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Flash cupping and its effect on soft tissue elasticity

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Abstract—**Cupping therapy is a growing treatment option for myofascial pain for its suggested ability to elongate and increase elasticity of biological tissue. However, the effect of suction on deeper tissues' elasticity has not been well documented. As such, elasticity was derived using a novel device that employs a flash cupping technique to move deeper fascia. Fourteen participants were recruited and tested with the device 5 cm subxiphoid on the abdomen and posterior calf muscle, given the relatively flat and wide geometries of each. Of results at the abdomen, 88% indicated immediate (within 30 seconds) increase in elasticity. At the calf, 64% of results indicated immediate increase in elasticity. In the short-term (1-3 minutes), stiffening occurred in 64% of results at the abdomen. Given results, it is of interest to consider the long-term effects of dry cupping on soft tissue elasticity to determine potential mechanical benefits of localized suction. The presented evidence of dynamic changes in elasticity may lend insight into the causes and treatment effects of myofascial pain.**

Keywords— **Elasticity, *in vivo*, soft tissue, cupping therapy, suction**

I. Introduction

Aspiration techniques, also termed suction, myofascial decompression [1], dry or flash cupping therapy [2], endermology, vacuotherapy, depressomassage, or vacuum massage [3], use negative pressure against the skin to induce a desirable physical or physiological effect. A 2016 review of aspiration as a tool in biomechanics found a significant number of benefits in device use, including myofascial pain (muscle pain) reduction, reduced tissue hardness and roughness, leading to its recommendation as a standardized tool in musculoskeletal medicine [3-4].

One benefit of suction poorly studied is the increase in soft tissue elasticity at the loading site [3, 5]. This phenomenon is of interest in aspiration tools, as it suggests a dynamic response in elasticity given prolonged loading. Research conducted using a popular micropipette suction device reinforces this concept by demonstrating asymptotic behaviour in tissue deformation after loading [6]. Aside from elasticity, thixotropic effects, a time-dependent fluidic thinning, have been found from myofascial release, and are largely attributed to increased blood flow to the perfused area [1].

Mechanically, during suction, tensile stresses are seen at the inner face of the suction device rim, while maximum compressive stresses are seen just under the rim [7]. Normal stresses decrease with tissue depth, such that deep muscles undergo lower stresses than that of superficial tissues [7]. Despite the decrease in normal stress at deeper fascia, an increase in longitudinal collagen fibers has been seen in deeper tissues undergoing suction [8]. Both results, however, indicate the effect of suction on deep tissues, and suggest the efficacy of a suction tool on a range of fascia beyond the superficial.

One of the most popularized aspiration tools for biomechanical evaluation of skin is the Cutometer. The Cutometer induces a suction through a narrow probe (2 to 8 mm diameter) and resulting tissue deformation is measured via a light sensor [9]. The work of Müller *et al*. has suggested deficiencies in the Cutometer, however, which have been remedied in a replacement device titled the Nimble [9]. The Nimble (probe diameter of 6 mm) measures elasticity conversely to the Cutometer; that is, measuring pressure incline to a known tissue deformation, rather than tissue deformation to a known applied pressure [6, 9]. Both devices, given narrow probe openings, are only able to measure elasticities of superficial tissues, such as the skin. Though alternative mechanisms for elasticity measurement exist, including ultrasound, magnetic resonance imaging, elastography, indentation, and more, suction remains the instrument of interest in the present research.

To the author's knowledge, there exists no biomechanical studies on the effects of suction on deeper tissue elasticity. Previous studies that objectively evaluated elasticity changes due to suction only used palpation or the Cutometer (a superficial tissue elasticity tool) to evaluate changes [10]. One study noted the separation of deep tissue layers via MRI during suction, though, elasticity was not mentioned [11]. Therefore, it is the effort of the present research to exploit a novel tool in soft tissue mechanics measurement for the evaluation of the effect of suction on deeper fascia.

II. Methods

Ethical approval for this study was received from a university's International Review Board prior to participant recruitment (A12-M63-19A). All participants provided informed consent during the study.

