

The Warm Up

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Abstract

Arthritis is an inflammatory disease that targets the joints of many individuals. Arthritis can be painful and make it challenging for individuals to perform actions that once brought them joy. Using insights from an interview with a professional clarinetist who has arthritis, our team decided to create a novel device aimed at assisting clarinetists, and more broadly musicians, with their joint pains. We hypothesize that induced heating of the palm and mechanical stimulation of the MCP joints will decrease the discomfort individuals with rheumatoid arthritis feel when practicing to play the clarinet. Our device prototype comprises two main parts: a glove with vibrational motors and a heating element to stimulate the hand, and a clarinet body replica as a practice tool with sensors to provide feedback to the glove's actuators. To test the efficacy of this intervention, a study involving 10 clarinet players with arthritis evaluating the perceived effect of the device to warm up for a performance is proposed. The results of our process has the potential to pave the way forward for arthritis treatment for musicians and beyond.

I. INTRODUCTION

Arthritis is an autoimmune disorder that leads to chronic inflammation in the joints around the body and affects 24 percent of people in the United States [1]. The immune system ends up attacking itself in persons with this condition and while it usually does not progress past joint tissue damage, it can result in organ failure in extreme cases [2]. Arthritis can greatly limit a person's ability to perform daily tasks and lead to chronic pains. Currently, there are many drugs and treatments one can take to slow the effects or dull the pains of arthritis but there is no known cure to the affliction. Non-medicinal treatments like heating of the hands and compression have also had benefits for patients [3]. Still, there is a great area left for development of devices to assist people with arthritis to perform some of the tasks they love like; gardening, exercising and playing music. This project aims to look at musicians, specifically clarinet players, and see how assistive technology might help them maintain their playing.

A. Background

Typically, arthritis can be subdivided into osteoarthritis and rheumatoid arthritis with differences centered on which joints are more commonly affected. This paper will focus on rheumatoid arthritis which generally targets the proximal interphalangeal (PIP) and metacarpophalangeal (MP) joints [2]. Rheumatoid arthritis has been shown to be closely correlated with age and individuals most often see symptoms emerging after they pass age 35. The effects of the disease can vary from joint discomfort to long term disability [2]. The disease typically has a relatively slow evolution starting with symptoms in smaller joints and extending to larger joints and organs, but the progression process differs widely between individuals and exact reasoning for this difference is still under study [4].

Treatment options: The most common treatment options come in the form of anti-inflammatories, opioids and disease-modifying antirheumatic drugs which are continuing to be developed today. Many of these options are in place to stop pain or slow the growth of rheumatoid arthritis and certain options, like opioids, have been shown to have serious side effects if taken for too long [2]. Other home remedies are also popular for patients who do not have as severe of symptoms. One such remedy is locally applied heating and cooling pads. According to The Cleveland Clinic, "Most studies dealing with the effects of heat and cold on pain, joint stiffness, grip strength, and joint function in inflamed joints report beneficial effects" and doctors often recommend this for non extreme cases. The palm is a focus area for this heating as it contains roughly half of the muscles that control finger and thumb movement and heating can help reduce tension and prevent tendon rupturing [5].

Role in Music Play: Developing arthritis can cause severe pain for musicians and may even stop them from playing.. Historically, playing instruments has seen to be an activity too strenuous for patients with arthritis but new studies in 2014 by the Arthritis UK Sunderland Group revealed that music playing can actually help soothe joint discomfort. By “releasing endorphins, which help alleviate pain, improve[ing] the dexterity and strength[ening] joints”, healthy or assisted playing methods could be the future to ensuring individuals can maintain their careers and hobbies [6]. In the following sections of this paper we will look at the user group of clarinet players with arthritis and propose a possible remedy to promote healthy long term playing.

B. Overview

We hypothesize that induced heating of the palm and mechanical stimulation of the MCP joints will decrease the discomfort individuals with rheumatoid arthritis feel when practicing to play the clarinet. Additionally, we feel that our product, The Warm Up (TWU), would help reduce the time it takes for individuals to feel ready to play and help prevent mouth fatigue before performances. In section II, we discuss preliminary results with an interview. In section III we propose a device that incorporates both mechanical and thermal stimulation to the hand alongside a modified clarinet-body for emulating the clarinet-playing experience to provide real-time feedback to the hand. In addition, we have designed a study involving clarinet players with and without arthritis to obtain quantitative data on the efficacy of this intervention. In Section IV, we will also discuss the broader impacts of the device.

