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The Influence of Dry Needling of the Trapezius Muscle on Muscle Blood Flow and Oxygenation

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Article Outline

AbstractÂ

Objective

The purpose of this study was to investigate the effect of dry needling on the blood flow and oxygen saturation of the trapezius muscle.

Methods

Twenty healthy participants participated in this study. One single dry needling procedure was performed in the right upper

trapezius, at a point located midway between the acromion edge and the seventh cervical vertebrae. Using the oxygen to see device, blood flow and oxygen saturation were evaluated at the treated point and 3 distant points (similar point in the left upper trapezius and 30 mm laterally from this midpoint). Measurements were taken at baseline and in the recovery period (0, 5, and 15 minutes posttreatment).

Results

After removal of the needle, the blood flow and oxygen saturation increased significantly from the pretreatment level in the treated point (*P* â‰¤ .001), and these values remained high throughout the 15-minute recovery period. There were only minor changes in the distant points.

Conclusions

These results suggest that dry needling enhances the blood flow in the stimulated region of the trapezius muscle but not in a distant region used in this study.

Key Indexing Terms:Â Muscles, Microcirculation, Laser Doppler Flowmetry

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Neck/shoulder pain is a common health problem in participants performing sedentary jobs. The pain is often located in the upper trapezius muscle and is believed to develop in response to prolonged low-level static exercises.[1], [2] It is known that continuous long-lasting muscle activity in patients with neck muscle pain may induce changes in type I motor units, such as mitochondrial disturbances and reduced capillarization, leading to local metabolic changes, which my sensitize nociceptors.[3], [4], [5] Included in this sequence is an ongoing energy crisis, in which continuous activity of a subset of muscle fibers impedes the delivery of oxygen to other, deprived muscle fiber. In this way, muscle metabolism turns toward an anaerobic state.[6]

Different studies have reported changes in microcirculation during static low-level muscle contractions. Cagnie et al[7] and Flodgren et al[8] demonstrated a significant decrease in oxygen saturation of the trapezius muscle over time during a 1-hour typing task and 30-minute repetitive work, respectively. This decrease is likely to coincide with an increase in lactate, which is interpreted as a normal response to increased physical demands.[9], [10], [11] The findings in participants with work-related myalgia are, to some extent, conflicting. Some authors have found decreased oxygenation and increased lactate production[7], [11], [12] compared with healthy controls, whereas others did not find a difference between both groups.[9], [10]

Because different studies have demonstrated a decrease in blood flow and oxygenation, implementation of intervention strategies to counteract this decline are essential. A treatment technique that currently gains in importance is dry needling, although its exact working mechanisms remain elusive. Besides the more mechanical effects such as mechanical disruption of trigger points[13] and localized stretch to the contractured cytoskeletal structures,[14] it is suggested that dry needling may influence the metabolic mediators and microcirculation. Several authors have demonstrated that needle insertion in the calf muscles increased both skin and muscle blood flow.[15], [16], [17], [18] Shah and Gilliams[19] demonstrated a change in inflammatory mediators after dry needling of the upper trapezius, which he suggested to result from increasing local blood flow to the trigger point region.

The previous studies have some methodological drawbacks. Shah et al[20] have used an invasive microdialysis technique that may cause microtrauma to the muscle tissue, affecting the blood flow. Sandberg et al[16], [17] used a custom-designed optical probe with accompanying photoplethysmography instrumentation, which may have a heating effect, leading to a local temperature increase. The Oxygen to see (O2C) (LEA Medizintechnik, GieÃŸen, Germany) is a relatively new, noninvasive device, based on the combination of white light spectroscopy and laser Doppler technique, allowing simultaneous evaluation of perfusion and oxygenation. This technique has been widely used in the evaluation of microcirculation in Achilles tendon problems[21], [22], [23] but has been shown to be also very applicable for the trapezius muscle.[7]

The aim of this study is to investigate the effect of dry needling on blood flow and oxygen saturation of the trapezius muscle in healthy participants. We hypothesize that dry needling is able to immediately increase oxygen saturation and blood flow in the region where dry needling is performed, whereas no changes at the nonneedled sites are expected.

