International Journal of EXERCISE SCIENCE

*Original Research*

# The Immediate Effects of Dry Cupping the Lumbar Paraspinals on Range of Motion and Temperature

NATASHA T. SCAVARELLI† and PAOLO SANZO‡

Department of Kinesiology, Lakehead University, Thunder Bay, Ontario, CANADA

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

***International Journal of Exercise Science 17(3): 551-564, 2024.*** Dry cupping is a therapeutic modality proposed to produce a negative pressure, stretching the skin and underlying tissue. This mechanism is said to promote regional blood flow of oxygenated blood and causing a physiological stretch in the tissue, allowing it to elongate and potentially changing skin temperature. The possible effects of the application to the lumbar spine paraspinal muscles, however, has not been thoroughly examined. The purpose of this pilot study was to explore the immediate effects of dry cupping the lumbar paraspinals on lumbar spine range of motion (ROM) and overlying skin temperature. 30 healthy individuals aged 18-30 years completed the study. The dry cupping was placed on the lumbar paraspinal muscles for 10-minutes. Two plastic cups were placed on the bilateral paraspinals muscles at L1 and L5. Lumbar spine flexion ROM and skin temperature were measured pre- and post-intervention. Descriptive statistics and paired sample *t*-tests were used to analyze the data ($p < .05$). There was a statistically significant increase in lumbar spine flexion ROM measured with the Sit and Reach Test, $t(29) = 12.62$ $p = 0.001$; $d = 2.34$, and inclinometry, $t(29) = 11.10$, $p = 0.001$; $d = 3.86$, with a large effect size. There was also a statistically significant decrease in the skin temperature of the lumbar spine paraspinals, $t(29) = -2.23$, $p = 0.034$; $d = 0.75$, with a medium effect size, post- intervention. Dry cupping may be an effective strategy to increase lumbar spine ROM and decrease stiffness, promote recovery, and reduce functional limitations. Future research may examine the difference in effectiveness of static compared to dynamic cupping in a symptomatic population.

KEY WORDS: Performance, physical therapy, Chinese medicine, mobility

## INTRODUCTION

The main muscles that overlay the lumbar spine are the paraspinal muscles including the iliocostalis, longissimus, and spinalis muscles. These muscles play a primary role in general movement of the spine into extension, side flexion, and rotation and act as stabilizers. Considering the essential function of these muscles in combination with normal daily functional, occupational, and sport specific tasks that an individual completes, they may be easily subjected to fatigue and develop tightness (20). This tightness can impair the flexibility of the lumbar spine and the hips and cause lumbopelvic hypomobility or pain (30). Furthermore, this may lead to the development of functional, occupational, or sport limitations and possibly the development

of acute or chronic low back pain. This is quite common in the population with up to 84% of the population experiencing an episode of acute low back pain worldwide with the vast majority of the conditions that impair the lumbar spine being mechanical in nature (7, 13). Interventions to prevent or address this common complaint need to be explored as a method to curb the potential low back complaint.

The use of cupping is one option that has a history dating back thousands of years ago as a domain of Chinese medicine. Cupping practices have a very long history, however, the physiology behind the mechanisms as well as the benefits of its treatment have not been thoroughly examined (23). Original techniques consisted of wet cupping, which involved puncturing the skin to release blood. Modern techniques use the same principles; however, the suction cups are just applied, and the skin is left unwounded. This practice is referred to as dry cupping (19).

The process of dry cupping involves placing plastic, glass, or rubber suction cups on various landmarks of the skin (11). Dry cupping can either occur statically, whereby the cups are left stationary on the skin, or dynamically, which involves moving the cups throughout the intervention to produce a massaging effect (32). Often, beeswax is applied to the skin to prevent the cup from moving, especially on individuals with body hair in the region. The cups are left on the skin for about 7-10 minutes, at which point suction is released and hyperpigmentation of the skin is often seen (23).

The resultant hyperpigmentation is an indication of the extravascular blood flow to the affected area (21). It has been proposed that this promotes both anti-inflammatory and antioxidant properties, without the associated trauma of a typical bruise. In addition, cupping is proposed to cause a negative pressure on the skin, which stretches both the skin and underlying tissue. This mechanism allows the capillaries to dilate and promotes the flow of oxygenated blood to the area being treated (21). Furthermore, this intervention is proposed to increase lymphatic flow and promote an anti-inflammatory response (32).

Range of motion (ROM) is determined by the ability of a joint and soft tissue structures in the area to move through a plane without pain or restriction (31). Cupping interventions have been proposed to increase the ROM of a joint and the soft tissue structures in various parts of the body (23). The negative pressure within the cup is suggested to cause a physiological stretch in the muscle which allows it to lengthen post-intervention (8). The physiology of muscular stretching begins with the sarcomere, the contractile unit of muscular tissue. When a muscle fibre is at its maximum resting length, the sarcomeres are fully stretched (2). The administration of the cupping intervention and the associated negative pressure on the tissue is proposed to cause a gapping within the soft tissue layer of the muscle, allowing the fibres to stretch past their resting length, leading to a potential increase in ROM (15).

