Facial Muscle Activation Patterns Across Woodwind Instruments

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Introduction

Playing related pain among wind instrumentalists has the potential to influence performance. These concerns are exasperated when a musician plays multiple instruments, including students pursing advanced "multiple woodwinds" degrees in performance. NASM accredited universities grant advanced degrees in this field of study, as proficiency across multiple woodwind instruments is essential when performing in theatre pit orchestras, big bands, and studio recording sessions. Students enrolled in these degree programs are required to showcase expertise in flute, saxophone, clarinet, oboe, and bassoon. One concern for these musicians relates to changing musculoskeletal demands when moving from one instrument to another.

Unfortunately, little is known about the specificity of these changing demands across woodwinds. Because each instrument requires distinct embouchures and varying musculoskeletal demands, performing multiple woodwind instruments may increase the risk for muscular pain and injury. While previous studies have used electromyography to characterize facial muscle activation patterns during musical tasks, no known studies have used EMG to characterize and compare muscle activation patterns across woodwind instruments.

Purpose

The purpose of the study was to characterize and compare muscle activation patterns across the five major woodwind instruments: bassoon, flute, oboe, saxophone, and clarinet.

Specific Aims

1. Identify and measure muscle belly locations using cadavers for sensor placement purposes
2. Measure bilateral EMG activity of the sternocleidomastoid, temporalis, zygomaticus major, and masseter muscles while performing five woodwind instruments (bassoon, flute, oboe, saxophone, and clarinet)
3. Compare EMG measurements of each muscle's activity across the five woodwind instruments
4. Identify bilateral discrepancies in muscle activity across the five woodwind instruments
5. Compare EMG measurements of each muscle's activity within each instrument
6. Identify bilateral discrepancies in muscle activity within each instrument

Method

The muscles identified and examined in this single-case research design included the masseter, temporalis, sternocleidomastoid, and zygomaticus major. Utilizing the anatomy lab at the University of North Texas Health Science Center, foundational research was conducted using cadavers to identify specific locations of muscle bellies of aforementioned muscles. Measurements were acquired using discernable landmarks across twenty-six specimens to ensure precise EMG sensor placement on the single subject.

In a research lab at the University of North Texas, the Trigno Wireless EMG system (Delsys) was used to collect EMG data from four specific bilateral facial muscle groups. The research was designed to characterized patterns generated by a single subject (multiple woodwind expert) who performed on all instruments.

Using IRB approved protocol, the sensors were placed bilaterally on the masseter, temporalis, sternocleidomastoid, and zygomaticus major by a board-certified physician. All eight EMG sensors remained in place throughout the duration of the data collection process in order to compare within-subject changes.

The subject performed identical musical excerpts on bassoon, flute, oboe, saxophone, and clarinet (displayed in Figure 1). To ensure accurate data collection across instruments, the subject remained sitting while carefully changing instruments with the sensors in place.

Data analysis was completed using the EMGworks software by Delsys. Graphs were generated and organized to 1) compare muscle activation patterns across the five woodwind instruments, and 2) compare the activation patterns across the four muscle groups while performing each specific woodwind instrument.

Figure 1. Musical Excerpts Performed on Bassoon, Flute, Oboe, Saxophone, and Clarinet

Results

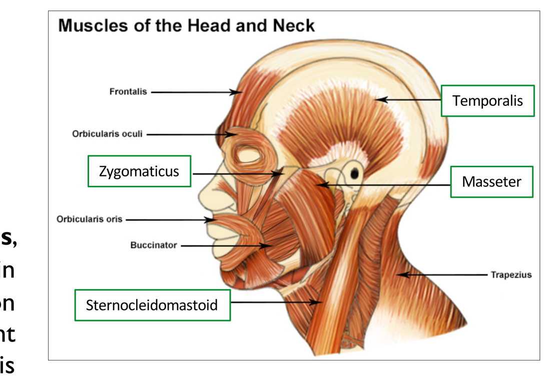
Figure 2. Measurements of Muscle Locations