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MethodsÂ

ParticipantsÂ

Twenty right-handed healthy female office workers (mean age, 29.2 Â± 6.9 years) working full time and performing at least 4 hours of computer work daily participated in this study. They were selected provided that they had not experienced pain or discomfort for more than 8 days during the last year in the neck/shoulder region with intensity of 2 or above. Participants with past traumatic injuries or surgical interventions in their neck or upper limb regions were excluded. All participants gave their informed and signed consent before inclusion in the study. The study was approved by the Ethical Committee, Ghent University Hospital.

General ProtocolÂ

Participants were asked to lay prone on a treatment table to acclimate to the laboratory conditions for 10 minutes before the experiment (FigÂ 1). Environmental factors such as light and temperature were kept constant for standardization. Skin markers were placed for transducer placement and to ensure exact reapplication during the 5 measurement moments. After 10 minutes of rest (pre1), blood flow and oxygen saturation were determined at 4 points: a first point at both the right and the left upper trapezius muscle (MP1 and MP3) was located in the center of the line, which tied up the acromion edge to the seventh cervical spine spinous process. The other point (right [MP2] and left [MP4]) was located on the same muscle, 30 mm laterally from the first point. Five minutes after the first measurement, a second measurement (pre2) was performed at all 4 points, to evaluate the stability of the measurement.

FigÂ 1Â
Experimental setup of the investigation.

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After that, a stainless needle of 0.30-mm diameter and 30-mm length was inserted in MP1. After needle insertion to the targeted depth (15 mm), the needle was moved up and down (2- to 3-mm vertical motions with no rotations) at 1 Hz for 10 seconds. Immediately after withdrawal of the needle, the blood flow and oxygen saturation were measured (post1) and repeated after 5 minutes (post2) and 15 minutes (post3). All assessments were done by the same examiner.

MeasurementsÂ

Oxygen to SeeÂ

Muscle tissue oxygenation and blood flow data were collected by use of the O2C device. The O2C is a relatively new noninvasive device that is capable of measuring the perfusion and oxygenation of the subcutaneous tissue up to a depth of 8 mm. The technology of the O2C is based on 2 physical principles: white light spectroscopy (wavelengths of 500-800 nm) and the laser Doppler technique (830 nm and 30 mW). The O2C system transmits continuous wave laser light and white light to tissue, where it is scattered and collected on the skin surface with fibers of the probe. The collected light is split into its spectral components and converted into an electrical signal by a charge-coupled device array. The white light spectroscopy allows to detect hemoglobin parameters such as oxygen saturation and the relative amount of hemoglobin. The oxygen saturation is determined by the color of the blood, which changes according to the degree of saturation of the hemoglobin with oxygen. Oxygen saturation of hemoglobin is expressed in percent S_{O2} (%) and reflects mainly the capillary-venous oxygen saturation because 85% of the hemoglobin is in the capillary-venous compartment of the microcirculation.[24] The laser Doppler flowmetry allows to determine perfusion parameters in the tissue as it detects all moving erythrocytes. The number of moving erythrocytes combined with the blood flow velocity is processed to the parameter blood flow. This is expressed in arbitrary units. This device has been shown to be reliable[25], [26] and valid.[27]

The O2C allows to evaluate the different parameters at 2 distinct tissue depths (2 and 8 mm). Because previous studies have calculated that the mean distance between the skin surface and the fascia of the trapezius muscles is between 5.8 Â± 1.7[28] and 7.7 Â± 1.7,[29] only the depth at 8 mm was further used to evaluate the oxygenation and perfusion parameters in the trapezius muscle.