Murray and Clarkson examined the effects of hamstring cupping on hip ROM (26). In this study, a 15-minute dynamic cupping intervention was conducted on 21 healthy individuals. It was

reported that one short term cupping session had an average increase in ROM of 7%, as measured by the Straight Leg Raise Test (26). A similar study by Yim et al. (33), examined the effects of static cupping on the cervical spine of healthy individuals in their early twenties. A cross-over design was used to assess the differences in effectiveness between dry cupping and manual stretching in increasing the cervical spine ROM. Based on the cupping intervention, the results showed an average 11% increase in ROM in all directions when measured using an inclinometer, which was more significant than the observed differences following the manual stretching intervention (33). Limited research has sought to examine the effects of cupping treatment on the lumbar spine, despite the high prevalence of stiffness and limitations in this area.

Since cupping has been proposed to promote an increase in circulation, it is also suggested that cupping will increase the temperature of the treated skin, however, this area has not been thoroughly examined (4). Cage et al. (4), explored the effects of a cupping intervention on the forearm skin temperature. The study was conducted in a temperature monitored room, and the cups were removed every 5 minutes to allow the skin temperature to be measured. It was reported that skin temperature, as measured by an infrared thermometer, increased an average of 2 degrees Fahrenheit throughout a 15-minute intervention and an additional 1 degree Fahrenheit, 5 minutes post- intervention. This suggested that a cupping intervention may directly impact skin temperature (4). Conversely, the process of cupping does not actually generate any heat in the area of skin being treated, so some questions may arise as to whether this effect actually occurs physiologically. A study by Xu et al. (34), further examined this phenomenon. Using infrared thermal imaging, localized skin temperature was measured pre- and 10-minute post-cupping intervention. A total of 43 participants completed the study and the results displayed that the post-intervention skin temperature was 0.4 ± 0.9 °C lower than the pre- intervention skin temperature. This finding supports the queries as to whether the skin is actually heated through the dry cupping intervention (34). Thus, these contradicting findings require further examination of the effect of cupping treatment on skin temperature, specifically in the lumbar spine.

Various other factors may contribute to the change in skin temperature noted in some of the previous findings. Skin temperature can be impacted by individual factors such as age, level of exercise, and hormone and stress levels (14). Environmental factors may also contribute to changes in one's skin temperature, such as the air temperature, weather conditions, and clothing the individual is wearing (14). Thus, the observed changes may be due to individual and environmental conditions rather than the physiological mechanism of the cupping intervention itself.

As previously stated, dry cupping techniques have not been widely researched. Most of the relevant and available literature displays a greater focus on the lower extremities and yields rather limited information related to the lumbar spine region (13). As discussed, low back impairments account for the most reported type of disability worldwide. With the epidemiological data reporting that an average of 84% of the population will experience a low

back related condition at some point in their lifetime, being proactive about improving the mobility of the lumbar spine musculature may assist with preventing these conditions and adding to the available research examining these conditions (7). Therefore, the purpose of this pilot study was to explore the immediate effects of dry cupping the lumbar paraspinals on ROM and temperature of the lumbar spine.

The following research questions were used to guide this study:

1. What is the effect of dry cupping the lumbar paraspinal muscles on lumbar ROM as measured by the Sit and Reach Test?

2. What is the effect of dry cupping the lumbar paraspinal muscles on lumbar ROM as measured by inclinometry?

3. What is the effect of dry cupping the lumbar paraspinal muscles on skin temperature of the lumbar spine as measured by an infrared thermometer?

It is hypothesized that the cupping treatment will lead to an increase in ROM as measured by the Sit and Reach Test/inclinometry as well as an increase in skin temperature as measured by an infrared thermometer, post-treatment.

## METHODS

*Participants*

This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (27). After obtaining ethical approval from the Lakehead University School of Kinesiology Undergraduate Research Ethics Committee, a total of 30 participants completed this pilot study (12 males and 18 females). The sample size was chosen through conducting a power analysis a priori using a sample size calculator with a confidence interval of 95% and a margin of error of 5% (5). Participants were recruited using purposive and convenience sampling. Snowball sampling was also utilized as participants were encouraged to refer other individuals who met the inclusion criteria. Recruitment methods included the use of posters which were posted throughout the academic institution as well as various social media platforms including Instagram© and Facebook©. The recruitment period began on December 1st, 2022, and ended on January 20th 2023.

Participants were included in this study if they met the following criteria:

1. Healthy males and females;
2. Between the ages of 18 - 30 years; and
3. Successfully completed the Get Active Questionnaire (GAQ).

Participants were excluded from the study if they met any of the following criteria:

1. Any individual with an injury or surgery that occurred within the last 6 months to the lower body which may have affected their hip and/or knee ROM;

2. Any individual with a history of low back pain;
3. Any individual who was confirmed or suspected to be pregnant; and
4. Any individual with a confirmed or suspected blood/blood clotting disorder (i.e., hemophiliac).

*Protocol*

The following instruments and equipment were used to carry out this study:

Hansol Professional Cupping© therapy equipment set: The cups used were made of high-quality transparent plastic allowing the researcher to monitor changes to the skin through the clear plastic. The suction within the pumps was increased using a hand pump. Each cup was pumped 3 full times (465 mmHg of pressure) for consistency across all participants (18). Four cups were used for each participant and placed on the paraspinal muscles at the levels of L1 and L5 bilaterally.

Rockrub® beeswax: Rockrub® Beeswax is a soft tissue lubricant that was used to increase the seal between the cups and the surface of the skin. This improved the degree of suction and adherence to the skin, especially for those with body hair in the intervention area.

