Cold Air therapy

CryoOne

Therapy book

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Cold air therapy at -30 °C

Physiological reactions to cold

Therapeutic effects of cold applications

Short, sharp cooling initially causes vasoconstriction which is followed, once finished, by vasodilatation.
This is particularly evident in the skin. The serial application of cold stimuli stimulates vasomotor function involving a training effect on vascular dynamics because vasodilatation after cooling perceptibly heats the treated area via reactive hyperemia. Short bursts of cold air to the trunk act as a strong reflex stimulus for systemic metabolic activity, with generalized improvement in the peripheral microcirculation and thus, warming, as is known from use in Kneipp therapy.
In addition to the local effects on vasomotor function mentioned, cold air also has a two-stage systemic effect, particularly when applied to the trunk. This is characterized by an initial stimulation of respiration, an increase in blood pressure and cardiac activity followed by calming. This also occurs when cold stimuli are applied to the extremities but the latter must be warm. If cold stimuli are applied to cool/cold extremities, the microcirculation and metabolic activity are further reduced, even deep inside, and the patient develops frostbite. Care must therefore be taken to ensure that frostbite does not occur particularly when applying cold air to the extremities. If need be, the areas adjacent to the portion of the limb being treated must be covered to be kept warm, in order to prevent the dissipation of heat from the area inadvertently cooled. Contrastingly, the application of considerable cold stimuli to the face must be avoided unless there has been prior acclimatization, because this may lead to short-term apnea (diving reflex) with an increase in pressure in the chest (Valsalva maneuver) and to a considerable rise in blood pressure due to generalized constriction of the resistance vessels. The eyes should also be protected against cold air. In the case of acute inflammation, associated with local heating, among other things, cold air is a preferred method of pain control and prophylaxis of edema.
For an initial ergotropic (sympathicotonic) situation, cryotherapy is ideally administered to the back for its general soothing properties and to promote sleep. This is in direct contrast to the relaxing, refreshing effect of mild cooling in an initial trophotropic (vagotonic) situation, especially of the face and neck region.

Other effects include

- Alleviation of mechanically, biochemically or infection-induced inflammation
- Reduction in inflammation activity
- Decrease in nerve conduction velocity
- Analgesia
- Inhibition of nociception (pain generation) and pain conduction as from 13 °C
- Blockade of nerve conduction from 8 °C
- Diminished metabolic activity
- Release of pain-inhibiting neurotransmitters

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Effect on muscle tone
› Short cold stimuli increase the activity of the muscle spindles and lead to an increase in muscle tone.
› Long cold stimuli reduce the activity of the muscle spindles and lead to a decrease in muscle tone and muscle spasticity
› Decrease in the nerve conduction velocity of motor fibers

Vasoconstriction
› Immediate, persistent constriction of local superficial blood vessels through stimulation of the noradrenergic nerve endings in the vessels
› Immediate, general vasoconstriction (even at depth) via CNS reflex arcs
› Delayed, generalized vasoconstriction through activation of the posterior portion of the hypothalamus due to the return of cooler blood

Vasodilatation below a tissue temperature of 15 °C
› Temperature-dependent approximately 2 – 6 minutes after beginning cold therapy (as a protective function triggered by vasomotor "paralysis" of arteries, arterioles, veins, venules and lymph vessels)

„Hunting response"
› Wave-shaped fluctuations in blood flow during long-term cooling (from approximately 30 minutes)

Autonomous nervous system
› Increase in blood pressure and tachycardia with the sudden onset of the cooling action
but!
› Bradycardia following the application of cold therapy to the face