Pain IntensityÂ

To evaluate the effect of dry needling on pain, pain intensity was verbally rated using a numerical rating scale (NRS), ranging from 0 (no pain) to 10 (worst possible pain) at each time point (pre1, pre2, post1, post2, post3).

Statistical AnalysisÂ

Analysis was performed using the SPSS statistics 19 (SPSS, Chicago, IL). Descriptive statistics (mean and SD) were calculated for oxygen saturation, blood flow, and NRS.

The stability of the measurement of oxygen saturation and blood flow was evaluated by calculating intraclass correlation coefficients (ICC) (2-way mixed effect modelâ€"absolute agreement), SEM, and smallest detectable difference (SDD). Defined with respect to a 95% level of confidence, the SDD is equal to 1.96 âˆš2 * SEM.

Oxygen saturation and blood flow were further analyzed by use of analysis of variance with repeated measures with within-participant factors being measurement point (MP1-MP4) and time (pre1, pre2, post1, post2, post3).

Post hoc pairwise comparisons (Bonferroni) were made when required. Statistical significance was accepted at the .05 Î± level.

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ResultsÂ

Stability of the MeasurementÂ

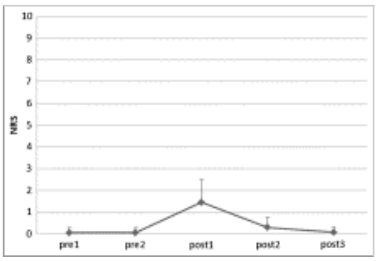
The ICC was 0.95 and 0.89 for S_{O2} and blood flow, respectively. Both SEM and SDD are listed in TableÂ 1.

TableÂ 1. Stability of S_{O2} and blood flow measurements (ICC, SEM, and SDD)

	ICC	SEM	SDD
S_{O2}	0.95	2.35	6.51
Blood flow	0.89	13.86	38.43

Numerical Rating ScaleÂ

The NRS score increased significantly from pretreatment to post1 (*P* â‰¤ .001) to recover to baseline measures at post2 and post3 (*P* â‰¤ .001) (FigÂ 2).



FigÂ 2Â

Mean values of NRS ratings at baseline and in the recovery period (0, 5, and 15 minutes posttreatment).

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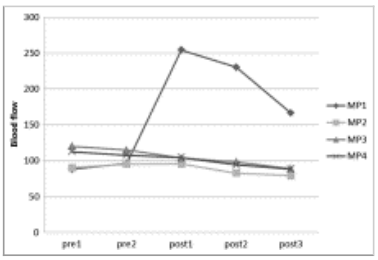
Blood FlowÂ

The analysis of variance yielded a significant interaction effect time Ã— measurement point (*F* = 54.481, *P* < .001). There was a significant difference in blood flow between the measurement points at baseline: blood flow in both measurement points on the right side was significantly lower compared with the left side (*P* â‰¤ .036).

Post hoc tests on each measurement point separately revealed that blood flow (FigÂ 3) increased significantly with 164% in MP1 from pre2 to post1 (*P* < .001). There was no significant difference between post1 and post2, whereas blood flow decreased significantly with 28% from post2 to post3 (*P* < .001). Hence, 15 minutes after the needling, blood flow was still 72% higher compared with baseline. There was no significant difference in blood flow for MP2 between the different time points, whereas blood flow in MP3 and MP4 was significantly lower in post2 and post3 compared with pre1 (*P* â‰¤ .020; 16%-26% drop).



FigÂ 3Â

Mean blood flow (Â± SD) at the 4 measurement points (at baseline and in the recovery period).

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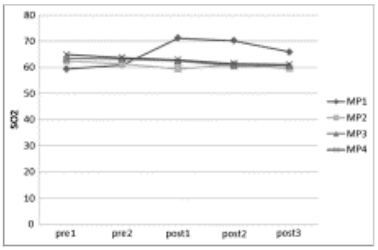
Oxygen SaturationÂ

Similar trends were observed for the S_{O2}. The analysis of variance yielded a significant interaction effect measurement point Ã— time (*F* = 6.180; *P* = .001). There were no differences in S_{O2} between the measurement points at baseline.

