Assistive Shaker for Bartenders to Reduce Occupational Wrist Strain

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Abstract

Tasks in bartending require high activity in the hands and arms, which may result in fatigue after several long work shifts. Specifically, the task of repetitive cocktails shaking requires tight grasping and fast dynamics of the wrist, elbow, and shoulder. We developed an assistive device that relieves stress while mixing drinks, aiming to prevent development of fatigue and wrist strain. A locking mechanism was implemented and tested as one method for assisting rigid fixation to the arms, as opposed to grasping with the fingers. The device successfully allows the user to mix the drink effectively while reducing the applied force by 60 percent. Future work is needed to determine whether this device successfully reduces occupational fatigue and prevents injury in the wrist.

I. Introduction

When someone thinks about professions that require manual dexterity, one may think of physicians or surgeons. However, this project targeted a population that may not immediately come to mind when considering high demand for manual dexterity; bartenders. Bartenders are constantly utilizing their fingers, hands, and wrists while performing shaking, mixing, opening, muddling, and serving beverages. Grasping onto a shaker to make a drink requires a great deal of dexterity, and in order to avoid the shaker bottle from opening up and spilling, manual pressure must be applied. Coordination and stamina are also essential especially when working a long shift.

When shaking drinks, bartenders' hands often get very cold and cramp up, hindering their tactility [1], [2]. Additionally, the frequent grasping and shaking motion oftentimes causes wrist and finger joint pain [3]. Moisture from shaker condensation as well as consistent exposure to irritants such as citrus and cleaning agents increase glabrous skin irritation [4], [5], [6], [7]. This proposal explores a potential remedy for such discomfort by testing a device that could reduce the required gripping pressure when being used in rigorous cocktail shaking during a routine work shift.

A. Background

Boston Shakers: Boston shakers which are industry standard do not have a twist on seal. The two-piece device relies on a manual seal created by exerting pressure on the top piece. This strong seal also makes the device difficult to open. While this type of shaker is very effective and conceptually easy to use, it requires repetitive motions and large amounts of force to use.

Shaking Technique: While traditional shaking technique varies across users, both hands are generally wrapped around either the body of the shaker or the top and bottom of the shaker. Although most bartenders redirect their force to come from their upper arms, tension must be maintained in the wrists to have a tight grasp onto the shaker. Additionally, techniques known as flair movements are heavily used to create more excitement and increase the likelihood of receiving tips. These flamboyant flips, spins, and pivots require a lot of axial wrist movement which can amplify any existing discomfort [8]. Although our proposal is not targeted for a specific medical condition, varying diagnoses attributed to bartending have been identified. Conditions such as De Quervain's tenosynovitis [9], bartender's hand [10], and carpal tunnel syndrome [11] are included in the spectrum of disorders that arise from the overuse of joints and soft tissues in the hand and wrist.

Alternative Solutions: Most solutions to wrist discomfort due to excessive and repetitive shaking are reactive rather than proactive. Icing, OTC pain relievers, and wrist braces are commonly used to stabilize and minimize the pain associated with on-the-job work [9], [3]. However, due to the fast paced nature of bartending, the pain is not noticed or tended to during the action itself. Automated shakers use a motor to shake the entire bottle, but completely eliminate the social aspect of bartending and therefore have not been adopted by most establishments [12], [13].

B. Overview

In Section II, we synthesize insights from an interview with a bartender to understand her needs and experiences. In Section III, we propose a device to effectively address the sensory needs of the bartender to reduce wrist strain while maintaining the showmanship of the profession. We also describe a protocol to test the usability and functionality of our locking mechanism device. We hypothesize that bartenders who use a locking mechanism will exert less force from their wrists onto the shaker than those who grasp the shaker traditionally without an assistive device. To study this, we propose using a force sensing resistor (FSR) to measure the force applied by bartenders through the mechanism during the preparation of a drink. Preliminary results from benchtop testing indicated a 60-70 percent reduction in force applied with the device, indicating that the grip strength and subsequent strain created when traditionally shaking was reduced.