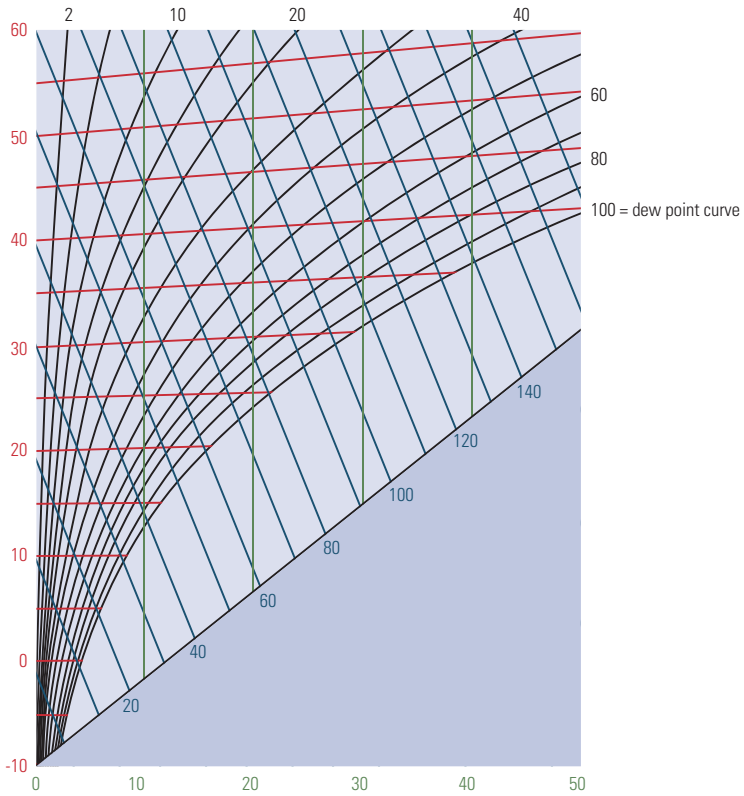
Activating respiration and O_2 consumption
› Especially on applying a current of cold air to the trunk (chest and back)

Metabolic activity in the muscles and joints
› Slowing down of metabolic rate in cooled tissue and reduced O_2 consumption
› Diminished enzyme activity in inflammatory processes, consequently inhibition of breakdown of cartilage, for example

Analgesia
› Inhibition of the release of algogenic agents (e.g. catecholamines, histamine)
› Reduction in the conduction velocity and impulse frequency of pain-conducting nerve fibers
› Onset of analgesic effect at approximately 13 °C (pain receptor temperature)
› Nerve blockade from approximately 8 °C (nerve temperature)

Cold air therapy

h', x diagram / Molier diagram
Pressure p = 966,6 mbar



Relative humidity %
Temperature °C
Enthalpy h kj / (1 + x) kg air
Water content x g water / kg dried air

The water content of the air at -35°C is approximately 0%.

Non-contact cooling is an important therapeutic property of cold air therapy. The amount of water vapor in the air decreases as the temperature drops such that the cold air of the CryoOne, with a starting temperature of up to -35°C, represents dry treatment.

This minimizes the risk of frostbite.

The production of ice on the skin by freezing the moisture from the swirling surrounding air is likewise impossible since the air current prevents stationary condensation.

The following comments have been made in relation to other methods:

› Cool spray: the extremely rapid cooling of the skin masks the risk of local frostbite. The temperature of the skin falls very quickly, as a result of which deeper tissue cannot be cooled.

› Ice bags, cold packs: a substantial amount of heat is initially removed from the skin until the balance between heat loss from the tissue and heat influx is adjusted.
In addition, a layer of vapor forms between the pack and the skin producing condensed water. At low temperatures (dry ice) and with a lack of skin protection (no intermediate layer), frostbite can occur. On the other hand, a substantial drop in temperature in deeper layers is not possible if the pack temperature definitely prevents any damage to the skin.

In contrast to the application of cool packs or ice packs, when cold air is used there is no moist layer of vapor on the skin making longer, sustained cooling difficult. Cooling with cold air is thus more effective.

› Cold air: when used properly, the skin does not cool to harmful temperatures. With cold air, sufficient heat can be removed even from deeper layers of tissue during prolonged application, in order to lower the temperature in these locations to therapeutically desirable values without damaging the skin.

The delivery of cold air can be carefully controlled via changes in airflow velocity and the distance of the nozzle from the skin.