II. PRELIMINARY RESULTS

To ensure that our device would be effective for clarinet players, we interviewed a professional clarinetist with early stage rheumatoid arthritis symptoms. We conducted the 90 minute long interview via Zoom but we were still able to witness our interviewee play the clarinet virtually. We had our interview discussing their 50 year long clarinet playing journey and talked to them about specific needs that they feel are unmet in their current playing practice environment.

The interviewee discussed that their joint discomfort they were feeling usually manifested in a need to practice for a longer duration of time before they felt ready to play. They likened this experience to that of taking a break from playing the clarinet, explaining that they felt out of practice even though they had been playing a normal amount. They expressed specific discomfort in the fingers which felt “slower” and less connected to the brain. They demonstrated them practicing scales, a routine involving quick movement up and down the entire instrument, and commented how they felt like their hands were lagging behind their thoughts.

Additionally, they felt increased soreness in their mouth and hands after a day of performance which they attributed to increased time spent practicing. While the interviewee had not sought medical treatment for the discomfort, they did express that they wished they could soak their hands in warm water before playing or do something similar to heat up the hand quickly.

A final need, besides the physical pain, was a growing anxiety they felt in relation to their playing. Our interviewee expressed that they had a clarinet teacher in the past who was no longer able to play because of their arthritis and told us that they feared they were heading down a similar path.

Our interview helped us clearly identify the aspects we wanted our device to target and our interviewee was incredibly helpful and generous throughout the process. We have attached a condensed list of needs below in **Table 1**. From this list, we agreed to pursue a device that would physically stimulate and warm the hands while an individual was practicing their clarinet to hopefully address the physical challenges of playing the clarinet with rheumatoid arthritis.

Table 1: Condensed Needs Chart

Interviewee Statement	Interpreted Need
"It has slowed down my hands a little bit. You know that that feeling I described is like that wonderful feeling in the hands I don't get anymore."	The device should stimulates the fingers to help build mind muscle connections
"Or if I maybe soak my hands and some warm water or something like that that'll help."	The device should involve heating of the hand
"I probably will move around a lot...if there's not a microphone involved, if I don't have to be amplified I'll just walk all over the place, because it's fun. "	The device should target practicing rather than being used on stage
"I do remember my teacher, when I was in college, who was older than I am now. He had stopped playing because he had arthritis in his hands ... I'm afraid that I might be heading in that same direction, hopefully not"	The device should reduce anxiety associated with the condition
"I would spend all day long practicing. I play a gig, then I go to a jam session and then it will be like two in the morning and my hands will be sore from playing all day."	The device must not add to existing practice time or further strain the mouth

III. METHODS

To accomplish the task of warming up the hands of a clarinet player with arthritis, we have conceptualized a device that consists of a modified replica of a clarinet body and a glove to provide heat and mechanical stimulation. Overall, this device aims to provide a way to practice their clarinet routines with mechanical feedback and warmth without having to strain their lips and mouth before a performance.

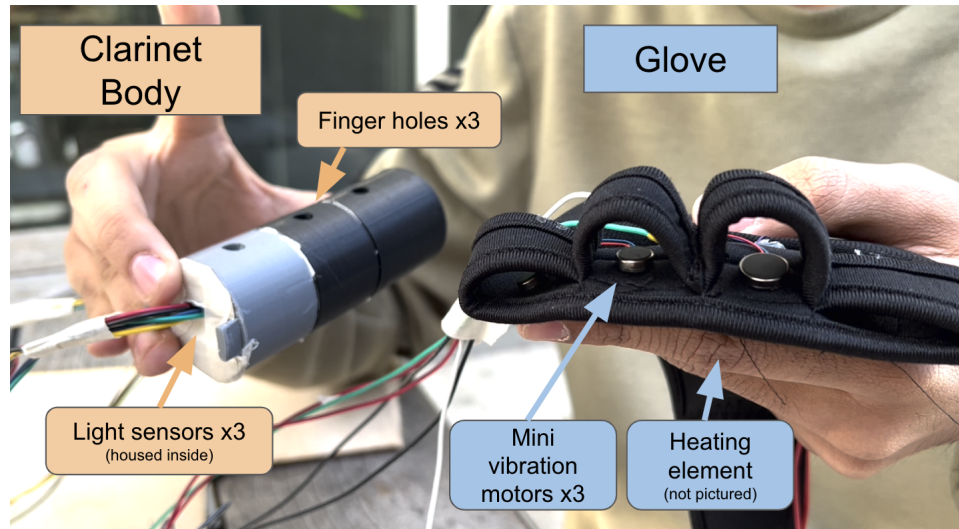


Fig. 1. Figure 1: Labeled visual of "The Warm Up"