II. Preliminary results

We contacted a former bartender and conducted a 90 minute interview to determine her needs. This interview was conducted remotely via Zoom with audio, video, and transcript recording. Our team of three interviewers consisted of 2 note takers and one main interviewer asking questions with support as needed. The need-knower had experience working in bars and clubs across Florida, USA and provided larger context for the bar and restaurant industry. The need-knower confirmed many of our initial findings, but did identify many challenges that were heavily relevant when developing our project. Three major areas where our need-knower identified problems on the job was the continuous wrist motion, sensitivity of the skin, and wet hands. The need-knower said that if she were to continue in the industry she may develop weak wrists or carpal tunnel syndrome due to the repetitive motion and strain. Many tasks such as measuring alcohol, pouring liquid from heavy bottles, and flare movements compound stress especially when combined with daily tasks. The need-knower said this pain would be noticeable when she would do other things outside of work such as writing in classrooms or while lifting weights at the gym. By the end of a shift, sensitive skin would be a challenge to the need-knower as she would easily cut and scrape her hands. Bartenders come in contact with many harsh ingredients such as cleaners, citrus, and alcohol. Constant hand washing and softening of the skin due to wet, cold objects make them more susceptible to injury. Additionally, wet hands can create larger issues such as loss of sensation since objects such as shakers and cups would slip out of wet hands. The numbness, diminished fine motor skills, and lack of grip make it difficult for the bartender to manipulate heavy, glass objects.

Throughout our interview, the need-knower emphasized certain aspects of her job that influenced our project, while challenging us to create a viable product. The need-knower performs a variety of tasks which may vary between types of shifts. This leads to various opportunities for intervention with a device but the lack of depth with a specific motion made it difficult to pinpoint a targetable need. We discussed the social dynamics of the bartender's job heavily which complemented our desire to create a truly human-centered design. The showmanship of the profession had to be preserved, which dissuaded us from pursuing heavily automated ideas. Finally, the need-knower had been upfront with her pain, saying that the strain was manageable, but was damaging as a part-time worker. This led us to investigate a need that would be significant enough to improve the quality of life for our need-knower.

Classification	Preliminary Needs
Sensory	Needs to maintain a tactile, comfortable hand feeling
	Needs to alleviate strain on wrist during shaking
Task-Oriented	Needs to cut a variety of fruit in large quantities and different sizes
	Needs to speed up and ease the bottle opening process

Fig. 1. Identified Needs from Primary Interview

III. Methods

Our proposed study is intended to evaluate the actual engagement of bartenders between our device and the traditional Boston shaker as well as the usability of whether it is a viable solution in the bartending industry.

Device concept: To test the functionality, we designed a cocktail shaker with a locking mechanism attachment that allows the user to grasp their hand onto the shaker - taking the pressure out of their hand. The locking mechanism consists of two parts where the male part could be inserted into the female part, and locking can be achieved when the male part rotates 45 degrees. As shown in Fig. 2 and Fig. 3, the concept has a forgiving tolerance with chamfers cut around the connection, making the process of attaching and detaching effortless. The curvature on the female part also allows a smooth connection to the shape of the shaker. Inside the locking mechanism, there is a force sensing resistor (FSR) sensor that documents the times the lock is engaged - a feature that will be used only for testing. When designing the device, a great deal of consideration was taken to increase comfort as the bartender may be used to working more effectively with a traditional Boston shaker. Due to this, we designed a locking attachment that does not alter the core mechanism of a Boston shaker. The female part is simply secured to the shaker using an adjustable metal ring clamp. The male part is sewn to a close-fitting glove that adjusts to hand size and leaves several fingers bare to preserve skin tactility. The idea is for the device to have passive functionality, and aside from the attachment mechanism, leave the cocktail mixing task as similar to the unmodified version as possible. This allows for bartenders to either work using our design or a traditional one, and the times that they opt for our design will be documented.