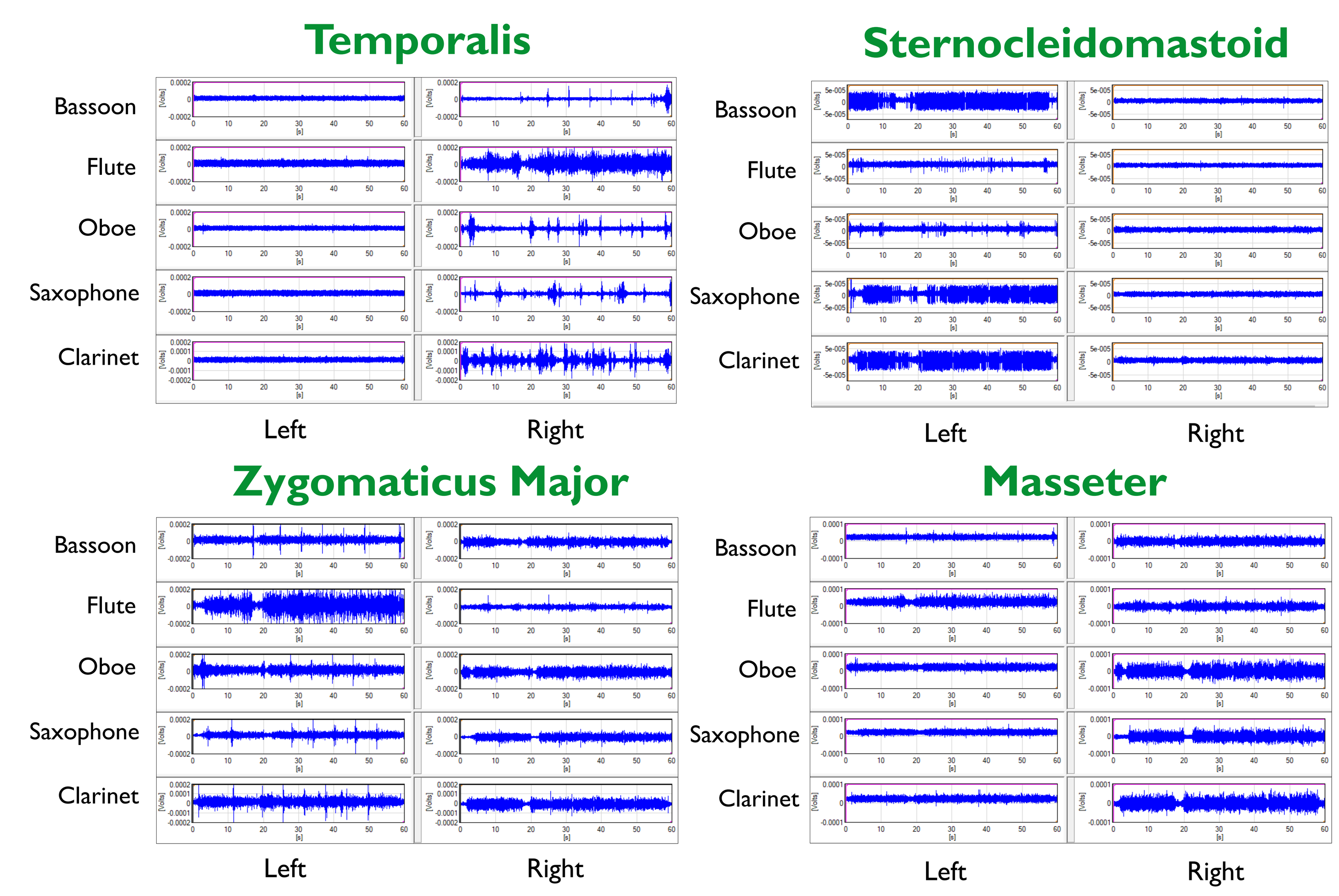
Collected with the assistance of anatomist Dr. Cara Fisher at the UNT Health Science Center, Figure 2 displays measurements of facial muscle locations from twenty-six cadavers. Measurements were calculated in millimeters using specific landmarks including the tragus and the corner of the mouth. Distance was measured between the landmark and muscle belly in order to ensure precision and accuracy of sensor placement during EMG data collection.

