Swiss International College of Osteopathy

Detection of Intraosseous Strains in the Adult Tibial Bone: Osteopathic Palpation and Thermography

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Thesis Protocol Presented to the International Jury

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Also my biggest thanks are to all the teachers of SICO who taught me the art of Osteopathy - as Philippe Druelle tends to say during courses “This is a big secret!”. Yes, it is a big secret, taught from Osteopath to Osteopath it is shared knowledge within our professional community.

THESIS ADVISOR

Julie Brown, BSc (Kin), DO (MP), Canada

HYPOTHESES

1. Intraosseous strains of the tibia can be detected with thermal imaging by observing an area of altered average skin temperature of the anterior tibial surface.
    1.1. The **mean average skin temperature (MAST)** of the intraosseous-affected side is lower than
        - **MAST** of the contralateral (healthy) side of the intraosseous group.
        - **MAST** (baseline temperature) of the control group.
    1.2. The **MAST difference** between the intraosseous-affected side and the **MAST difference** of the contralateral (healthy) side in the intraosseous group will be significantly higher than **MAST difference** between left and the right side within the control group.
    1.3. There is a *negative* correlation between rigidity of the tibia and its average skin temperature of the intraosseous-affected tibia in the intraosseous group.
    1.4. There is a *positive* correlation between the expression of Vitality of the tibia and its average skin temperature of the intraosseous-affected tibia in the intraosseous group.
    1.5. There is *no* correlation between the age of an intraosseous strain and the average skin temperature of the intraosseous-affected tibia in the intraosseous group.

In order to make it easier for the reader to understand the hypotheses stated above, a schematic figure of the taken thermal images and a table with formula-like descriptions of the hypotheses are added below:

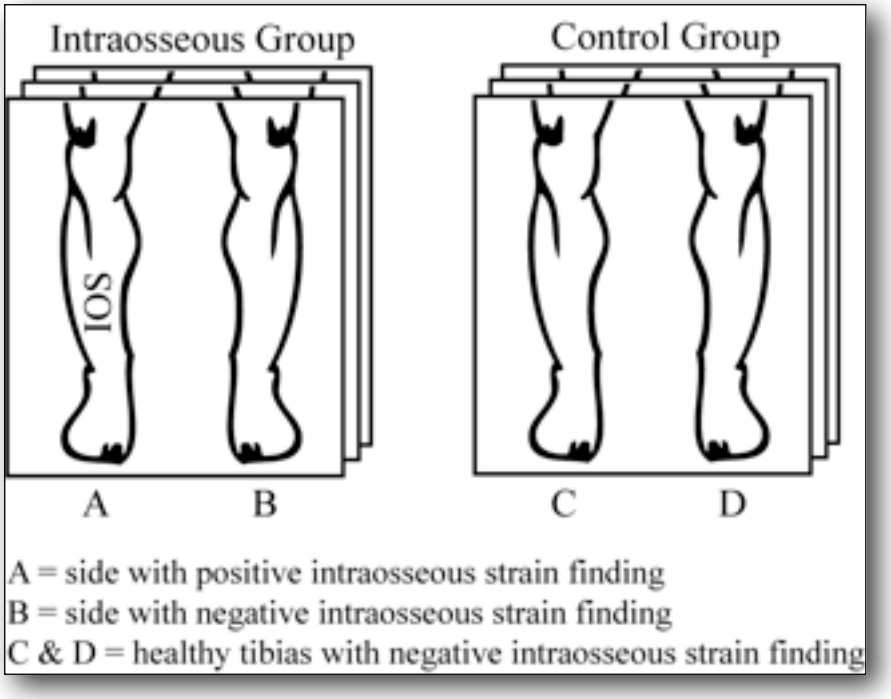

Figure. 1: Thermal images schematic

Hypothesis 1.1	**Hypothesis 1.2**
MAST (A) < MAST (B) MAST (A) < MAST (C & D)	MAST (B-A) > MAST (C-D)
Hypothesis 1.3	**Hypothesis 1.4**
Rigidity (A) correlates **negatively** with its average skin temperature	Vitality (A) correlates **positively** with its average skin temperature
Hypothesis 1.5	MAST = mean average skin temperature
Age (A) does **not** correlate with its average skin temperature	

Table: 1. FORMULA-LIKE DESCRIPTION OF THE HYPOTHESES

ABSTRACT

The concept of intraosseous strains is widely accepted within the osteopathic community worldwide. Osteopaths manually detect and treat intraosseous strains on a daily basis, but to the knowledge of the author, no quantitative research has been done to prove its actual existence.