A novel device of radius, a, as described in [12] was used as a flash cupping method to evaluate elasticity changes in soft tissue. Flash cupping refers to pulsating applied suction (pressure held less than 30 s), on healthy skin to induce a tissue deformation (w). Typical applied suction is light; between 10 and 30 kPa (100-300 mbar). In the present study, suction (P_{app}) was applied and immediately released, at pressures between 2 and 4 kPa per impulse. Contrary to the authors' previous work, elasticity (E) was determined by

$$E = (\alpha(\zeta, \nu)3\phi(\eta)P_{atm} - P_{app})a)/(2\pi w) \quad (1)$$

Where $\alpha(\zeta, \nu)$ is a coefficient dependent on the ratio of tissue thickness (t) to pipette inner radius (R_i) ($\zeta = t/R_i$) and Poisson's ratio (ν = 0.499), $\phi(\eta)$ is a geometric coefficient, and P_{atm} is atmospheric pressure [6]. This change in elasticity calculation was due to the high sensitivity of previous equations to estimated values [12]. The present equation alternatively is tuned to a patient's anatomy, such as t, to provide more accurate readings. P_{app} and w were measured with sensors onboard the novel device and reported to a local computer for mathematical interpretation.

A. Participants

All participants were older than 18 years old and without myofascial pain at the abdomen or posterior calf. Sex was not an exclusion criterion, however, women who were or had previously been pregnant were ineligible. Additional exclusion criteria included a history of abdominal surgery, use of muscle relaxants, acute peritonitis, abdominal mass, acute injury to the urinary bladder, acute cystitis, neurogenic bladder, pelvic hematoma, and pelvic fracture.

B. Procedure

Part 1

Three sets of 3 suction pulses were applied 5 cm subxiphoid on the abdomen with 1-2 minutes of relaxation between tests. Participants were in supine position with no abdominal activation, and measurements were taken at end expiration. Elasticity at each suction pulse was reported. One tester completed the first two sets of 3 suction pulses, and a different tester completed the final set.

Part 2

One set of 3 suction pulses was applied at the widest portion of the posterior calf with 1-2 minutes of relaxation between tests. Participants were asked to lie prone, with feet hanging off the edge of the bed in a relaxed state, and each calf (left and right) was tested. No muscle activation occurred. Elasticity at each suction pulse was reported. The same tester completed tests on both legs.

Part 3

Finally, suction in 5 consecutive pulses was applied, then with delays increased to 30 seconds over 3 pulses, and 1 minute over 3 pulses at 5 cm subxiphoid on the abdomen. Timing was approximated to allow for measurements to take place at end expiration. Elasticity at each suction pulse was reported. The same tester completed all test sets in this phase.

III. Results

Fourteen participants (7 male, 7 female) were recruited for Parts 1 and 2, with physiological details (including body mass index, BMI) outlined in Table 1.

Table 1 Summary of participant descriptions.

Item	Age	Gender	BMI	Abdominal Circumf. [cm]	Avg. Calf Circumf. [cm]
01	26	M	24.7	91	36.5
02	31	F	23.7	90	N/A
03	30	M	23.8	85.5	36.5
04	33	M	26.6	98	37
05	25	M	25.8	87.5	37
06	24	F	18.6	66.5	N/A
07	25	Fr	22.4	80	37.25
08	27	M	26.4	98	40.5
09	24	M	28.0	103.5	41.25
10	30	F	20.5	75.5	33.75
11	28	M	27.0	99.5	38.25
12	29	F	23.5	76	N/A
13	28	F	19.3	75	33.25
14	27	F	22.3	74	34.25

Due to time constraints, only participants 01 and 03 participated in Part 3.

A. Part 1

In 88% of abdominal impulse sets, a decrease in Young's modulus (E) was seen, indicating increased elasticity. The mean (standard deviation, SD) reduction in E was 3.45 (10.10) kPa. However, when pulses were averaged, an increase in E between sets was identified in 64% of results. The mean (SD) increase in E was 3.17 (18.70) kPa.

B. Part 2

At the posterior calf, only 64% of impulse sets saw a decrease in E. The mean (SD) reduction in E was 2.69 (31.78) kPa. Results are compiled in Table 2 for individuals due to patient-specific differences.

Table 2 Changes in Young's Modulus (E) at varying anatomical locations where (+) indicates a decrease in E. One measurement set refers to the average of 3 suction pulses.

	Average reduction in E among 3 measurement sets [kPa] (SD) – Abdomen	Average reduction in E [kPa] among 2 measurement sets (SD) - Calf
01	5.82 (3.93)	5.63 (4.76)
02	2.24 (2.62)	N/A
03	3.69 (1.33)	-1.39 (9.86)
04	1.24 (2.26)	-15.73 (36.96)
05	4.92 (7.11)	61.13 (86.82)
06	5.40 (3.67)	4.43 (4.41)
07	0.82 (8.58)	2.49 (N/A)
08	1.83 (4.94)	-0.72 (8.25)
09	17.74 (26.45)	-0.44 (4.77)
10	3.30 (1.37)	-24.12 (50.81)
11	1.54 (1.76)	-10.38 (4.33)
12	-8.46 (23.72)	10.88 (N/A)
13	5.03 (6.21)	4.47 (3.59)
14	3.74 (0.95)	N/A

C. Part 3

The elasticity results at each pulse including those with increased delays are shown in Fig. 1. Delay increases are denoted by vertical lines. No correlation between delay time and elasticity could be derived with the given data.