1	SAB# and Side	Zygomaticus Major	Zygomaticus Minor	Levator Labii Superioris	Masseter	Depressor Anguli Oris	Depressor Labii Inferioris
2	51834L	7.3	Removed	9	4.4	2.5	1.5
3	62486R	6.7	Removed	9.2	5	2.3	2.1
4	59524R	6.4	7	10.1	5.4	2.3	2
5	59524L	6.6	Removed	10.4	5.1	2.3	2.2
6	54946R	6.5	7.5	9.4	4.4	2.2	2.1
7	54946L	6.6	Removed	9.5	4.4	2	2
8	56543R	6.5	Removed	10.4	4.9	2.3	1.9
9	56543L	7	Removed	10	Removed	2.2	2
10	54943R	7.8	8.9	10.4	4.7	2.2	2
11	54943L	7.9	Removed	10.6	5.5	2	1.9
12	65374R	Removed	Removed	11.2	5.1	2	2.1
13	65374L	7.5	8	10.8	4.8	2.3	2.3
14	65388R	7.4	8	9.5	4.5	3.5	2
15	51822R	7	Removed	9.2	4.3	3	2
16	51822L	7	Removed	8.5	4.2	2.7	2
17	59557R	7	7.8	10.4	4.9	3	2.3
18	59557L	8	8.7	9.8	5.4	3.5	3
19	51835R	7.8	8.1	9.9	5.5	2.4	2.4
20	51835L	7	Removed	9	4.6	2.4	2
21	65423R	8.6	Removed	10.5	4.3	2.5	2
22	62441R	7.3	8.1	9	4.8	2.1	1.5
23	62441L	7	8.2	8.7	5.5	2.3	1.8
24	62325R	8.2	Removed	10	5.7	3.4	2.9
25	65374R	Removed	Removed	11.2	5.1	2.3	2.3
26	65374L	7.5	8	10.8	4.8	2.1	2
27	65493R	7.3	Removed	9.2	4.6	2.4	2.4
28	65493L	Removed	Removed	7.8	4.7	2	2.6

Figure 3. Comparison Graphs of Four Separate Muscles Across the Woodwind Instruments

Displayed in Figure 3, bilateral EMG measurements are compared across each instrument, graphed separately in regard to each muscle. The left side of each graph indicates the left muscles; the right side of each graph indicates the right muscles. From top to bottom, measurements are displayed for bassoon, flute, oboe, saxophone, and clarinet. It is important to note the differences in amplitude when looking at each graph.





When looking at the **temporalis**, one can see a visual difference in amplitude of muscle activation between the muscles on the right and left sides; the right temporalis is significantly more engaged during each the performance of each instrument in this single case study. Across instruments, the flute engages the right temporalis significantly more than any other woodwind instrument. Muscle activation during clarinet performance comes second, with the temporalis least active during the performance of saxophone, oboe, and bassoon.

The **sternocleidomastoid** indicated substantial differences bilaterally, as well as across instruments. The left sternocleidomastoid produced greater muscle activity than the right sternocleidomastoid, as can be seen visually in the graph. Across instruments, bassoon, saxophone and clarinet engaged the sternocleidomastoid substantially more during performance than the flute and oboe.