Acuflex® 1 Sit and Reach box: The Acuflex® 1 Sit and Reach box was used as a pre- and post-measurement method of lumbar spine flexion ROM. The lumbar spine flexion ROM was measured in centimeters (cm) before and immediately after the cups were applied. The Sit and Reach Test has been shown to be a safe, and easy to perform measure of low back flexibility, with good criterion-related validity reported (9). It is an accurate, safe, and easy to perform measure of low back flexibility, with little variance (9, 25). The minimal detectable change (MDC) for the Sit and Reach Test is between 1.13 cm to 1.74 cm (12).

Maximum™ laser thermometer: The Maximum™ infrared non-contact laser thermometer (Model N08064) was used to measure the skin temperature (degrees Celsius; $^{o}$C) over the lumbar spine at the location of all 4 cups. The laser thermometer was able to measure temperatures ranging from -38 to 520 ℃ (24). The use of an infrared thermometer has shown to be an accurate and reproducible method of obtaining skill temperature at various anatomical locations (29).

Get Active Questionnaire (GAQ): The GAQ is a highly reliable and standardized screening tool developed by the Canadian Society for Exercise Physiology© (CSEP©) that accurately determines one's readiness to engage in physical activity (6). It is a self-administered questionnaire that is applicable for all age groups and physical activity levels. Upon completion of the questionnaire, the researcher reviewed the forms to ensure it was safe and appropriate for the participant to engage in the study.

Tyenaza© inclinometers: Two Tyenaza© inclinometers (Model B0989PFZVW) were used to measure joint angles in degrees ($^{o}$). These devices were used to measure the amount of lumbar spine flexion achieved by the participant pre- and post-cupping. The use of inclinometry to measure ROM of the lumbar spine has shown good reliability and criterion-based validity,

suggesting it is an accurate method to measure lumbar spine flexion (17). Inclinometry has shown to yield accurate and reliable results due to its ease of use and the ability to use more than one device at a time, allowing for an average measurement to be taken (28). The MDC for inclinometry is between 1.50° and 3.41° (3).

Procedures: After potential participants contacted the researcher regarding their interest in the study, a detailed information letter was provided to them, written informed consent obtained, and the participant completed the GAQ and a Participant Demographic form which included their gender, age (years), height (cm), and body mass (kg).

Once all preliminary forms were completed and the participant positioned in prone lying, the researcher landmarked the spinous process of the L1 and L5 vertebrae and marked the location with a washable, skin-safe marker. This was located by palpating for the iliac crests and following them directly inward to landmark the spinous processes of L4 (10). From there, using soft tissue palpation, the L5 spinous process was marked approximately one thumb-width inferior to the spinous process of L4. Similarly, the L1 spinous process was found by sequentially palpating superiorly and marked approximately three thumb-widths up from the L4 landmark on the spine (10). The researcher then measured 3 cm lateral to the spinous processes of L1 and L5 using a measuring tape and marked to determine the location of the four cups for the intervention component of the procedure. After the locations were marked, baseline measurements were taken for the skin temperature using the Maximum™ (Model N08064) Laser Thermometer at all four marked cup locations. The mean skin temperature was calculated by taking the average of all four measurements (one at each location) and this value was recorded. Next, the participant completed the Sit and Reach Test using the Acuflex® 1 Sit and Reach box. The Sit and Reach Test was conducted by instructing the participant to remove their shoes and sit on the floor with their legs out straight (31). The feet were placed into the foot pedals and the hands were clasped together and rested on the metal measuring piece. The participant was asked to keep their legs flat, and feet pressed against the pedals. They were then asked to reach forward as far as possible, pushing the metal measuring piece with their fingertips. After 3 warm-up tries, the participant held the fourth trial for 3 seconds and the measurement was recorded to the nearest cm. Finally, the participant was asked to stand, and two Tyenaza© inclinometers (Model B0989PFZVW) were placed on the L1 and L5 landmarks on the ride side of the spine (22). The participant was instructed to bend forward as far as comfortably possible. The mean of the two values measured by the Tyenaza© inclinometers (Model B0989PFZVW) was recorded. This process was completed again with the Tyenaza© inclinometers (Model B0989PFZVW) on the left side and the mean of both the L1 and L5 values was recorded ($^{o}$). Next, the final lumbar flexion value was determined by taking the mean of the right and left side values ($^{o}$).

Following the baseline measurements, the dry cupping intervention was applied. With the participant positioned in prone lying on the examination table, a light layer of Rockrub® beeswax was applied to the participant's lumbar spine at the 4 cupping locations, to improve adhesion of the suction cups. Four medium sized Hansol© plastic cups were placed on the four

landmarked locations (i.e., right L1, left L1, right L5, and left L5). Each cup was pumped three times using the hand pump for consistent suction. The cups were left in a static position for a total of 10 min. After the intervention was concluded, the suction was released, and the cups were removed and placed into a bin to be disinfected by the hydrogen peroxide solution.

Immediately following the removal of the cups, the skin temperature at all four cup locations was taken again using the Maximum™ (Model N08064) Laser Thermometer and the mean recorded. The Sit and Reach Test and dual inclinometry lumbar flexion tests were repeated, and the post-intervention results were recorded, as previously described.