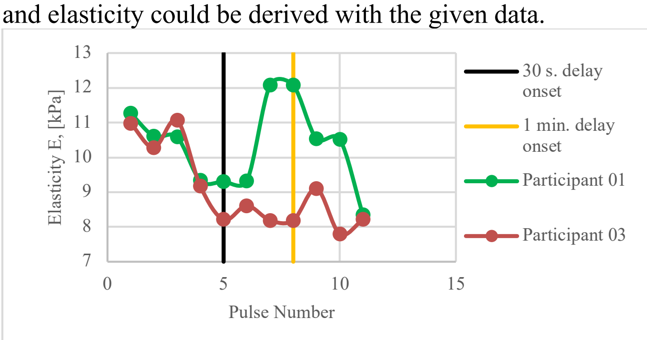

Figure 1: Changes in Young's Modulus (E) given varying pulse delays.

IV. Discussion

Cupping therapy is a growing treatment option for myofascial pain, however, the effects of suction on deeper tissues' elasticity has not been well documented. As such, elasticity was derived using a novel device that employs a flash cupping technique to move deeper fascia. Results indicated immediate increase in elasticity (decrease in E), and short-term stiffening.

The results of this study describe only a small sample of homogeneous participants. This limitation narrows the focus of this paper and restricts possible conclusions. Further, the novel device used to test elasticity has not yet been validated for use as an absolute measurement tool, thus, results should be analyzed as relative measures. It is recommended to use an accepted measure of deep tissue elasticity, such as magnetic resonance elastography (MRE) as a comparative measure to validate the novel device.

As an observation, at both the abdomen and the calf, an increase in elasticity (decrease in E) was identified given consecutive, immediate suction pulses (flash cupping), a finding in agreement with previous studies [3, 10]. Less common, however, is the decrease in elasticity (increase in E) between test sets. It is known that suction causes increased blood flow to an area, therefore, this short-term stiffening may be credited to blood recession following perfusion during consecutive applied suction. However, further research is needed to critically identify the cause.

Work by Adcock *et al*. has shown that, more significant than the suction force, itself, is the effect of force from massage during cupping therapy [8]. In the present study, two testers were studied, and both saw increases in elasticity given consecutive suction pulses. That said, the initial force applied by each tester to achieve device seal against the body was not measured. This initial force may have had an effect on progressive short-term stiffening of the tissue. To standardize future studies, it is recommended to train testers to apply a consistent amount of initial pressure. This allows conclusions on the effect of suction pressure to be reached, rather than the greater effect of massage force.

After 5 subsequent pulses, elasticity continued to increase. Soft tissues, or fascia, are known to be viscoelastic materials [1], such that their presenting elasticity changes given changes in loading patterns. An increase in elasticity, however, suggests an asymptote must exist, though whether this is a universal or individual asymptote is of interest. Regardless, there may be an effect of reaching said asymptote in therapy and its conjunction with myofascial pain relief. It is recommended to study the limits of elasticity in soft tissue given applied suction pulses, and determine whether reaching said limit has clinical benefits.

Human tissues are composite materials comprised of many layers of individual fibers, including muscle, bone, and fascia. To dissect the elasticities of these individual fibers and gain insight into individual layer mechanics, changes in suction cup diameter may be used. This variation changes the thickness of suctioned tissue, which may then be compared to wider cup sizes for elasticity changes. Alternatively, the Cutometer or Nimble may be used to determine superficial fascia elasticities, which then may be compared to the novel device results. In all, these comparative measures yield more refined, absolute measures for tissue mechanics.

V. Conclusion

In summary, a novel tool was exploited to evaluate the effect of suction on deeper fascia. The immediate and short-term effects of flash cupping therapy on soft tissue elasticity were evaluated. Immediate (within 30 s.) increase in elasticity was noted, with short term (1-3 min.) stiffening to follow. It is recommended to consider a wider range of cupping techniques, particularly by varying time durations and number of treatments in dry cupping. This may lend insight into the long term, rather than immediate effects of localized suction on deeper tissues' mechanical properties.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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