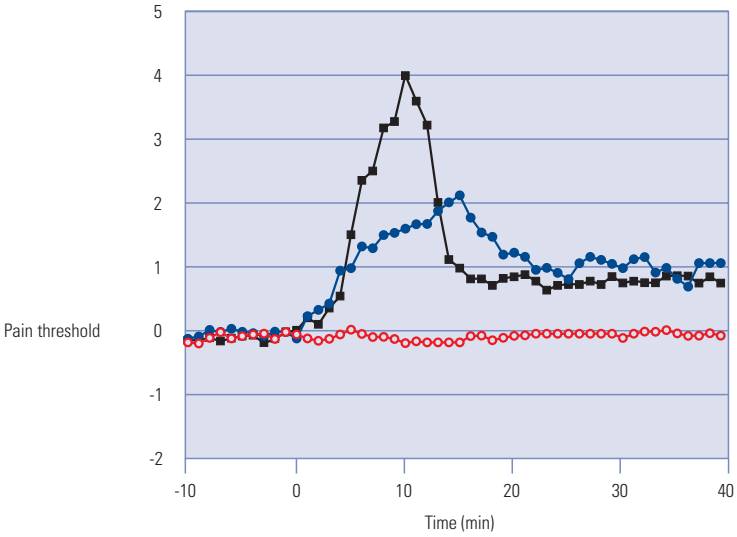
Cold air therapy is suitable for both short-term, rapid, intense skin cooling as well as for longer-lasting moderate cooling, in order to lower the temperature to therapeutically relevant values even in deeper layers of tissue (joint space, muscle).

In deeper layers of tissue, the temperature only falls with the prolonged use of cold air since the stratum corneum and subcutaneous fatty tissue possess considerable insulating properties. Depending on the thickness of the subcutaneous fatty layer, cooling times of 15 min to 30 min are required in order to effectively cool the tissue underneath the layer of fat. Furthermore, reactive hyperemia induced by the prolonged cooling period no longer occurs.

The temperature of the air flow substantially increases with the removal of the air current such that there is no risk of excessive body cooling in adults, even with prolonged use.

In the case of children, care should be taken to ensure that untreated areas of the body are covered and kept warm. This is also recommended for adults in long-term cooling. Even if there is no risk of excessive cooling, steps can still be taken to ensure that the patient does not develop frostbite or muscle tremor, etc.

Compared to the methods of dry cooling with cold air, the therapeutic effect is also clearly more intense as measuring the pain threshold shows.



Reactive hyperemia

Joints and muscles must be cooled for a sufficiently long period since cooling procedures of just a few minutes' duration only cool the skin surface and superficial skin layers and result in more intense blood flow in the overall region due to a regulatory mechanism in the body. This is known as reactive hyperemia.
Since, for instance, blood flow through an inflamed joint is already too high because of the inflammation, this effect is exacerbated by inadequately long or inefficient cooling.

Inadequate or inefficient cooling often therefore leads to more inflammation and more intense pain. The desired effect of pain relief is not achieved under any circumstances.

It should also be noted that the effects on vasomotor function, initial vasoconstriction and subsequent vasodilatation with reactive hyperemia during short-term cooling not only impact upon the skin but also affect deeper layers of tissue such as periarticular tissue and the muscles as a result of skin reflexes.

With a sufficiently long cooling period, the temperature can also drop at depth. Deep sensors are stimulated to prevent the regional increase in blood flow described above. The outcome is a reduction in local inflammation and alleviation of pain.

› Short-term cooling with cold air leads to reactive hyperemia
› Longer-lasting cooling avoids reactive hyperemia.

The general guideline for avoiding reactive hyperemia

› A large joint such as the knee joint should be cooled for approximately 20 – 30 minutes. The same applies to muscles in areas with a thicker subcutaneous fatty layer.
› Smaller joints such as the elbow joint or wrist and muscles in areas with a thinner layer of subcutaneous fat should be cooled for a somewhat shorter period of time (approximately 15 – 20 minutes).

Skin temperature

Distance between the nozzle and the skin

The critical temperature is 0°C. Frostbite certainly occurs at a skin temperature of -2°C. The range of temperature to be assumed for the transformation of water into ice in tissues is -4°C to 0°.

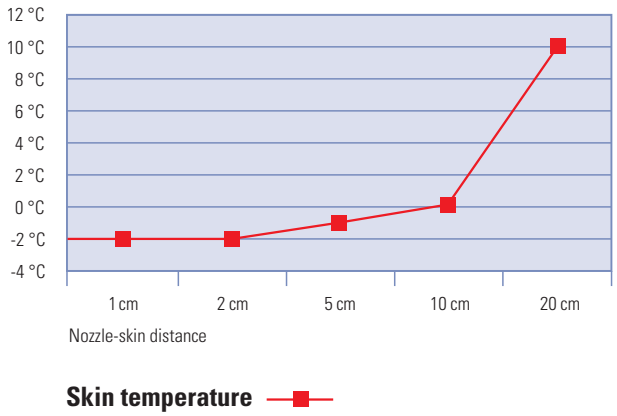
Based on the anticipated cooling of the skin and the area at minimum temperature, the following recommendations are made noting that the area cooled decreases the greater the nozzle to skin distance. Because larger areas should generally be cooled with moderate to greater distances between the nozzle and the skin, dynamic application of the nozzle over these treatment areas is recommended.