This quantitative single-blinded non-experimental research wants to ascertain if it is possible to detect intraosseous strains in adults by comparing thermal patterns of the overlying skin of the anterior tibia. Furthermore, it wants to show statistically significant relations between osteopathic manual palpation sensations, age of the intraosseous strain and thermal information. This study uses a minimum of N=40 sample size which will give statistically significant data through cross-tables and other statistical calculations. Strict inclusion and exclusion parameters in both sample groups (intraosseous and control group) are defined to ensure valid image material.

First, all subjects will fill out a questionnaire which will supply information on the person itself, the symptoms at present time and the history of any traumatic incidents with possible dates. Second, a standardized thermal image of the anterior surface of the tibias will be taken in compliance with international standards in medical thermography. Third, the blinded examiner performs a strictly defined osteopathic palpation to locate and classify any intraosseous strains. Palpatory parameters such as rigidity of the bone within all three dimensions and expression of Vitality will be assessed and categorized. At last, the given data will be processed and analyzed statistically.

The purpose of this study is to assess thermography as a valid detection tool for intraosseous strains.

Keywords:

intraosseous, lesion, strain, tibia, vascularization, thermography, imaging, osteopathic, palpation, infrared, Vitality, CRI, PRM, thermal imaging

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1 CHAPTER ONE: INTRODUCTION

The primary aim of this thesis is to confirm a quantitative method - thermography - for detecting intraosseous strains of the tibia in adults. This knowledge will prepare the path for further research on the physiological nature of intraosseous strains and on the effectiveness of testing and treatment methodologies. Thermography is being tested here for the first time in association with intraosseous strains according to current research knowledge of the author. Little written information is found on testing, treatment, physiological nature and classification of intraosseous strains in adults (Brown, 2008; Chauffour & Prat, 2002; Heller, 2005, 2011a). Chaffour & Prat (2002) teach methods for testing and treating intraosseous strains in their courses. Heller (2011a), a certified Chiropractor and student of Chaffour & Prat, wrote some articles about their testing and treating methods. This gathered information will be used for a precisely defined testing protocol within this study.

A small pilot study performed by the author in 2010 showed that in the affected area of an intraosseous strain, average skin temperature of the anterior surface of the tibia is altered, usually decreased.

Some theses known to the author were written about the subject "intraosseous strains"[1], one qualitative by Brown (2008) and three quantitative by Thibault (2009), Arcand (2011) and Horton (2011).

Brown (2008) performed a qualitative research on the term „intraosseous lesion" which is being used in the Canadian College of Osteopathy and also in the Swiss International College of Osteopathy and stated the following definition:

[1] author's note: in SICO/CEO/CCO, they call it an "intraosseous lesion", Brown (2008) recommends naming it "intraosseous strain" due to high potential of misunderstanding in the medical world.

"An intraosseous lesion/strain is an osteopathic term that describes the altered state of osseous matrix in a part of a bone due to a sudden or chronic force, expressed by increased rigidity, altered force transmission, and reduced vitality."

Thibault (2009) wrote a thesis about treatment of intraosseous lesions *after* a fracture of the radius bone and its results measured with quantitative ultrasonography. This thesis covers the whole aspect of intraosseous lesions beyond the fracture threshold of bones, thus not of intraosseous strains. Furthermore, quantitative ultrasonography was not able to measure any significant difference between the group being treated osteopathically and the control group. Horton (2011) also wrote a thesis about treatment of consolidated traumatic fractures measured by quantitative ultrasound (QUS) before and after application of a specific regime of osteopathic intraosseous techniques. No significant change ($p= 0.165$) in bone quality was found between pre treatment, post treatment and follow up QUS scans for either group but other significant discoveries were made (Horton, 2011). Within those subjects with a pre treatment osteopathic intraosseous dysfunction, the data analyses revealed that a significant increase in Speed of Sound (SOS) occurred between pre and post treatment measures but not the follow up, in both the experimental and control group ($p= 0.050$). Horton suggested that in order for bone quality to improve from specific osteopathic intraosseous treatment, there must be a perceivable osteopathic intraosseous dysfunction present, pre treatment.

In a thesis written by Arcand (2011), the author researched the effect of osteopathic treatment of "non-fractured intraosseous lesions" in relation to unipodal postural stability and pain, so no conclusive information on the physiological nature of intraosseous strains.

In order to gain valid palpatory and thermal data, the author chose the tibial bone for this research is that the tibia is relatively easy to palpate, its anterior surface is covered with little soft tissue (skin, fascia and m.tibialis anterior) and the tibia is often affected in mechanical

traumata of the legs (Heller, 2005). All these mentioned advantages should maximize useful quantitative results within this study.