Following the completion of the final test, the participant was thanked for their involvement and cups cleaned using a 3% hydrogen peroxide solution. This solution was created by combining one part 35% hydrogen peroxide with 11 parts water. Similarly, the examination table, Tyenaza© inclinometers (Model B0989PFZVW), and Acuflex® 1 Sit and Reach box were cleaned using a disinfectant spray (16).

*Statistical Analysis*

Data analysis was completed using IBM® SPSS® Statistics 28. The dependent variables included lumbar spine ROM (º of motion) and skin temperature (ºC). The independent variable was time (pre-intervention and post-intervention). Descriptive statistics were used to determine the mean and standard deviation values for the variables of interest with a *p*-value of .05. Paired sample *T*-tests were used to determine the difference between the pre- and post-intervention values.

## RESULTS

Participant demographics are highlighted in Table 1.

**Table 1**. Participant Demographics.

| | Number of Participants | Mean Height (cm) | Mean Weight (kg) | Mean Age (years) |
|---|---|---|---|---|
| Male | 12 | 181.29 | 79.30 | 20.67 |
| Female | 18 | 165.94 | 64.91 | 21.50 |
| Total | 30 | 172.08 | 70.60 | 21.17 |

Sit and Reach Test: There was a statistically significant increase in the flexion ROM of the lumbar spine as measured by the Sit and Reach Test following the application of dry cupping, $t(29) = 12.62$, $p = 0.001$; $d = 2.34$, with a large effect size (Fig 1). There was a mean increase of 5.40 cm (2.343 cm) from the pre-intervention 24.13 cm (6.96 cm) to post-intervention 29.53 cm (6.91 cm). The increase in ROM as measured by the Sit and Reach test exceeds the MDC (1.13 cm to 1.74 cm).

Lumbar Flexion Inclinometry: There was a statistically significant increase in the flexion ROM of the lumbar spine as measured by inclinometry following the application of dry cupping, $t(29) = 11.10$, $p = 0.001$; $d = 3.86$, with a large effect size (Fig 2). There was a mean increase of 7.82° (3.86°) from the pre-intervention 81.58° (5.70°) to post-intervention 89.40° (7.33°). The increase in ROM as measured by inclinometry exceeds the MDC (1.50° to 3.41°).