› Small nozzle-skin distances (up to 5 cm) are suitable for short-term cooling (1 cm up to 10 sec; 5 cm up to 30 sec.), e.g. for rapid, short-term skin anesthesia with static cooling or for intensive cooling of larger areas of skin and underlying tissue layers with dynamic nozzle movement
→ blockade of pain fibers

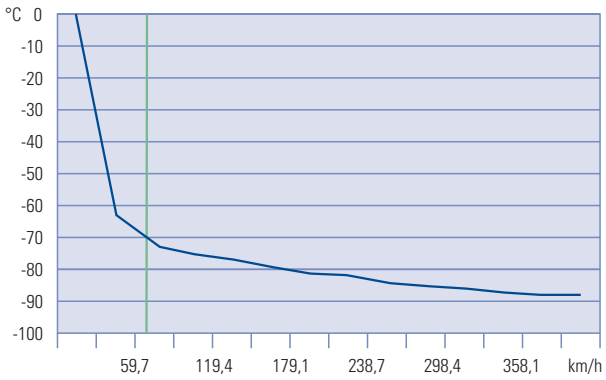
› Moderate distances between the nozzle and the skin (approximately 10 to 15 cm) are suitable for the dynamic cold air therapy of larger areas of skin and for the static treatment of small regions of skin even with longer treatment times (approximately 15 – 30 minutes).
→ **A nozzle-skin distance of 10 – 15 cm is ideal for treating joints and muscles.**
→ Blockade of pain fibers
→ Decrease in muscle tone and muscle spasticity by inhibiting the conduction velocity of the motor nerve fibers
→ Prevention of inflammation without reactive hyperemia.

› Large nozzle-skin distances (15 – 20 cm) are suitable for the dynamic cold air therapy of larger areas with prolonged treatment times (> 30 minutes).
→ Pain relief by inhibiting conduction velocit and increasing the stimulus threshold of pain fibers
→ Inflammation prophylaxis without reactive hyperemia.

Nozzle-skin distance	Temperature at mid air flow	Diameter of min temp.	Area of min temp.	Skin temp. 20-50 sec
0 cm				
1 cm	-25°C	14 mm	154 mm^2	-2°C
2 cm	-25°C	10 mm	79 mm^2	-2°C
5 cm	-21°C	8 mm	50 mm^2	-1°C
10 cm	-10°C	4 mm	13 mm^2	0°C
20 cm	3°C	2 mm	3 mm^2	10°C



„wind chill"



Effective biological temperature ——

The air current prevents the formation of a stationary layer of vapor between the skin and the cold air carrier, thus ensuring efficient cooling.

It should be noted that the biological effect of the cold air does not depend on the starting temperature alone but also on the speed of the air current, i.e. the wind chill effect. The biologically effective temperature is derived from the two factors – air temperature and air speed.

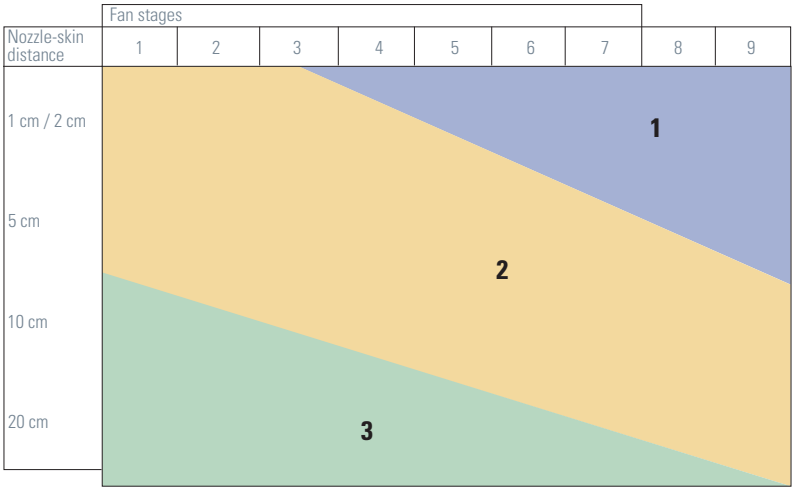
The wind chill effect is essentially relevant up to an air speed of approximately 90 km/h, i.e. in the region of fan stage 3.