As a result to all mentioned statements above, this thesis will try to fulfill the following purpose:

„The purpose of this study is to confirm thermography as a valid detection measurement device for intraosseous strains and to show statistically significant links between osteopathic palpatory parameters, age of the intraosseous strain and measured temperature values.“

This thesis will be designed as a single-blinded quantitative non-experimental research.

2 CHAPTER TWO: RESEARCH JUSTIFICATION AND CURRENT STATE OF KNOWLEDGE

2.1 RESEARCH JUSTIFICATION

Osteopaths around the world find, test and treat intraosseous strains (Stone, 2002). Stone (2002) mentions that with a bit of practice, one can palpate the "elastic recoil properties" of bones. This increase of density[2] alters the whole dynamic of the bone, affecting its natural spring and resilience and ultimately contributes to articular stress and soft tissue pain (Stone, 2002). As far as the authors knowledge goes, all literature on intraosseous strains is based on empiric experience and not on quantitative research. It seems that no one has proven its existence before.

Within osteopathic training in the Swiss International College of Osteopathy, the author received methodologies in assessing and treating intraosseous strains. As mentioned above, no scientific data was given within this training to prove its existence.

This thesis will try to fill this gap.

2.2 CURRENT KNOWLEDGE ABOUT INTRAOSSEOUS STRAINS

As stated in the introduction chapter, an intraosseous strain is an osteopathic term that describes the altered state of osseous matrix in a part of a bone due to a sudden force or repeated mechanical stress, expressed by increased rigidity, altered force transmission, and reduced Vitality (Brown, 2008). Brown (2008) preferred to use the term "strain" instead of "lesion" because its use within the medical profession usually indicates cancerous processes. In medical literature, the term "lesion" is generally connected with structural damage of tissue.

[2] the author and Brown (2008) prefer the term *rigidity*. Rigidity rather describes a functional change within bone matrix and not a structural change as the term *density* would suggest interpreted by common language.

In order to clarify this issue, a search in PubMed (Database, 2011) for terms associated to intraosseous strains within the research titles was performed and following results were delivered:

Table: 1. SUMMARY OF PUBMED RESEARCH FOR SPECIFIC TERMS

Term	Result
Lesion(s)	89055
Strain(s)	47973
Intraosseous	2224
Bone fracture(s)	1007
Bone lesion(s)	898
Bone strain(s)	97
Bone bruise(s)	23
Intraosseous lesion(s)	4
Intraosseous strain(s)	none

The given results clearly show that the osteopathic term *intraosseous strain/lesion* in this specific combination is hardly not used in medical literature. First of all, the term *intraosseous strain(s)* did not return any results at all. The term *intraosseous lesion(s)* is mainly used to describe cystic changes (Sanerkin, Mott, & Roylance, 1983) and cancerous processes (Park, Nam, Park, & Kim, 2008; Sikes, Ghali, & Troulis, 2000) within bone tissue. The term *bone bruise(s)* mainly describes a fractured state of bone tissue (Newberg & Wetzner, 1994), *bone strain(s)* mainly describes bone strain measurements (mechanical loading) (Yang, Bruggemann, & Rittweger, 2011) and *bone lesion(s)* mainly describes cancerous processes within bone tissue (Brousse, Piette, Ackermann, Kahn, & Boisaubert, 2011; Nichols & Dixon, 2011).

The term *intraosseous* in medical literature is mainly used as a description of an access method into bone tissue (Heyder-Musolf, Giest, & Strauss, 2011; Schalk, et al., 2011) or in relation with cancerous processes (Budhdeo, Ibrahim, Hofer, & Gillies, 2011; Cil, Simsek, & Yildiz, 2011) within bone tissue. The term *strain(s)* gave various results, mainly describing biomolecular processes and microorganisms as viruses et cetera. The term *lesion(s)* brought up most results and is generally being used as a specification for any structural change within any tissue.

In order to clarify the term *intraosseous strain*, some quotes from Osteopaths are mentioned here:

> *"Interosseous compressions are compressions between two bones; an intraosseous compression is a compression within the bone structure itself." (Handoll, 2000)*

> *"...the bone loses its capacity to diffuse or spread out the impact of stress." (Chauffour & Prat, 2002)*

Philippe Druelle, DO qualitatively explains the intraosseous lesion as:

> *"...la lésion est comme un trou noir qui aspire la vitalité des articulations en périphérie" and "...une zone de densité anormale qui donne une impression de plein et de vide en même temps. À la fois dense et homogène, un peu comme une pierre ponce.", translated, "a zone of abnormal density which gives an impression of fullness and of a vacuum at the same time. At the same time dense and homogenous, a little like a sharpening stone" (as cited in Thibault, 2009)*

Intraosseous strains are usually not detected by common medical imaging, or better said "not looked for" since this phenomenon - as described in osteopathic literature - is not known in the medical profession. This might be also because osteopathic intraosseous strains seem to be under the bone fracture threshold (Chauffour & Prat, 2002; Heller, 2011a; Stone, 2002).