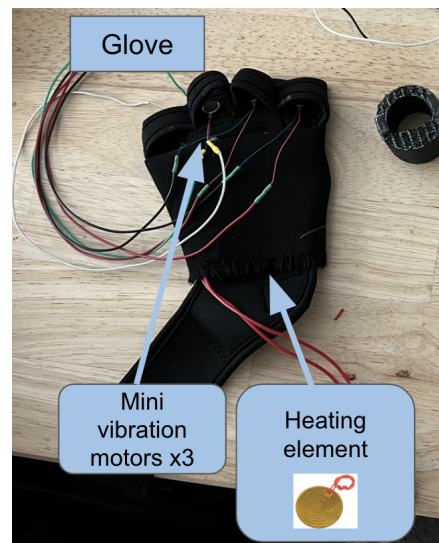


Fig. 2. Figure 2: Labeled visual of The Warm Up's glove sub-assembly

As seen in **Figure 1** and **Figure 2** above, the clarinet body is a 3D printed part segmented into three modular pieces connected with transition-fit pegs, where each module contains a light sensor in the chamber that senses when a finger is covering the corresponding hole. Its purpose is to provide the opportunity for the user to warm up their fingers on a physical object similar to the clarinet while providing auditory feedback without the need to blow into it. In addition, this sub-assembly feeds the glove information about which hole is covered. This is achieved via a light sensor in the chamber that detects whether or not a finger is placed on each hole and emits the appropriate square-wave sound to a speaker based on the state transition diagram shown in **Figure 3**. For our prototype, we have only

included one half of the clarinet body that will be used with the left hand but could easily be expanded for the entire clarinet.

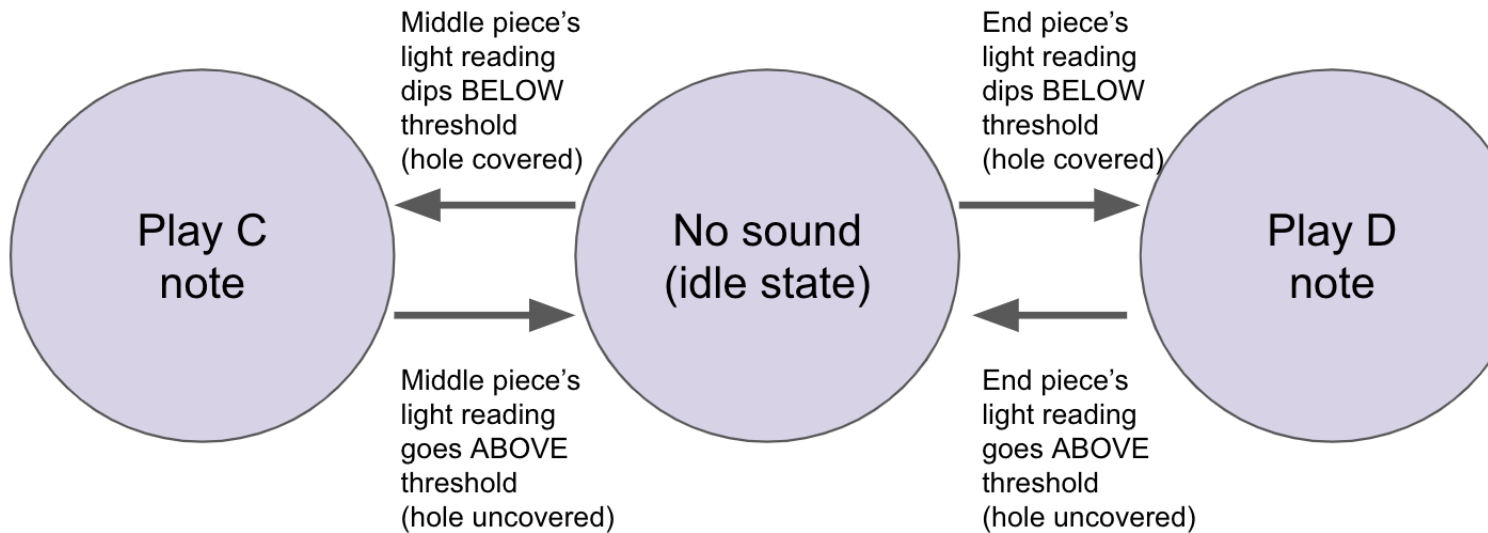


Fig. 3. Figure 3: State transition diagram for The Warm Up's operation

Additionally, the glove contains vibration motors attached to the metacarpal joints on each finger that will be activated when the relevant hole on the clarinet body is covered to provide mechanical stimulation. Alongside that, a flexible heating element on the glove will provide heating to the palm of the hand at a constant rate.