Higher air speeds have only a minor additional wind chill effect because the moisture is removed 100% from the air by the air current, including the water vapor which forms as a result of the heat within the skin.

Totally dry conditions therefore exist as from fan stage 4. Skin damage is therefore ruled out if the skin is intact and provided that the method is implemented correctly.

The following diagram provides information on recommended treatment strategies depending on the nozzle-skin distance and fan stage. This is based on the biologically effective temperature of the air used for the treatment and the skin temperatures recorded at the same time.

Biologically effective indications taking the wind chill effect into account



1. Reactive hyperemia:
Suitable for the rapid superficial cooling of the skin (shock cooling for surface anesthesia)
Application time: up to 30 sec

2. Reduced reactive hyperemia:
Suitable for the intensive cooling of the skin (epidermis and dermis) and surface tissue
Application time: 3 min

3. No reactive hyperemia:
Suitable for cooling deep tissue (joints and muscle)
Application time: max. 30 min

Indications

1. Painful conditions of the musculoskeletal system, acute and chronic
› Arthritis
› Bursitis
› Tendinitis
› Tendosynovitis
› Myositis
› Fibrositis
› Muscle tenseness
› Cervical syndrome
› Post-whiplash disorders
› Lumbar syndrome
› Injuries (bruises, strains, sprains) of the muscles or joints

2. Pain reduction, improved mobility and reduction of joint stiffness in rheumatic conditions
› Rheumatoid arthritis (progressive chronic polyarthritis)
› Status post synovectomy

3. Neurological diseases, decrease in spasticity
› Multiple sclerosis
› Post-apoplectic hemiplegia

4. Support for movement therapy through the previous application of cold (15 – 20 min cold air)

5. Combination with compression in cases of acute injuries

6. Prevention of oedema and haematoma formation

7. Prophylactic early-stage treatment immediately following major exertion during sports before symptoms occur, such as after a competitive event

8. To treat muscular trigger points in combination with stretching

Cooling with cold air is recommended and successfully used in dermatological and cosmetic treatments for pain relief during and after therapy with:
› Laser therapy
› Injections
› Photodynamic therapy

Contraindications

1. Cryoglobulinaemia

2. Cold agglutinin disease and cold haemolysis

3. Cold urticaria

4. Parts of the body with impaired circulation

5. Raynaud's syndrome

6. Parts of the body with impaired sensitivity

7. Trophic disorders

8. Hypersensitivity to cold

Relative contraindications and precautionary measures

1. In children, parts of the body that are not being treated must be covered and kept warm.

2. When treating the face, the eyes must be covered.

3. Treatment should not be performed on the face or torso of patients with severe arterial hypertension and severe heart failure (NYHA III and IV).

4. The patient should not become excessively cold during cold air treatment.

Treatment guidelines

N.B. Contraindications

Patients with known contraindications to cold therapy must be excluded from treatment.

Treatment and dose recommendations can obviously only be given for individual cases with reservations.

The applications discussed are variable guidelines that must be adapted in line with the patient's clinical picture and individual reaction.

The reducing attachment with a diameter of 10 mm is recommended for targeted treatment of trigger points.

Sudeck's disease

Definition
The onset of painful soft tissue and bone dystrophy in the arms and legs due to a reflex-induced disorder of the sympathetic nervous system

Symptoms
I. Severe pain, swelling
II. Pain, trophic changes, stiffness
III. Atrophy of the skin, bones, soft tissue, stiffness

Treatment targets
To regulate blood flow
Pain relief
Mobilization

Positioning	Depending on the affected joint (mostly wrist, elbow, ankle), relaxed, pain-free
Treatment	Stage 1 Active movements several times a day in a cold air current
N.B.	No cold air if the patient cannot tolerate the cold and only at stage I

Post-stroke spasticity

Definition
Spastic muscle dysfunction following a cerebral insult

Symptoms
Spasticity with or without loss of sensitivity

Treatment targets
Pain relief (shoulder pain)
Muscle relaxation

Positioning	Relaxed, pain-free
Treatment	Sweep the painful and paralyzed area, applying simultaneous moderate mobilization. Treatment is also feasible if sensitivity is impaired.