Post hoc tests on each measurement point separately revealed that S_{O2} (FigÂ 4) increased significantly in MP1 from pre2 to post1 (*P* < .001) with 17%. There was no significant difference between post1 and post2, whereas S_{O2} decreased significantly from post2 to post3 (*P* = .001) with 6%. There was no significant difference in S_{O2} for MP2 between the different time points, whereas S_{O2} in MP3 and MP4 was significantly lower in post2 and post3 compared with pre1 (*P* â‰¤ .010; 4%-6% drop).



FigÂ 4Â

Mean S_{O2} (Â± SD) at the 4 measurement points (at baseline and in the recovery period).

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DiscussionÂ

This study demonstrated a local increase in both blood flow and oxygen saturation due to a single dry needling intervention in healthy office workers, which did not return to the pretreatment level until 15 minutes after removal of the needle.

The measurements of both S_{O2} and blood flow were highly reliable, with ICCs of at least 0.89. There was no increase in muscle blood flow during the first 5 minutes at baseline, indicating no environment-induced influences on circulation parameters in this group. The reproducibility of the blood flow values determined with the O2C system has previously been tested in the forearm of 20 healthy participants using a test-retest design. An average 5% intraparticipant variability was calculated.[25] Recently, Forst et al[26] conducted an analogous study in both diabetic and healthy participants and demonstrated

a proper intraindividual reproducibility of all parameters (*r* varying between 0.65 and 0.85).

Although at baseline, blood flow and oxygen saturation were both higher on the left side compared with the right side, this difference was only statistically significant for blood flow. It is known that right-handed participants performing a reasonable amount of computer work are known to have more right-sided activation due to mousing tasks. It is hypothesized that reduced blood flow may be related to higher intramuscular pressure, specifically in parts of the muscle where individual motor units are active compared with overall muscle activity.[30] Indications for this clustering of motor units have been found in the trapezius muscle, which may support this hypothesis.[31]

The results in response to needle stimulation were in accordance with previous studies performed in the extremity muscles and trapezius muscle. Sandberg et al[16] and Kubo et al[18] performed different studies in the calf muscles by using photoplethysmography and red laser lights, respectively. In healthy participants, blood flow and oxygen saturation increased significantly from the pretreatment level, and these values remained high throughout the 20- and 30-minute recovery period. In both studies, the needle was left in situ for at least 10 minutes, which is in contrast with the procedure of this study, where the needle was only left in place for 10 seconds.

There are different mechanisms suggested to explain the local muscle response of blood flow to needle stimulation. A first mechanism is the release of vasoactive substance such as calcitonin gene-related peptide and substance P upon activation of A-Î´ and C-fibers via the axon reflex, leading to vasodilatation in small vessels and increased blood flow.[32] However, based on the mean NRS score in this study, the dry needling was hardly painful. This may be explained by the fact that human nociceptive afferents may be vigorously activated by mechanical stimulation without eliciting painful sensations.[33], [34] Hence, an axon reflex vasodilatation may be elicited by activation of nociceptors even in the absence of a conscious pain perception, as was the case in this study.[34], [35]

By antidromic activation of collaterals, nociceptive stimulation is suggested to also innervate adjacent tissue, resulting in vasodilatation and increases in blood flow extending the site of stimulation.[15] In this study, there was only a significant increase at the stimulated site, with a decrease in blood flow and oxygen saturation on the left side, 5 and 15 minutes after stimulation. Ohkubo et al[36] also did find an increase in oxygenation in the stimulated region of the trapezius muscle, but no response in the same muscle approximately 3 cm away from the stimulation point. In contrast, Sandberg et al[15] did find a transient significant increase in contralateral blood flow in the trapezius muscle after needle stimulation, although this increase was significantly less than in the stimulated muscle and apparently only at first/second minute after the needle stimulation. According to Sandberg et al, this increase may represent a sympathetic stress response, which is in line with previously detected short-lasting increase in sympathetic nerve activity at needle manipulation in healthy participants.