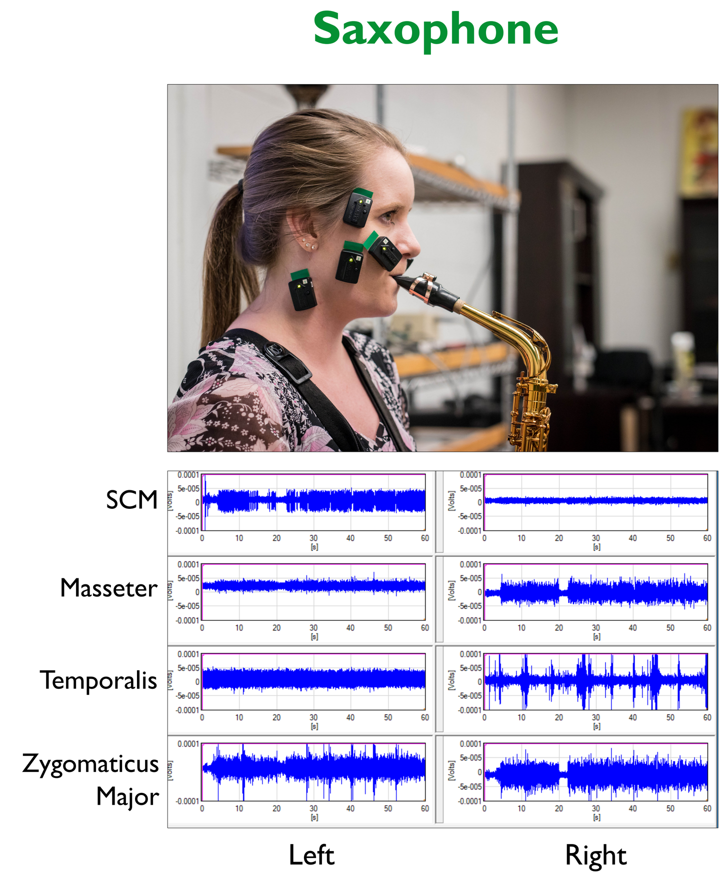
Comparing the **zygomaticus major** bilaterally, as well as across the instruments, substantial differences in activation patterns are apparent. The flute engages the left zygomaticus major significantly more than the right zygomaticus major; the left muscle is also much more engaged during flute performance as compared to the other four instruments. Omitting any bilateral differences, average activation of the zygomaticus major is most prevalent during performance of the flute, followed by clarinet, oboe, bassoon, and finally, saxophone.

The strongest muscle of the body, the **masseter** muscle, showed highest activity on the right side of the face. This was consistent during performance of every instrument except the flute, during which bilateral measurements were relatively equal. When comparing the masseter across instruments, its activation patterns were highest during performance of the oboe, followed by clarinet, saxophone, bassoon, and then flute.

Figure 4. Comparison Graphs of Activation Patterns of Four Muscles Within Each Woodwind Instrument

Displayed in Figure 4, bilateral measurements are compared across each instrument, graphed separately in regard to each muscle. On the left side of each graph are the left muscles; on the right side of each graph are the right muscles. From top to bottom, measurements are displayed for bassoon, flute, oboe, saxophone, and clarinet. It is important to note the differences in amplitude when looking at each graph.

Saxophone



While performing the **saxophone**, there are visible differences in activity between various muscles controlling the embouchure. The zygomaticus major was the most active on each side, followed by the right masseter and left sternocleidomastoid. The temporalis displayed constant activity on the left side and sporadic pulses of activity on the right side.