Fig. 2. Locking mechanism design renderings. Left: female component. Right: male component.

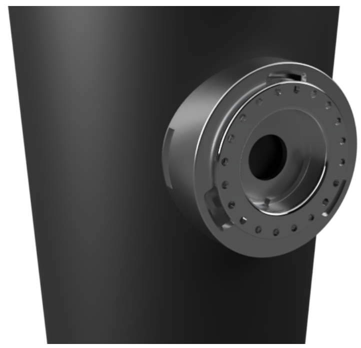

Fig. 3. Lock assembly on a Boston shaker.

Internal Group Testing: Prior to proposing our study, we performed internal testing on our prototype to determine the effectiveness of the design. Our internal testing consisted of measuring the percentage of force reduced by the design of the locking mechanism. The output values with the locking device can be compared to baseline values obtained from carpal bone and metacarpophalangeal pads on the palm without the device– two locations where contact is made with traditional shaking technique. To accomplish this, we assembled the device and first tested it while using a traditional grip to establish a baseline, which was measured to have an average of 603.6 ohms . Next, we attached our device in order to evaluate if there was a reduction in force when performing shaking. It was found that the average measured value decreased by 60 percent to 242 ohms. This result allowed us to conclude that our device is functional, and thus is adequate to be used in the proposed study.

A Proposed Study: In order to assess the concept's functionality in the real world, a study will be conducted by 10 bartenders throughout their work shifts. We will collect data over one work shift for each human subject. The subject will be asked to wear the donned portion for the entirety of the shift, or to report if they remove it. Throughout these sessions, the sensor will record the number of times that the lock is engaged, disengaged and how long it is in either state. In addition, subjects will be surveyed to gain their perspectives and attitudes toward the device at the close of the their sessions. The data will be used to analyze the likelihood of the user using our design versus choosing the traditional one.

Expected Outcomes: The ideal end result would be that after demonstrating the functionality of our shaker design, bartenders would be willing to use our device during their shift, and the quantified outcome of grip force reduction would be substantial to relieve wrist and finger joint pains.

IV. Intellectual Merit

Our study can be generalized to address the idea of relieving stress during a dynamic grasping task. Mixing cocktails involves tight grasping of the shaker and fast cyclical movements of the wrists and shoulders, but the device investigates alternative methods for performing this task. Through rigid fixation

Fig. 4. Final wearable glove prototype.

of the shaker to the palm, force is transferred through the twist-lock mechanism, rather than the fingers, which minimizes stresses in the fingers and prevents muscle fatigue. By placing the device elsewhere on the arm, energy could be generated solely from elbow and shoulder flexion/extension, which preserves the wrist joints, and over time, this may prevent the development of carpal tunnel syndrome. In the current study, we are not directly measuring the link between gripping and wrist movement due to practical sensor limitations. However, if we find that qualitative survey data and use of the device is high, then this will be worth studying further using precision flex sensors that may be attached to the wrist directly.

The device does not really serve to reduce movements in the elbows or shoulders, so there is still potential to develop fatigue in those joints. Additional studies might attempt to find a way to generate the same large motions while reserving the activity of all joints in the arm. It would also be good to continue developing other ways to assist grasping tasks that relieve stress in the fingers and wrists.

V. Broader Impact

The study of testing how many times bartenders opted for our device allows us to evaluate the likelihood of a bartender using an assistive device for long term benefits. It also demonstrates the potential of being beneficial without causing complications in bartenders' work routines. The product can be used by professional and amateur bartenders, whether with or without wrist issues. Not only can the product relives the wrist strain, it also works as a preventive measure for the long term health of wrist and finger joints. This project has brought to light the common attitudes of bartenders to dismiss common pain as an occupational necessity. However, this daily strain can create long-term negative consequences especially when compounded with other daily tasks.