Over the course of the prototyping process, we discovered that only two of the three holes could be sensed with our light sensors because the sensor we selected only has two possible I2C addresses, meaning only a maximum of two light sensor readings can be differentiated by the micro-controller. This is enough for a proof of concept prototype; however for use in the proposed study below it would be more appropriate to source a different sensor, perhaps with an SPI interface, that allows for light sensing in all of the clarinet's holes.

To test the efficacy of our prototype, we propose to carry out a study involving 10 similarly-skilled clarinet players with arthritis and 5 control participants without hand and finger pain. Each participant will be instructed to schedule one 45-minute study session where they will complete the study individually in a campus classroom. For 10 minutes, one half of the arthritis patients will use TWU before a clarinet performance and the other half will warm up with conventional techniques. The control group is also given TWU before playing to test whether or not the intervention affects those who do not have arthritis. Afterwards, all participants will be asked to rate on a Likert scale how warmed up they feel before a performance on our "Pre-performance survey" (Table 2 in Appendix A).

Its purpose is to quantitatively evaluate subjective, qualitative perceptions of using the device. From there, all participants are asked to play a performance piece for 5 minutes. Following its conclusion, each participant will be asked to rate on a Likert scale on the "Post-performance survey" (Table 3 in Appendix A) how good they felt during the performance and how much they felt their warm up, whether or not was with TWU, affected how they played. Alongside this survey, we will also provide the "Performance reflection" (Table 4 in Appendix A) where participants provide written responses to a set of questions about the performance to elaborate on their experiences with TWU that informed their Likert scale ratings, honing in on any noticeable differences in comfort as a result of the intervention. Additionally, our control group serves to show us if TWU may be beneficial to the general population as well.

Prior to the study, participants will be asked to bring in their own clarinet to use in the study and prepare one performance piece that is at least 5 minutes long. In addition, they are asked not to have performed or warmed up in any way prior to the study. Upon coming into the classroom, participants who are assigned to be using TWU are instructed how to use the device to warm up their fingers. Once the instructions are clearly understood, all three participant groups (with arthritis using TWU, with arthritis not using TWU, without arthritis) will be asked to proceed with warming up and performing intertwined with survey response sessions according to the system outlined in the previous section. The completion of the final questionnaire indicates the conclusion of the study session and the participant is free to leave.

Before conducting trials, we will need to obtain IRB approval from the university with the protocol outlined above. Each researcher has completed CITI training to ensure we are following the proper academic research conduct at all times.

IV. INTELLECTUAL MERIT

The study we have outlined above serves as a first step to finding out how effective an intervention such as The Warm Up involving mechanical and heat stimulation is in helping clarinet players with arthritis achieve a more pleasurable, pain-free performance experience. We hope that this study is a stepping stone to further research in exploring higher-fidelity methods of warming up hand muscles for music performances and how it could potentially generalize to different instruments or different hand-tools that are difficult to use as a result of arthritis. Beyond academic research, there could also be potential for the creation of a market product to address this need of musicians with arthritis since this is a niche field that does not have any products targeted towards solving this need at the time of writing this report. Overall, this project can open doors to both research and product development.

V. BROADER IMPACT

Overall we believe that the study could have benefits for musicians suffering from rheumatoid arthritis. Ideally, this device could ensure that their condition never gets to a point where it prevents them from playing their instrument. We think that the technology could be expanded past just the clarinet and be adopted into practice tools for other instruments as well. Instrumentalists without arthritis that struggle to create mind muscle connections due to other reasons, may also benefit from our device. This is a product that we hope would be widely integrated and thus we would want it to be open source rather than hidden behind a paywall. The music industry is an incredibly demanding space and we hope to help lower the existing barriers and ensure that everyone has a chance to start and continue playing instruments.

REFERENCES

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APPENDIX A
TABLES

Table 2: Pre-Performance Survey

	(1) Strongly disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly agree
I feel sufficiently warmed up for this performance					
The warm-up method I used was comfortable for my hands					
The warm-up method I used closely mimicked the movements I would make during a performance					
I would use this warm up technique before my regular practice sessions					
I would use this warm up technique before my performances					

Table 3: Post-performance Survey

	(1) Strongly disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly agree
My performance lived up to my standards					
My warm up routine contributed positively to the performance					
I felt pain in my fingers during my performance					
I felt fatigued after the performance					
I would use this warm up technique for future performances					

Table 4: Playing Questionnaire

Question	Answer
Describe your overall experience using "The Warm Up" device	
What did you like about "The Warm Up" device?	
What did you dislike about "The Warm Up" device?	
How closely does the experience of using "The Warm Up" mimic the real life clarinet playing experience? Please explain	
Would you use this device again for future practices and performances? Please explain	