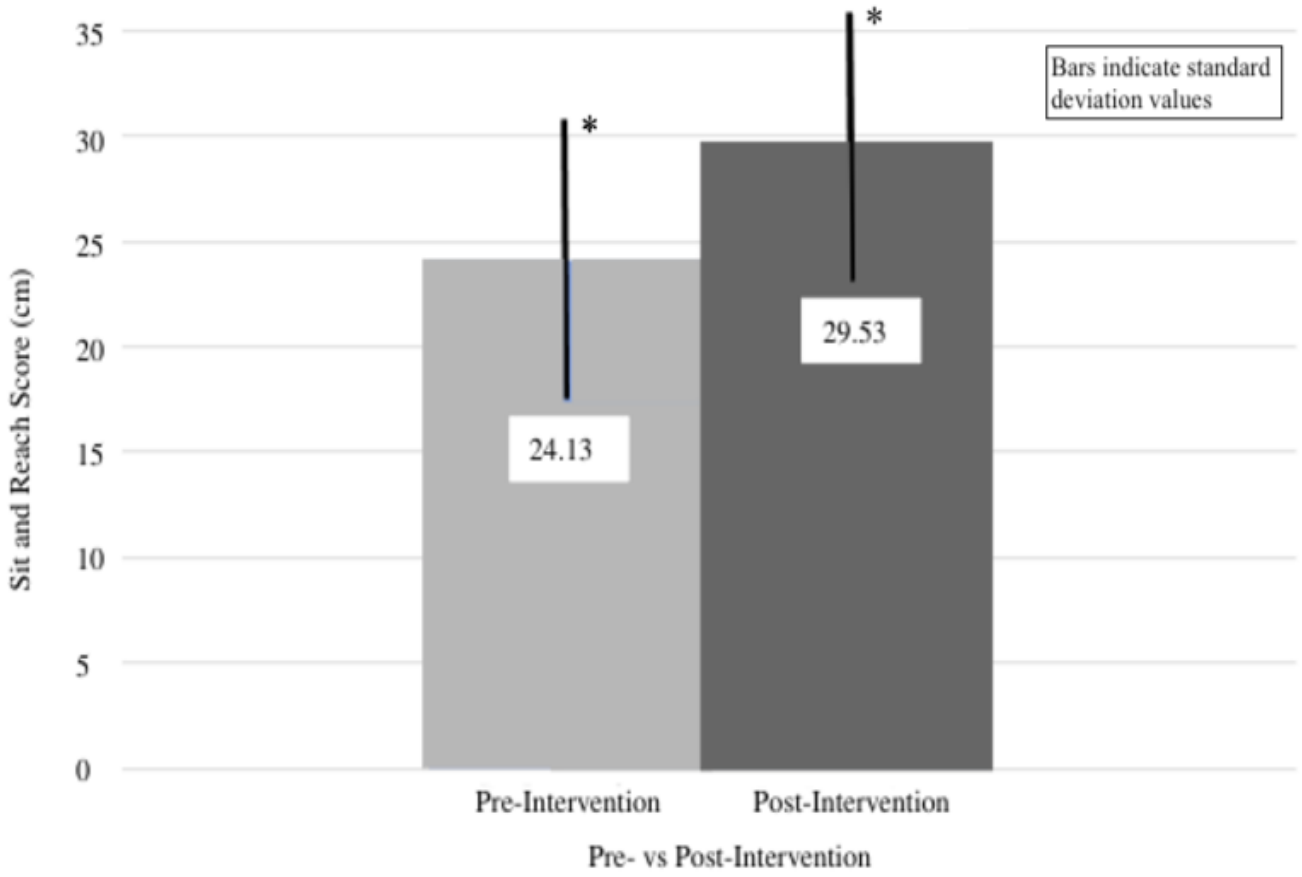


**Figure 1**. Pre- and Post-Intervention Sit and Reach Scores.
*indicates statistical significance

Temperature values: There was a statistically significant decrease in the skin temperature of the lumbar spine as measured by an infrared thermometer following the application of the dry cupping, $t(29) = -2.23$, $p = 0.034$; $d = 0.75$, with a medium effect size (Fig 3). There was a mean decrease of 0.31°C (0.75°C) from the pre-intervention 32.24°C (0.86°C) to post-intervention 31.93°C (1.04°C).