The invention is intended to be made open source due to the wide and highly accessible audience. The bartending industry is worldwide, with many in the profession facing the same challenges that could be alleviated with this device.

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Appendix A
Discovery Decomposition

1) Bartender's Hand An Unusual Form of Occupational Cumulative Trauma Disorder: [10].
Occupational cumulative trauma disorder can occur due to the overuse of joints and soft tissue structures of extremities, and this sort of disorder was discovered in a bartender. An examination of his hand was performed including an x-ray image to measure the pain location, range of motion, and grip strength.The patient was diagnosed to have flexor tendinitis from the repeated using of the beverage gun. After 6 weeks of not bartending, his symptoms were completely gone.

2) Shaken, Not Stirred: Deep Vein Thrombosis Due to Paget-Schroetter Syndrome from Tending Bar: [3].
A female bartender developed an upper extremity deep vein thrombosis from repetitive upper extremity activity, which is also called Paget-Schroetter Syndrome. An ultrasound examination was performed to diagnose the existence of DVT. During the process, compression of the subclavian vein was discovered with abduction of the right arm. This showed that Paget-Schroetter Syndrome can come from repetitively reaching overhead for bottles and shaking cocktail mixers.

3) Differential Diagnosis and Physical Therapy Management of a Patient With Radial Wrist Pain of 6 Months' Duration: A Case Report: [9].
The patient, a bartender, reported to have pain and stiffness in his right radial wrist for 6 months. The intensity of his pain would increase with repetitive movements at work and with carrying bottles from a storage to the bar area. Physical therapy and a thumb splint were prescribed to the patient but the symptoms did not improve. The pain level of the patient was measured during the examination and the diagnose was a neuropathy of the superficial sensory branch of the radial nerve. This showed that neuropathy of the superficial sensory branch of the radial nerve should be considered during differential diagnosis.

4) Effect of Cold Immersion on Grip Force, EMG, and Thermal Discomfort: [2].
Workers can be subject to various thermal conditions which may affect gripping abilities. Participants were given performance tasks after immersing their hands in cold and warm water. They were examined by skin temperature, grip contraction, electromyography, and discomfort. Cold immersion had a large effect on skin temperature which affects the maximum volitional contraction, and gender also had an effect on skin temperature.

5) Moisture-Associated Skin Damage: [4].
There are many known causes for skin damages like chronic inflammation and skin erosion. Research and experts are consulted to discuss moisture as another factor of skin damage. Evidence regarding prolonged exposure to moisture sources is analyzed in order to understand moisture-associated skin damage. It is found that moisture alone is insufficient to cause damage, but instead factors contributing to moisture-associated skin damage include chemical content of the moisture source and mechanical factors like friction.

6) The Effects of Glove Thickness and Work Load on Female Hand Performance and Fatigue During a Infrequent High-Intensity Gripping Task: [5].
Gloves are used in the workplace to protect the hands of the user. Glove thickness is investigated with regards to its effect on hand performance and fatigue. Forces, time differences, and hand endurance are measured during hand contractions using different thicknesses of gloves. Wearing thicker gloves hinders the ability to contract, but muscle fatigue is unaffected.

7) Fragrance Mix Reactions and Lime Allergic Contact Dermatitits: [6].
Contact dermatitis from food creates five responses: irritant, delayed allergic eczema, immediate urticaria, immediate vesicular eruption, and phototoxic. Citrus fruit produces all of these responses. A contact allergy patch test was applied to a patient with occupational exposure to citrus peel who developed a contact allergic sensitivity to lime, lemon, and orange peels. The positive, negative, or not detected results of the allergy test were measured across ten control subjects and the patient with sensitivity. The patient initially had what appeared to be irritant contact dermatitis, but patch test responses revealed a possible fragrance allergy. Additionally, the irritation seemed to arise from oils in the peel rather than the citrus juice itself. The patient's dermatitis resolved when the patient stopped working as a bartender and avoided skin contact with citrus peel.