Scars

Definition
Formation of replacement connective tissue following an injury

Symptoms
Inflammation in the early stages

Treatment targets
To inhibit inflammation

Positioning Relaxed, pain-free, depending on the site

Treatment Cool the tissue along the inflamed area at the junction of scar tissue with normal tissue

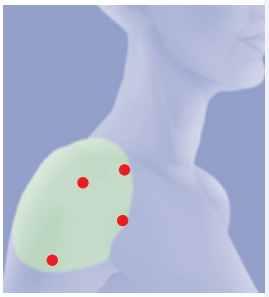
N.B. The scar must be closed and dry (after 3 weeks)

Subacromial impingement syndrome, humeroscapularis periarthritis

Definition
Tendinitis of the rotary cuff muscles and acromial subdeltoid bursitis, mostly caused by overloading the shoulder

Symptoms
Acute painful stiffness of the shoulder, very painful abduction (even passive) and elevation of the arm

Treatment targets
Pain relief
Inhibition of inflammation
Muscle relaxation



Positioning Relaxed, pain-free in the sitting position with arm support

Treatment Cool the shoulder with cautious mobilization; apply the cold air stream to sweep the shoulder

Muscle injury

Definition
Blunt trauma with bruising and/or rupture of muscle fibers

Symptoms
Persistent pain, especially on movement
Local swelling and hematoma

Treatment targets
Pain relief
Improved function

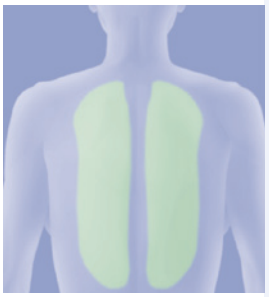
Positioning	Relaxed, pain-free
Treatment	Sweep the affected muscle over its entire length

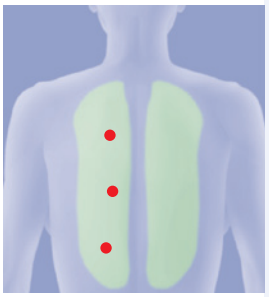
Thoracic spine pain

Definition
Painful impaired function with myosclerosis

Symptoms
Fulgurant, neuralgic pain; slow onset with herniated disks

Treatment targets
Pain relief
Muscle relaxation





Positioning	Relaxed, pain-free in the supine position
Treatment	Limited: cool the specific trigger points Extensive: sweep the entire painful area
N.B.	The patient should test the cold air application prior to treatment

Sprained ankle

Definition
Injury following overstretching to the lateral ligament of the upper ankle, possibly associated with fracture of the fibula

Symptoms
Swelling, pain on movement and touch, possible hematoma

Treatment targets
Pain relief
Prevention of swelling

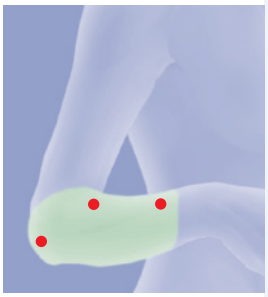
Positioning	Relaxed, pain-free, lying down with leg elevated
Treatment	Acute: Regional cooling of the injured area Chronic: Regional cooling of the affected area
N.B.	Cover areas not being treated

Epicondylitis

Definition
Acutely inflammatory irritation of the tendon insertions at the elbow, lateral or medial

Symptoms
Acute inflammation with local pain on movement and touch; pain radiating to the forearm and hand

Treatment targets
Pain relief
Inhibition of inflammation



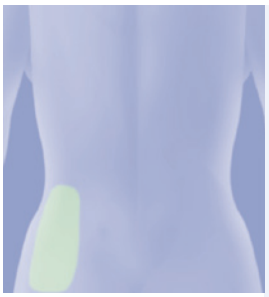
Positioning	Relaxed, pain-free in the sitting position
Treatment	Acute: Local cooling of the irritated area Chronic: Sweep the entire painful region
N.B.	Cover areas not being treated

Hematoma

Definition
Localized collection of internal blood due to various, mostly traumatic causes