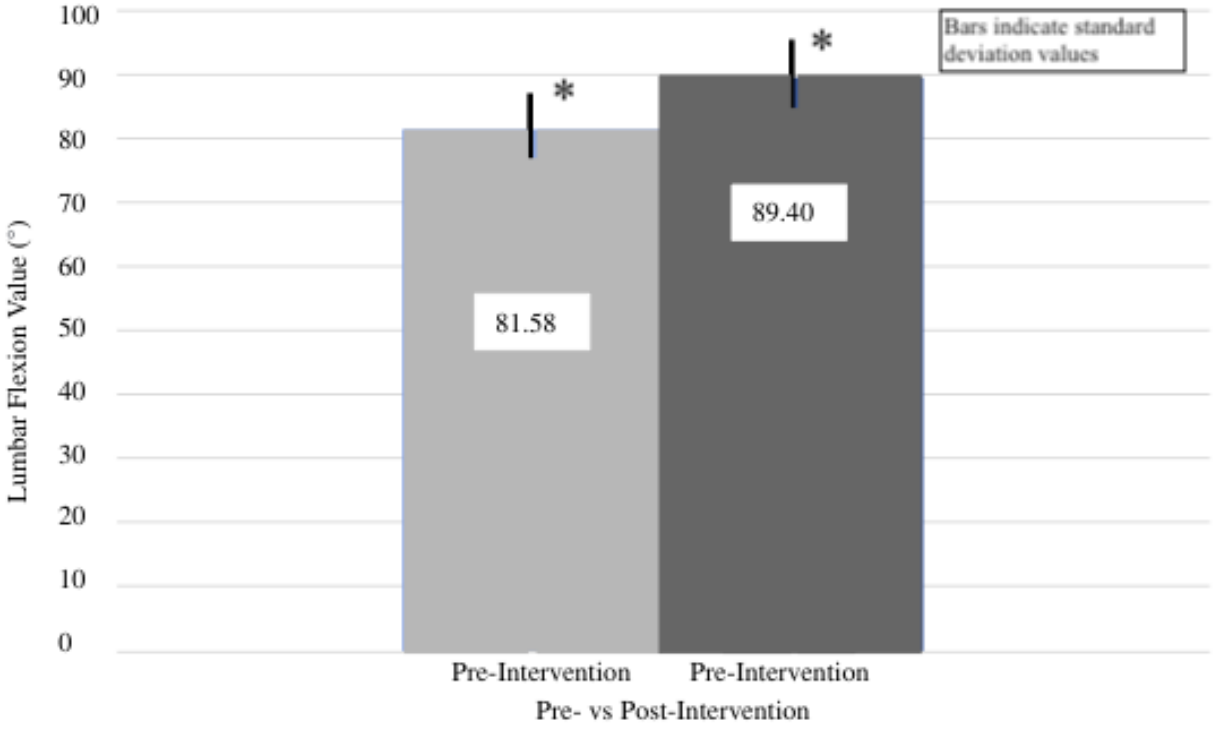


**Figure 2.** Pre- and Post-Intervention Lumbar Flexion Values.
*indicates statistical significance

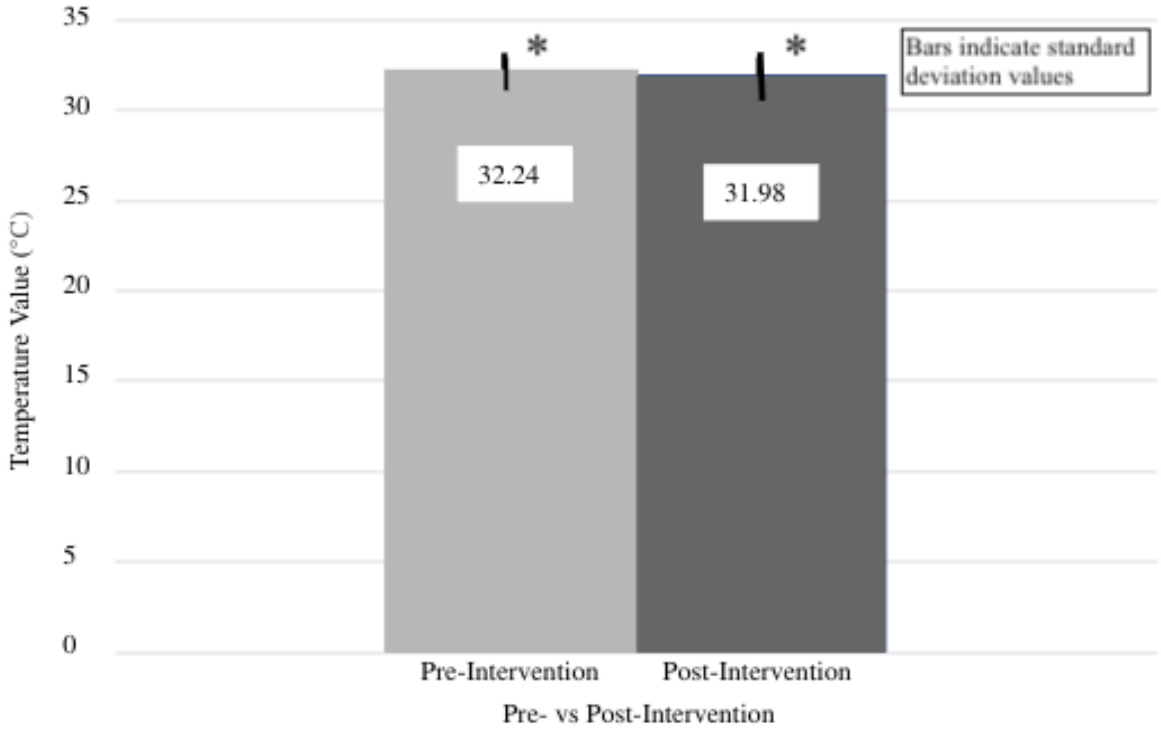


**Figure 3**. Pre- and Post-Intervention Temperature Values.
*indicates statistical significance

## DISCUSSION

The purpose of this pilot study was to explore the immediate effects of dry cupping applied to the lumbar paraspinals on ROM and skin temperature of the lumbar spine. Previous studies have examined the effect of cupping on ROM in various areas of the body and suggested that this intervention may lead to an increase in ROM (8). These studies, however, have mainly reported on the effects of intervention on the ROM of the lower extremities, with limited information related to the effects on the lumbar spine (13, 21, 23). The results of this study support the hypothesis that lumbar spine ROM may increase following the application of static dry cupping with a mean increase of 5.4 cm (22.4%) in Sit and Reach Test scores, and a mean increase of 7.8° (9.6% improvement) in inclinometry values.

The larger observed increase in ROM as measured by the Sit and Reach box compared to the inclinometer may be attributed to the difference in measurement methodology. The inclinometry method is more reliant on the researcher for an accurate result as the user must accurately place and hold the devices throughout the testing procedure. Therefore, this allows for the greater possibility of systematic measurement error caused by the researcher. The Sit and Reach Test is more reliant on the device itself for an accurate measure, and this reduces the risk of measurement error in results by eliminating the effects of the researcher in obtaining the measure (25). Due to the associated potential for error, the 22.4% increase in ROM measured by Sit and Reach may provide a more accurate depiction of the treatment effects.

A similar study by Murry and Clarkson (26) revealed comparable results in ROM increases to those found in this study. The study by Murry and Clarkson (26) examined a similar population demographic in terms of both age range and gender involvement. The methodology for this study was also similar to that used in our investigation, however, the ROM was measured using a goniometer and the dry cups were placed on the knee joint as opposed to the lumbar spine. The results yielded a similar increase in ROM, with a 7% increase, comparable to the 9.6% and 22.4% increases seen in our study. The higher range of increased lumbar spine flexion in our results may be attributed to the different method used to measure ROM and the use of a different region of the body. One of our measurement methods included the use of inclinometry which has been shown to provide more accurate and reliable results than a goniometer as used by Murry and Clarkson (17, 26).

Our results may also be compared to those produced by Yim et al. (33), who examined the effects of static dry cupping on the ROM of the cervical spine. The methodologies for both studies included a dry, static cupping intervention, followed by ROM measured by inclinometry. The time of intervention differed by 2 minutes (8 minutes versus 10 minutes), but it has been previously suggested that any duration of intervention time ranging from 7-10 minutes would produce the same effect (20). Yim et al. (33) reported a mean increase in cervical spine flexion ROM of about 20%, which is comparable to the 9.6% and 22.4% increase seen found in our study for lumbar spine flexion ROM. As previously noted, it is likely that our Sit and Reach results provided a more accurate measure, and our findings almost mirror those by Yim et al. (33). The

slightly greater increase in spinal ROM observed in our pilot study may be attributed to the ability of the lumbar spine to move through a greater ROM than the cervical spine, therefore, giving it a greater ability to improve through this intervention (1).

Our findings further contribute to the existing literature that suggests dry cupping promotes an increase in ROM. These findings support the proposed mechanism of cupping in general, in that the negative pressure within the cup may cause a physiological stretch on the underlying tissue and a gapping in the muscle. This may promote extensibility in the muscle and soft tissue structures, allowing for an increase in ROM (23) but further research is required to understand the exact mechanism contributing to the increase in ROM in different parts of the body.