8) Acute and Chronic Paronychia: [7].
Paronychia is one of the most common infections of the hand. Noninfectious causes of paronychia include contact irritants and excessive moisture. People with occupations such as baker, bartender and dishwasher seem predisposed to developing chronic paronychia. This paper is a comprehensive analysis of the causes and effects of paronychia. Features such as clinical appearance, people at risk, pathogens, and treatment are identified. Those exposed to water containing irritants or alkali, and those who are repeatedly exposed to moist environments are at risk for paronchyia. Treatment of chronic paronychia involves antibacterial solution or ointment, acetic acid, or oral antibiotics. Additional surgical intervention may be needed.

Appendix B
Need-Knower Interview Notes

User: Female Bartender, age: mid 20s		**Occupation:** Bartender
Date: 2/22/2022		**Interviewers**: The Handymen
Prompt	**Customer Statement**	**Interpreted Need**
Typical duties/actions	Cutting up fruits such as strawberries to make them easier to muddle	Needs to cut a variety of fruit in large quantities and different sizes.
	Using metallic shakers (thinner, lighter, but feels colder) as opposed to glass shakers which numbs my hands.	Needs to mix drinks without losing sensation due to temperature.
	Repeated shaken motion at an angle for thorough mixing.	Needs to shake repeatedly to reach a desired consistency.
	Pouring at an angle with a heavy liquor bottle while raising your arm.	Needs to contort arms in different angles.
	Cutting up lime wedges and squeezing lime juice.	Needs to cut and squeeze large quantity of limes.
	Twisting off bottle caps, jars, and shakers.	Needs to twist open different items repeatedly.
	Peel oranges with peeler.	Needs to obtain peels for Old Fashioneds.
	Cleaning shakers and glasses using glass rinser.	Needs to keep glassware and shakers clean.
	Washing garnishes such as strawberries or basil.	Needs to clean fresh ingredients.
	Muddling fruits, stirring and straining drinks.	Needs to release the flavor of fruits.
	Rotating the wrist during shaking, mixing, or bottle opening process was the most taxing motion.	Needs to alleviate strain on wrist during shaking.
	Washing hands every time a drink is made or cash is touched.	Needs to clean hands often.
	Grabbing and moving wet or freezing cold glasses, and sometimes heavy bottles.	Needs to lift heavy objects at different temperatures and moisture levels.
Difficulties	Opening a lot of cans and bottles precisely each time.	Needs to accomplish opening precisely.
	Tender skin at the end of the shift is more likely to be injured.	Needs to protect skin during shift.
	Shaker glasses get stuck together which makes it difficult to separate and cause potential injury.	Needs to open tightly closed shakers
	Frozen beer glasses that were put into the freezer straight from the dishwasher sometimes would burst and leave glasses stuck into my hand.	Needs to chill glasses without making it fragile.
	Likelihood to develop carpal tunnels syndrome if bartending as a lifelong career.	Needs to protect wrist nerves
	Bartenders don't wear gloves because they get wet and uncomfortable. The rubber sensation on your hands is not good.	Needs to maintain a tactile, comfortable hand feeling.
	Gloves might hinder some of the movement and tactility.	Needs to feel the objects in hand.

Fig. 5. Full user needs chart pt. 1

Suggestions	Uses moisturizer a lot but hands get dry from industrial sanitizer and disinfectant.	Needs to keep hand skin protected and moisturized.
	Used clothes to quickly dry hands after rinse.	Needs hands to stay dry and clean.
	Automated processes aren't fast enough/take too long to set up.	Needs the automated process to be quick to set up and easy to use.
	Automated processes remove the human touch of bartending-- people can't see their drink being made.	Needs to use some motion since bartending is entertaining and social
	Automated processes may keep bartenders honest with the amount of alcohol they're pouring/prevent free pouring.	Needs to accurately measure alcohol in drinks.
	Cutting strawberries and other prep work could be automated with a metal cutter.	Needs to speed up and ease the cutting process.
	Opening cans or bottles could be automated.	Needs to speed up and ease the bottle opening process.
	Shaking isn't too straining because it takes pressure off wrists into arms and shoulders.	Need to alleviate wrist strain using arm and shoulder
	Dr. Scholls for your hands would give you grip to preserve sensory features.	Needs to have a good grip when interacting with other objects.