Symptoms
Red/blue/violet discoloration of the skin
Pain on pressure
Swelling

Treatment targets
Acute: prophylaxis, containment
Chronic: resorption



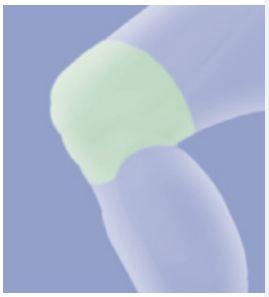
Positioning	Relaxed, pain-free
Treatment	Acute: Continuous, local cooling Chronic: Local cooling, possibly several times a day
N.B.	Cover areas not being treated

Status post cruciate ligament reconstruction

Definition
Status post surgical reconstruction of the anterior cruciate ligament

Symptoms
Irritation, swelling, minimal effusion, diffuse bruising (especially in the case of a gracilis-semitendinosus procedure), pain

Treatment targets
Pain relief
Prevention of inflammation and swelling



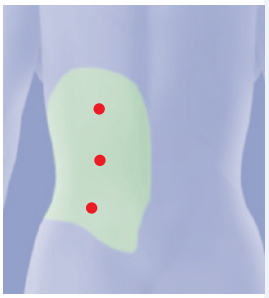
Positioning	Relaxed, pain-free in the sitting position, knee should be bent > 15°
Treatment	Acute and post-operative: continuous cooling, especially around the patella
N.B.	Cover areas not being treated

Low back pain

Definition
Muscle pain in the lower back region, sudden pain and inhibited movement in facet block

Symptoms
Kyphotic posture, severe, painful muscle tension, limited movement and pain on movement

Treatment targets
Pain relief
Muscle relaxation



Positioning Relaxed, pain-free, lateral supine position

Treatment
Acute:
Intensive short-term cooling
Chronic:
Sweep the lower back area with cold air current

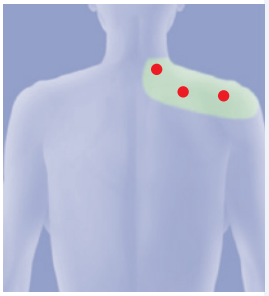
N.B. Cover areas not being treated

Neck-shoulder-arm syndrome

Definition
Pseudoradicular syndrome caused by muscle imbalance and cervical hyperlordosis

Symptoms
Pain irradiating to the arm, limited cervical movements and muscle tension

Treatment targets
Pain relief
Muscle relaxation



Positioning Relaxed, pain-free in the sitting position

Treatment
Acute:
Cooling of pain and trigger points over a small area
Chronic:
Sweep the painful region with cold air current

N.B. Cover areas not being treated, especially the face and eyes

Lymphedema

Definition
Accumulation of fluid in the interstitium due to impaired lymph flow

Symptoms
Swelling of an extremity

Treatment targets
Improved resorption due to an increase in tissue pressure

Positioning	Relaxed, pain-free in the supine position, treatment area raised
Treatment	Sweep the extremity with cold air current
N.B.	Skin damage or atrophic skin

Rheumatoid arthritis

Definition
Chronic inflammatory autoimmune disease of the joints

Symptoms
Destructive, chronic inflammation, mostly in the finger and toe joints with acute episodes of long duration

Treatment targets
Pain relief
Restoration of movement

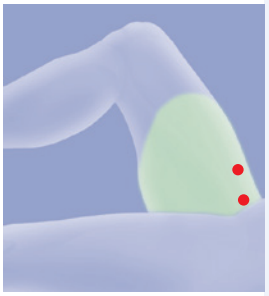
Positioning	Affected joints relaxed, pain-free
Treatment	Sweep joints with cold air current
N.B.	Only cautious passive exercising during cooling

Inguinal pain

Definition
Tendinitis of the adductor longus muscle at its origin on the pubic bone

Symptoms
Inguinal pain, increasing on stretching and moving
Pain at tendon insertion on pressure

Treatment targets
Pain relief
Restoration of movement



Positioning Relaxed, pain-free in the supine position, hip bent, slightly abducted and rotated outwards, placed on a cushion

Treatment Sweep the affected area (groin and inside of the thigh) with the cold air current

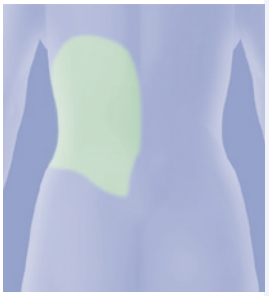
N.B. Only cautious passive exercising during cooling