Previous research has revealed contradictory findings related to temperature change as it relates to cupping. Contradictory findings are present in the limited available research with some reporting that following a cupping intervention, the skin temperature of the focus area may increase as the cupping promotes an increase in blood flow to the skin caused by the negative pressure within the cup (4). Conversely, some research has suggested that cupping may in fact decrease the temperature of the skin but noted that mechanism for the decrease in temperature was not physiologically explained (32). Our results further support this potential temperature decrease but it is proposed that in the case of our pilot study, the resultant decrease in temperature is likely associated with environmental factors, rather than the intervention itself. The laboratory environment in which the pilot study was conducted was not temperature controlled and susceptible to temperature fluctuation. The skin being exposed to the cold air for 10-minutes during the application of the dry cupping may have caused the surface temperature to decrease affecting our results. Furthermore, due to the cold winter outdoor temperatures during the time of the pilot study, participants often came with layered clothing which may have contributed to the initial temperature being higher than normal (14). Therefore, the associated change in skin temperature may not be directly attributed to the cupping itself, but due to the environmental factors associated with the intervention setting and requires further study.

Limitations of this pilot study include the lack of environmental temperature control in the laboratory in which the study was conducted. This lack of control may have contributed to the observed effects on skin temperature. Another limitation when examining the findings for this pilot study is the age of the participants included within this cohort. Even though the inclusion criteria allowed for individuals aged 18-30 years to participate, the mean age of participants was 21 years. A larger age range in the population may provide more generalizable results for intervention purposes. Examining the effects of a cupping intervention on various age ranges would provide a more comprehensive understanding of how this modality may be used to benefit a larger population of individuals experiencing different age-related changes or health challenges across the lifespan. Finally, the study had a single-arm design and lacked a control group, thus a potential placebo and time effect may have occurred.

There is a need for future research to examine the difference in effectiveness of static compared to dynamic cupping and their respective effect on ROM in the lumbar spine or other regions of the body. In addition, further research may examine the use of dry cupping as an intervention in a clinical trial over an extended period and various sessions to test for a potential cumulative effect. Future researchers may wish to further examine the connection between dry cupping and blood flow to the area, rather than temperature changes, for a more accurate understanding of the physiology behind the cupping treatment using doppler or ultrasound measures of flow. Finally, the use of a randomized control design would allow control over placebo and time and for a greater understanding of treatment effects.

Conclusion: The use of static dry cupping may be a safe and an effective modality to increase lumbar spine ROM and applied to symptomatic populations experiencing lower back pain, for example, or where stiffness in the lumbar spine contributes to functional, occupational, or sport changes and limitations. In addition, clinical implications may include the use of dry cupping by healthcare providers to promote recovery and reduce functional limitations due to stiffness. Dry cupping may be associated with a change in skin temperature; however, this relationship remains unclear. Further research is required to fully understand the clinical utility of different types of cupping (static versus dynamic) in different regions of the body, across the lifespan and ages, and in symptomatic patient populations.

## ACKNOWLEDGEMENTS

We would like to express our gratitude to the participants from Lakehead University and the surrounding community for their contributions, as well as the Lakehead University Department of Kinesiology for their support.

## REFERENCES

1. Anderson M, Barnum M. Foundations of athletic training: Prevention, assessment, and management. Philadelphia, PA: Lippincott ,Williams & Wilkins; 2021.

2. Appleton B. Stretching and flexibility. Available at: https://www.somatics.com/pdf/Stretching%20and%20Flexibility%20...pdf; 2010.

3. Boyd BS. Measurement properties of a hand-held inclinometer during straight leg raise neurodynamic testing. Physiotherapy 98(2): 174-179, 2012.

4. Cage SA, Warner BJ, Gallegos DM. Effect of cupping therapy on skin surface temperature in healthy individuals. J Sports Med Allied Health Sci 5(3): 2, 2020.

5. Calculator.net. Sample Size Calculator. Available at: https://www.calculator.net/about-us.html; 2021.

6. Cardinal BJ, Cardinal MK. Screening efficiency of the revised physical activity readiness questionnaire in older adults. J Aging Phys Act 3(3): 299-308, 1995.

7. Centers for Disease Control and Prevention. Acute low back pain. Available at: https://www.cdc.gov/acute-pain/low-back-pain/index.html#:~:text=Low%20Back%20Pain%20(LBP)%20is,in%20the%20prior%203%20months; 2022.

8. Chiu YC, Manousakas I, Kuo SM, Shiao JW, Chen CL. Influence of quantified dry cupping on soft tissue compliance in athletes with myofascial pain syndrome. PloS One 15(11): e0242371, 2020.

9. Chung PK, Yuen CK. Criterion-related validity of sit-and-reach tests in university men in Hong Kong. Percept Mot Skills 88(1): 304-316, 1999.

10. Duniec L, Nowakowski P, Kosson D, Łazowski T. Anatomical landmarks based assessment of intravertebral space level for lumbar puncture is misleading in more than 30%. Anaesthesiol Intensive Ther 45(1): 1–6, 2013.

11. Dunning J. Myofascial cupping therapy for pain, recovery and performance: evidence & proposed mechanisms. Available at: https://spinalmanipulation.org/2016/09/08/myofascial-cupping-therapy-for-pain-recovery-and-performance-current-evidence-and-proposed-mechanisms/; 2016.