Fig. 6. Full user needs chart pt. 2

APPENDIX C
INVESTIGATIONAL DEVICE DETAILS

				Solutions			
Criteria	**Weights**	Automatic Shake	Grippy Glove	Peeler/Cutter Glc	All-in One Glove	double shaker	insulated shaker
Ease of Use	2.5	5	3	3	5	3.5	4.5
Feasibility	1.5	1	4	4	4	5	5
Usefulness/Effectiveness	3	4	4	4	5	4	4
Scalability	0.5	2	3	2	4	4	4
Safety	2.5	5	5	1	4	5	5
	Score	39.5	39.5	29	45.5	42.75	45.25

Fig. 7. Decision matrix used for design selection.

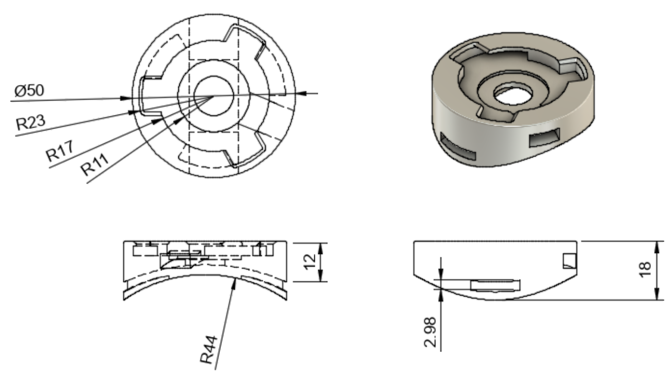

Fig. 8. Technical drawing of female component, unit: mm.

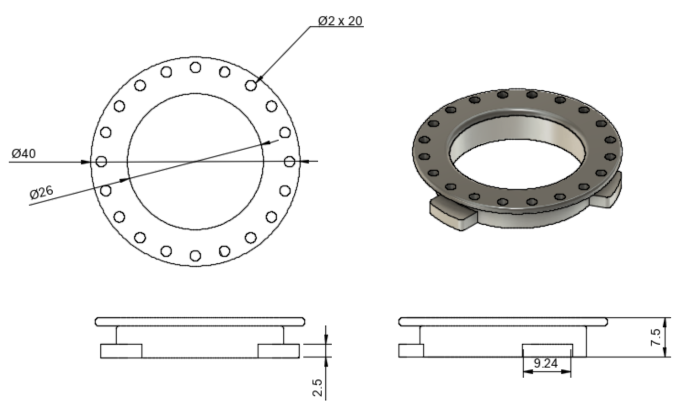

Fig. 9. Technical drawing of male component, unit: mm.

Bill of Materials		
Item(s)	**Cost ($)**	**Source**
3d printing	2	Jacob's
work glove	2	Amazon
hose clamp	2	Amazon
metal wire	0.05	Amazon
thread	0.05	Amazon
duct tape	0.05	Amazon
Total Cost:	**6.15**	

Fig. 10. Bill of materials of locking mechanism design prototype.

```
#include <HX711.h>

#define FSR A4
#define LOAD A0
#define M1PWM 6
int FSR_val;
void setup() {
Serial.begin (115200);
pinMode(FSR, INPUT);
pinMode(LOAD, INPUT);
contact = 0;
pinMode(M1PWM, OUTPUT);
digitalWrite(M1PWM, LOW);
}

void loop() {
FSR_val=analogRead(FSR);
LOAD_val=analogRead(LOAD);

Serial.println(FSR_val);
Serial.print(",");
Serial.println(604);
}
```

Fig. 11. Internal Group FSR Testing Code