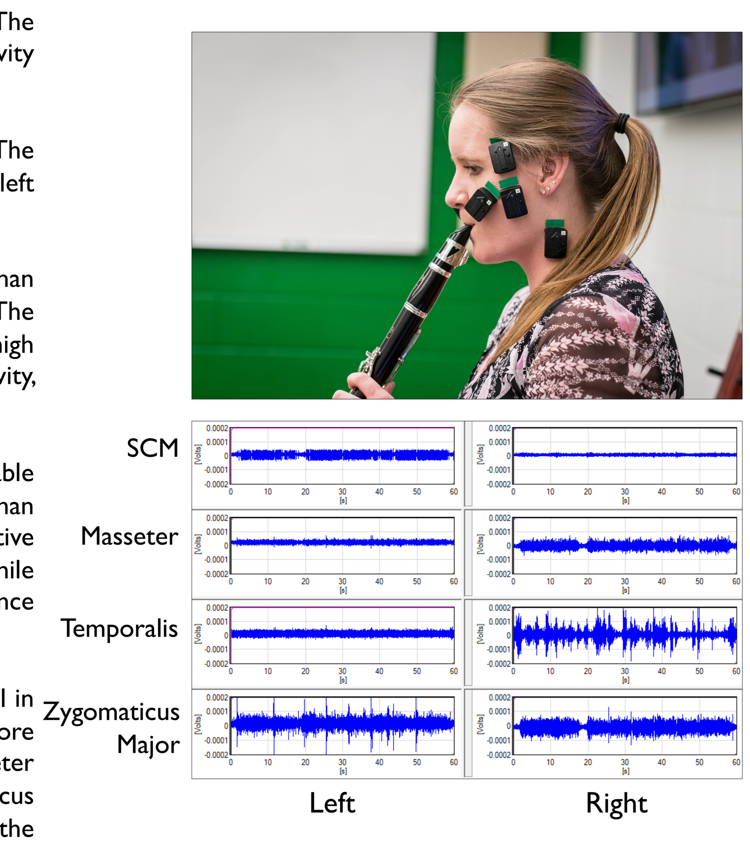
Bassoon followed a very similar pattern of muscle activity as the saxophone. The zygomaticus major displayed the highest levels of activity, followed by the left sternocleidomastoid, right masseter, and then the temporalis.

During **clarinet** performance, the muscle activation patterns were different than those generated during performance of the other woodwind instruments. The zygomaticus major was the most active, though the right temporalis displayed high pulsations of muscle activity. The right masseter had the next highest level of activity, followed by the left sternocleidomastoid.

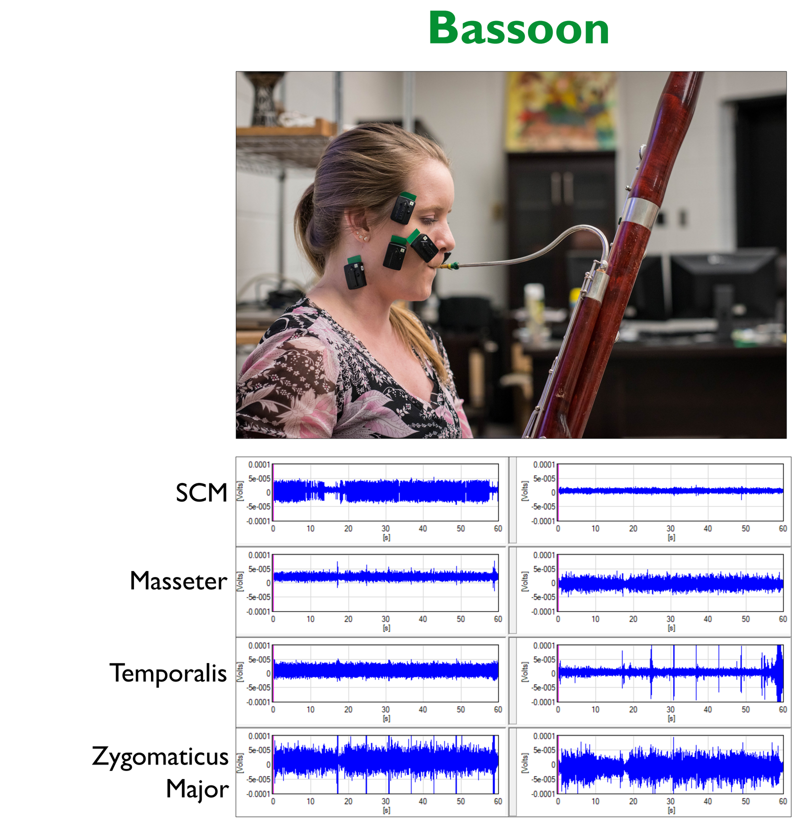
Interestingly, the data generated during **flute** performance shows notable differences bilaterally. The left zygomaticus major was substantially more active than the right zygomaticus major, and the right temporalis was substantially more active than the left temporalis. Likely, this is a result of the positioning of the body while performing the flute. The masseter was only slightly active during flute performance and the sternocleidomastoid was very inactive.