12. Fang H, Ho IMK. Intraday reliability, sensitivity, and minimum detectable change of national physical fitness measurement for preschool children in China. PloS One 15(11): e0242369, 2020.

13. Hoy D, Bain C, Williams G, March L, Brooks P, Blyth F, Woolf A, Vos T, Buchbinder R. A systematic review of the global prevalence of low back pain. Arthritis Rheum 64(6): 2028–2037, 2012.

14. Jarvis C. Physical examination and health assessment. 3rd ed. Toronto, CA: Elsevier; 2018.

15. Kim JE, Do KS, Kim HJ. Effect of cupping therapy on range of motion, pain threshold, and muscle activity of the hamstring muscle compared to passive stretching. J Korean Soc Phys Med 12(3): 23-32, 2017.

16. Kohlmeier P. How to clean your cups. Available at: https://cuppinginternational.com/blogs/news/how-to-clean-your-cups; 2018.

17. Kolber MJ, Pizzini M, Robinson A, Yanez D, Hanney WJ. The reliability and concurrent validity of measurements used to quantify lumbar spine mobility: An analysis of an iPhone® application and gravity based inclinometry. Int J Sports Phys Ther 8(2):129-37, 2013.

18. Lee JY, Shim DW, An SK, Kim ES, Lee BR, Yang GY. Developing a pressure control valve for air extraction cupping device. Korean J Acupunct 38(4): 308-316, 2021.

19. Lempke AF, Hertel J, Saliba S. Clinical usage, application procedures, and perceived effectiveness of cupping therapy among healthcare professionals in the United States: A cross-sectional survey. Complement Ther Clin Pract 48: 101610, 2022.

20. Li Y, Yu J, Zhang J, Zhang Z, Wang X. Quantifying the stiffness of lumbar erector spinae during different positions among participants with chronic low back pain. PloS One, 17(6): e0270286, 2022.

21. Lowe DT. Cupping therapy: An analysis of the effects of suction on skin and the possible influence on human health. Complement Ther Clin Pract 29: 162-168, 2017.

22. MacDermid JC, Arumugam V, Vincent JI, Payne KL, So AK. Reliability of three landmarking methods for dual inclinometry measurements of lumbar flexion and extension. BMC Musculoskelet Disord 16: 121, 2015.

23. Markowski A, Sanford S, Pikowski J, Fauvell D, Cimino D, Caplan S. A pilot study analyzing the effects of Chinese cupping as an adjunct treatment for patients with subacute low back pain on relieving pain, improving range of motion, and improving function. J Altern Complement Med 20(2): 113-117, 2014.

24. Maximum. Maximum infrared thermometer manual. Available at: https://www.canadiantire.ca/en/pdp/maximum-no-contact-infrared-thermometer-with-mildew-alarm-0574663p.0574663.html?&&gclid=CjwKCAjw7c2pBhAZEiwA88pOF6tBueR7e5IjWonR8rloSQUyMK9gvARguCGtAmARyCGh4DzLufhVwBoCm1IQAvD_BwE&gclsrc=aw.ds; 2023.

25. Mayorga-Vega D, Merino-Marban R, Viciana J. Criterion-related validity of sit-and-reach tests for estimating hamstring and lumbar extensibility: A meta-analysis. J Sports Sci Med 13(1): 1-14, 2014.

26. Murray D, Clarkson C. Effects of moving cupping therapy on hip and knee range of movement and knee flexion power: A preliminary investigation. J Man Manip Ther 27(5): 287-294, 2019.

27. Navalta JW, Stone WJ, Lyons TS. Ethical issues relating to scientific discovery in exercise science. Int J Exerc Sci 12(1): 1-8, 2019

28. Nussbaumer S, Leunig M, Glatthorn JF, Stauffacher S, Gerber H, Maffiuletti NA. Validity and test-retest reliability of manual goniometers for measuring passive hip range of motion in femoroacetabular impingement patients. BMC Musculoskelet Disord 11: 194, 2010.

29. Osio CE, Carnelli V. Comparative study of body temperature measured with a non-contact infrared thermometer versus conventional devices. The first Italian study on 90 pediatric patients. Minerva Pediatr 59(4): 327-36, 2007.

30. Prather H, Van Dillen L. Links between the hip and the lumbar spine (hip spine syndrome) as they relate to clinical decision making for patients with lumbopelvic pain. PM R 11(Suppl 1): S64-S72, 2019.

31. Ratamess N. ACSM's foundations of strength training and conditioning. Philadelphia, PA: Lippincott, Williams & Wilkins; 2021.

32. Stephens SL, DeJong Murray D, Clarkson C. Effects of moving cupping therapy on hip and knee range of movement and knee flexion power: A preliminary investigation. J Man Manip Ther 27(5): 287-294, 2019.

33. Yim J, Park J, Kim H, Woo J, Joo S, Lee S, Song J. Comparison of the effects of muscle stretching exercises and cupping therapy on pain thresholds, cervical range of motion, and angle: A cross-over study. Phys Ther Rehabil Sci 6(2): 83-89, 2017.

34. Xu PC, Cui SL, Wee DAC, Sheng XU, Leang LT. Preliminary observation on effect of cupping on the skin surface temperature of patients with back pain. World J Acupunct Moxibustion 24(4): 59-61, 2014.