, B. Frachet, F. Chabolle, and F. Lofaso, Genioglossal electromyogram during maintained contraction in normal humans, *European Journal of Applied Physiology*, **88**, no. 1-2, 170–177, (2002).

[20] R. B. Fogel, J. Trinder, A. Malhotra, M. Stanchina, J. K. Edwards, K. E. Schory, and D. P. White, Within-breath control of genioglossal muscle activation in humans: Effect of sleep-wake state, *Journal of Physiology*, **550**, no. 3, 899–910, (2003).

[21] J. E. Remmers, Wagging the tongue and guarding the airway: Reflex control of the genioglossus, *American Journal of Respiratory and Critical Care Medicine*, **164**, no. 11, 2013–2014, (2001).

[22] E. O. Acevedo, R. R. Kraemer, G. H. Kamimori, R. J. Durand, L. G. Johnson, and V. D. Castracane, Stress hormones, effort sense, and perceptions of stress during incremental exercise: An exploratory investigation, *Journal of Strength and Conditioning Research*, **21**, no. 1, 283–288, (2007).