The results of this study reflect some implications for rehabilitation strategies. Because different studies have demonstrated a decrease in blood flow and oxygenation in the trapezius muscle in office workers, intervention strategies are needed to counteract this decline. Previous studies have focused on the implementation of pauses (active and passive)[37] and exercises[38], [39] to reduce the decline in blood flow and oxygenation and found an increase over time in both participants with and without chronic neck pain. This study confirms earlier studies demonstrating that dry needling has quite an impact on the oxygenation and blood flow in the trapezius muscle. However, its long-term effect is not known because all studies limited their posttreatment evaluation to 30 minutes at most. Further studies are required to evaluate the long-term effect of single dry needling treatment on oxygenation and blood flow.

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LimitationsÂ

A limitation of this study is that only healthy participants were evaluated, so it is not known whether patients would react in a similar manner. It is thought that dry needling of trigger points in patients with neck pain induced by continuous low-repetition tasks would have a direct influence on the ongoing energy crisis: enhancing oxygen saturation and blood flow in a subset of muscle fibers may break the chain in this vicious circle. However, Sandberg et al[15] demonstrated that patients with trapezius myalgia responded less to needling, with a blood flow increase only during the first 5 minutes. Also, Andersen et al[38] observed a lower change in oxygenation in women with trapezius myalgia compared with healthy participants after cycling. They attributed this difference to the aggravated pain condition, involving altered processing of somatosensory input, and disturbances in the regulation of microcirculation. This observation highlights the need for further studies to evaluate whether similar or different patterns occur in participants with neck pain.

Coupled with the previous remark is the fact that dry needling was performed on a fixed location, that is, the midpoint of the distance between acromion and the seventh cervical vertebrae. This point is thought to be similar to the localization of a known trigger point (TP2) and is frequently indicated as a tender point in patients with work-related myalgia.[40] However, in clinical practice, the determination of the localization of dry needling is based on palpation and clinical signs and symptoms instead of needling fixed points. This requires a more pragmatic approach, which is not always appropriate or even acceptable for research purposes.

The present study used the O2C to measure the perfusion and oxygenation simultaneously and noninvasively, which makes it appealing to both researchers and clinicians. This device determines intracapillary hemoglobin oxygenation and flow, which present more precise data on local tissue oxygen supply compared with a simple measurement of tissue partial pressure of oxygen. Of further advantage is that the technology provides real-time data and is easy to set up and to use even for continuous measurements. In this study, measurement bias was avoided by standardization of environmental factors, that is, assessment by the same examiner, uniform participant's positioning, light and temperature, standardization. The major limitation of the O2C device is that parameters of microcirculation are insufficiently validated and normalized for human trapezius tissue. Although previous studies have demonstrated good reliability in measuring forearm muscles,[25], [26] further studies are recommended to investigate the validation and reliability of this equipment in measuring the trapezius muscle.

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ConclusionÂ

One session of needle stimulation induced an increase in blood flow and oxygen saturation in the trapezius muscle in healthy participants, and these values remained high throughout the 15-minute recovery period. There were no changes in regions distant to the needle site. Further studies in participants with myofascial pain and in specific trigger points are required.

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Funding Sources and Potential Conflicts of InterestÂ

Barbara Cagnie is supported by the Research Foundationâ€“Flanders. No conflicts of interest were reported for this study.

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Practical ApplicationsÂ

â€¢Blood flow and oxygen saturation increased significantly after a single dry needling intervention, and these values remained high throughout the 15-minute recovery period.

â€¢There were only minor changes in the measurement points at the upper trapezius on the other side.

â€¢These results suggest that dry needling enhances the blood flow in the stimulated region of the trapezius muscle but not in a distant region used in this study.

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