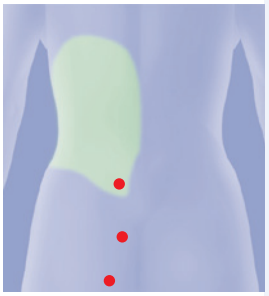
Sciatica

Definition
Nerve root compression with segmental sensory and motor episodes and pain patterns

Symptoms
Low back pain irradiating into one leg
In the case of radical symptoms, paresthesia and motor episodes in the segment

Treatment targets
Pain relief
Nerve root decompression





Positioning Relaxed, pain-free

Treatment Sweep the lower back region with cold air current

N.B. Cover areas not being treated

Multiple sclerosis

Definition
Inflammatory/demyelinating and degenerative disease of the central nervous system

Symptoms
Muscle stiffness as a pyramidal tract symptom in addition to a range of neurological disorders

Treatment targets
Pain relief (shoulder pain)
Prevention of muscle contraction

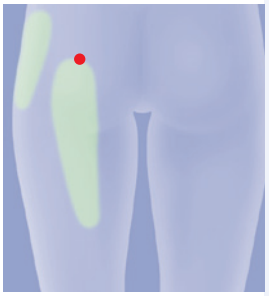
Positioning	Relaxed, pain-free
Treatment	Sweep spastic muscles with cold air current
N.B.	Sensory disorders

Piriformis syndrome

Definition
Tension in the piriformis muscle

Symptoms
Pseudoradicular pain symptoms, local pain elicited on stretching and pressure. Active trigger points with radiating pain

Treatment targets
Relaxation of the piriformis muscle



Positioning	Relaxed, pain-free, lateral positioning with flexion of hip and knee, leg supported by cushion
Treatment	Sweep the mid section of the gluteal region with the cold air current
N.B.	Cover areas not being treated

Achillodynia

Definition
Inflammatory irritation of the Achilles tendon due to microtrauma

Symptoms
Heel pain depending on loading, frequently radiating into the calf

Treatment targets
Pain relief
Relaxation of the gastrocnemius

Positioning	Relaxed, pain-free in the supine position
Treatment	Sweep the Achilles tendon, the tendon insertion and calf with cold air current
N.B.	Cover areas not being treated

Spasmodic torticollis

Definition
Dystonia caused by extrapyramidal disorder with central nervous damage

Symptoms
Incorrect head posture due to muscle spasm (rotated, tilting laterally, held forwards or backwards)

Treatment targets
Pain relief
Muscle relaxation

Positioning	Relaxed, pain-free in the supine position. Head on a cushion
Treatment	Sweep the neck muscles with the cold air current
N.B.	Cover areas that are not affected, especially the face and the eyes

Duration of treatment

The duration of treatment primarily depends on the extent of the area to be treated. Individual patient tolerance must be taken into account in this respect.

If no set programmes are used, the following guidelines apply:
Small joints (wrist, elbow, ankle):
up to 2 minutes
Large joints (shoulder, knee, hips):
up to 4 minutes

Support arm for the CryoOne treatment hose for manual treatment and mobilization

Continuous pain relief and the spasm-reducing effect of cold air combined with manual therapy and mobilization techniques offer treatment options that extend beyond traditional cold air applications.

› Chronic pain in arthrosis

› Post-operative mobilization following joint surgery

› Manual treatment and passive mobilization in chronic pain with muscle tension

› Spasticity with central paralysis as in the case of stroke patients

The advantage of long-term cold air therapy is the fact that it is effective at depth with only minor reactive hyperemia.

We therefore recommend fan stages 2 or 3 for at least 30 minutes with a nozzle-skin distance of 15 – 20 cm.

To treat muscle spasticity due to central damage such as a stroke, we recommend cooling the muscles with fan stage 2 or 3 for approximately 20 minutes before starting mobilization therapy. During the latter, the muscles can be further cooled but this should be avoided as the effect persists for at least 30 minutes.

A support arm is an important requirement for long-term cooling and/or cooling during manual therapy or mobilization, because it means that the therapist does not have to hold the hose for a long period during the (pre)cooling phase, thus leaving both hands free to treat the patient during the cooling process.

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Cold therapy

CryoOne

Therapy book

Enraf-Nonius B.V. | Vareseweg 127 | 3047 AT Rotterdam | The Netherlands
www.enraf-nonius.com | info@enraf-nonius.nl | +31 - (0) 10 20 30 600

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