In case of journal articles, books and other sources, little information is found on intraosseous strains. In osteopathic pediatric literature (Carreiro, 2009; Frymann, 1998; Liem, Schleupen, Altmeyer, & Zweedijk, 2010; Sergueef, 2007), some authors write about intraosseous strains, but they mainly talk about this phenomena in immature bones of infants,

especially of cranial bones like the occiput, the sphenoid and the sacrum. They mention that in a newborn and in infants, some bones (their embryological segments) are not fused yet and that one can treat lesions / strains in between these segments and within these segments[3]. This study solely involves adult subjects whose tibial bones are matured.

J.H. Juhl (2005) mentions in a letter written in the Journal of the American Osteopathic Association that he often observes intraosseous strains in the os coxae of adult patients and talks about finding them and treating them with various methods, mainly with "peripheral application of the cranial concept". This method is not further elaborated on in the mentioned published letter.

Paul Chauffour & Eric Prat (2002) and Heller (2011a) are one of the few authors who talk about methodology for testing and treating intraosseous strains in the adult. This testing methodology will also be used in this study.

Paul Chauffour & Eric Prat (2002), authors of the book The Mechanical Link offer an explanation for the nature of intraosseous strains, which run along the trabecular lines of force within the bone tissue. These intraosseous lines of force form a functional unity as they travel without interruption throughout the entire body. They refer to these osteopathic lesions as 'lines of force fixities' and state that they are "classically ignored, [and] are one of the most important discoveries we have made in the last few years" (Chauffour & Prat, 2002). These fixations are concerned with both the transverse and longitudinal 'lines of force'. They build upon the osteopathic principle that micro-motions govern macro-motions in the articulation, by proposing that intraosseous lines of force govern micro- and thus macro-motions (Chauffour & Prat, 2002). In an intraosseous line of force fixation, "the bone loses

[3] As mentioned by Philippe Druelle (E. Muntinga, 2011a) in the teachings of Swiss International College of Osteopathy, there are so-called "intra-intra-osseous lesions" (within an embryological segment) and "inter-intra-osseous lesions" (in between two or more embryological segments)

its capacity to diffuse or spread out the impact of stress" (Chauffour & Prat, 2002). Treatment is achieved via a recoil technique in which the parameters of force are accumulated, and then rapidly released.

Treatment of intraosseous strains will not be elaborated on in this study. It would be a very interesting follow-up study to compare infrared images of intraosseous-strain-affected bones pre- and post-treatment!

2.3 THERMOGRAPHY IN RELATION TO THE STATED HYPOTHESES

Areas with altered skin temperature - either increased, decreased or with heterogenous distribution - can be effectively shown on thermal images. Baglin, Crocker, Timmins, Chandler & Boughton (1991) have shown that infrared thermography is a simple non-invasive method of assessing vascularity and even state that this technique may be used to study bone marrow blood flow in bone marrow disorders.

Current research in the medical field confirms that it is possible to detect abnormal physiological processes underneath and within the human skin with thermography. Main examples here are Myelofibrosis (Baglin, et al., 1991), bone cancer (Amalric, Giraud, & Spitalier, 1974; Ebata, 1982; Farr, Laurent, Litvin, & Van Hasselt, 1982; Farrell, Wallace, & Edelken, 1968; Gardani, Bergonzi, Viganotti, Nessi, & Guzzon, 1983; Gudushauri, Venkhvadze, Giorgadze, Sepiashvili, & Gagulashvili, 1985; Pozmogov, Knysh, Chuvikin, & Leman, 1976; Trifaud, Amalric, Poitout, & Liegey-Bagarry, 1981; Wallace, 1974; Zweymuller & Strassl, 1973) and breast cancer (Amalric & Spitalier, 1975; Arora, et al., 2008; Chudacek, 1977; Farrell, Wallace, & Mansfield, 1971; Keyserlink, Ahlgren, Yu, & Belliveau, 1997).

Medical research has also shown that is is possible to show states of blood flow within the human body with thermal imaging (Chudacek, 1977). The author suggests the possibility that

one can detect intraosseous strains *indirectly* with thermal imaging by finding altered average skin temperature on the affected site.