Muscle activation patterns during **oboe** performance were relatively symmetrical in regard to the facial structure, though the right temporalis displayed more inconsistency during performance than the left temporalis, and the right masseter was more active than the left masseter. The most active muscle was the zygomaticus major, followed by the temporalis, followed by the masseter, concluding with the sternocleidomastoid.

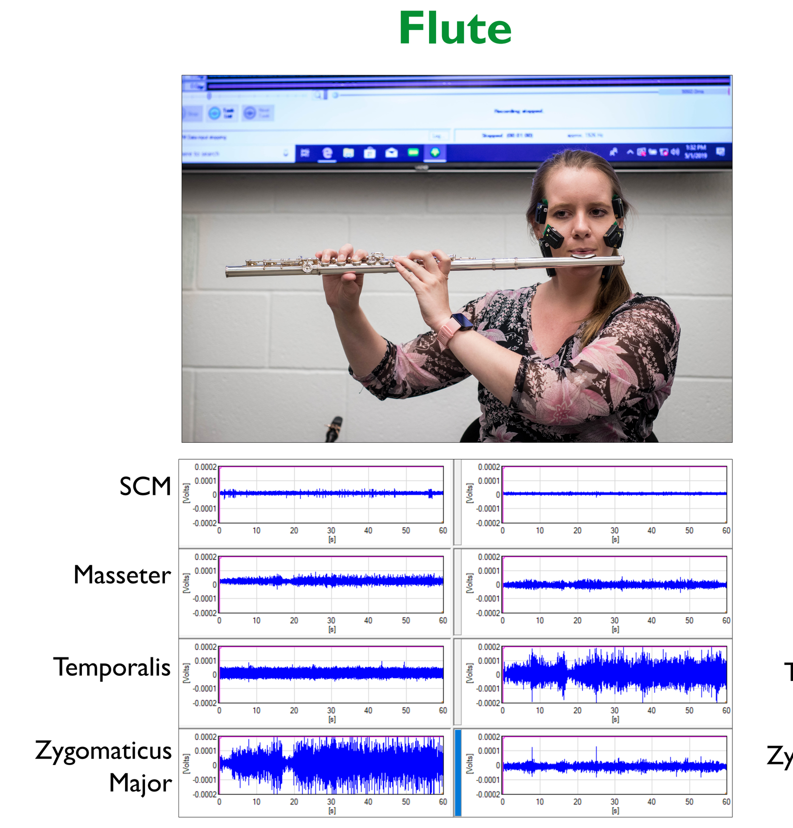
Clarinet



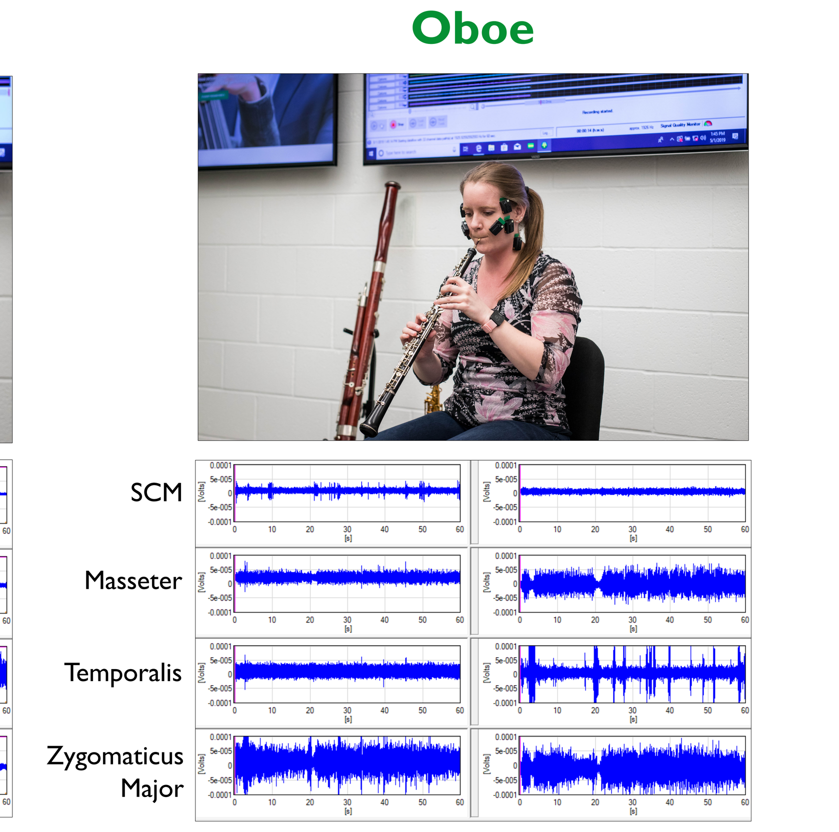
Bassoon



Flute



Oboe



Dr. Sarah Dunbar

Sarah Dunbar is an active performer, educator, and clinician specializing in woodwind instruments. Originally from Seattle, WA, Dunbar first studied at the Berklee College of Music before transferring to the University of North Texas. She recently completed a Doctor of Musical Arts Degree in Multiple Woodwind Performance, simultaneously holding a Saxophone Teaching Fellowship and pursuing a related field in Performing Arts Health. Dunbar holds a Master's Degree in Multiple Woodwind Performance with a related field in Music Education, a Bachelor's Degree in Jazz Studies, and a Bachelor's Degree in Classical Saxophone Performance.

In addition to solo and ensemble performances across the United States, including the inaugural American Single Reed Summit (2018) and the 2019 United States Navy Band International Saxophone Symposium, Dunbar has performed in Canada, China, and throughout Austria. She was selected as a finalist in the Coeur D'Alene Symphony Orchestra's National Young Artist Competition and the 2018 VSA International Young Soloist Competition, and won a scholarship to study and perform in Vienna, Austria through the 2018 VSMF International Concerto Competition.

As a winner of the 2018 American Protégé International Concerto Competition, Dunbar gave her Carnegie Hall debut in May 2018. She won First Prize in the 2018 "Golden Classical Music Awards" International Competition, awarding her a second solo recital performance at Carnegie Hall on in November 2018. She was most recently named the First Prize Winner of the North International Music Competition, based out of Stockholm, Sweden.

Dr. Sarah Dunbar currently resides in the Dallas-Fort Worth area and works with students of all ages and abilities. In her free time, she leads an active life style and is training for her fourth full marathon, the 2019 Chicago Marathon.

Conclusions

Measurable differences in muscle activation patterns across woodwind instruments, as well as across muscles influencing embouchure within each woodwind instrument are shown in this study. Bilateral discrepancies in muscle activation are concerning, and could explain why pain might be experienced for this particular musician.

This study warrants further investigation of facial musculoskeletal activation patterns generated while performing multiple instruments. Research is also needed to better understand the health challenges related to being a multiple woodwind specialist. EMG testing has the ability to identify unnecessarily overactive or imbalanced muscles during performance. This study should be expanded to include muscles outside of the face and neck, and musicians who perform non-woodwind instruments.

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