Plaugher et al. (1992) confirm that one can accurately measure skin temperature with thermal imaging, depending on the accuracy of the imaging device. The International Academy of Clinical Thermography (Thermology, 2003) gives exact specifications for devices which should be used for medical thermal imaging. Diadikes and Bronzino (2008), Ring and Ammer (Ring & Ammer, 2000) and Ring et al. (2004) give exact information on how to gain valid thermographical image material by standardization of image taking procedures for medical usage.

Research done on mice (Laing, et al., 2007) shows that a musculoskeletal trauma directly initiates a provascular response in the bone marrow, indicating that mechanical trauma of a bone and vasomotion[4] are directly linked with each other. The reason why this thesis wants to evaluate this measurement method is that manual thermal palpation is not as precise and objective as thermography. Although Barral (1996) states that manual palpation can give pretty exact information on the location of a change in temperature of the skin, he also states that manual palpation is not precise in determining of *how much* the temperature difference is and even if it is actually colder or warmer at the given location! Murff, Armstrong, Lanctot, Lavery & Athanasiou (1998) even say that manual palpation is not effective in detecting subtle temperature differences.

2.4 NORMAL SKIN TEMPERATURE OF THE LOWER EXTREMITY

To be able to compare the found average skin temperatures to average skin temperature of the healthy population, we have to know what the normal average temperature of the lower

[4] Vasomotion: “Change in the diameter of a blood vessel. Also known as angiokinesis.” Source: http://www.answers.com/topic/vasomotion#ixzz1RvLjEbdn. In the osteopathic world, vasomotion is defined as “capacity of the body to bring blood in each part of the body” (Druelle, 2011)

leg of a healthy adult is (baseline temperature). The author performed a literature survey (Lee, Lee, Kim, & Kwon, 1997; Lukowitz, et al., 2007; Muntinga, 2010c; Uchida, 2001) on this and came to the conclusion that this thesis should use the thermal results of the performed Pilot Study by Edward Muntinga (2010c) and the MAST[5] of both sides of the control group because the other authors did not exactly measure the skin temperature of the anterior tibia. As shown in the table below, a significant difference of 2,54 ˚C was found between the thermal average given by Muntinga (2010c) and the thermal data of Lukowitz et al. (2007), Uchida (2001) and Lee, Lee, Kim, & Kwon (1997). According to the authors opinion, this major difference in temperature is not acceptable.

Within this research, the baseline temperature will be defined by the mean average skin temperature of both anterior tibia's of all subjects within the control group.

Table: 2. AVERAGE TEMPERATURE OF THE LOWER LEG OF HEALTHY ADULTS - LITERATURE SURVEY

Authors	Mentioned average skin temperature
Lukowitz et al. (2007)	32,25 ˚C (skin temperature 15 centimeters above knee joint)
Uchida (2001)	33,92 ˚C (overall skin temperature of lower extremities)
Lee et al. (1997)	33,40 ˚C (overall skin temperature of lower extremities)
Muntinga (2010c)	30,65 ˚C (overall skin temperature of the anterior surface of the tibia)

2.5 THERMOREGULATION OF THE SKIN

Because in this thesis we measure average skin temperature by thermography, one needs to know more about thermoregulation of the skin.

[5] MAST = Mean Average Skin Temperature

Thermoregulation is a neural process that matches information about the external environment with the appropriate response to maintain a more or less stable internal environment relative to external variation (Nakamura & Morrison, 2008). The several stages can be divided into (Seebacher, 2009):

- Sensation of environmental conditions and the internal thermal state.
- Transmission of this information to the brain through afferent neural pathways.
- Initiation of a response by efferent signals from the brain.

In humans, body temperature is regulated at the hypothalamus region of the brain (Gisolfi, D.R., & Nadel, 1993) which regulates body temperature to function within +/- 1 ˚C of resting temperature over each 24 hour cycle (Folk, Riedesel, & Thrift, 1998).

According to Lim, Byrne & Lee (2008), the human body temperature comprises the temperatures of the core and shell. Core temperature refers to the temperatures of the abdominal, thoracic and cranial cavities, whereas shell temperature refers to the temperatures of the skin, subcutaneous tissue and muscles (Gisolfi & Mora, 2000). As stated above, core temperature is regulated by the brain (hypothalamus region).

For this thesis, shell temperature control is more interesting because this is being captured by the thermal camera. Shell temperature is influenced by skin blood flow and environmental conditions (Gisolfi & Mora, 2000).

Although humans are regarded as homeotherms[6] the dichotomy of body temperature into core and shell temperature is unique in that the core temperature is endothermic (regulated by the brain) whereas shell temperature is ectothermic (influenced by external environment) (Lim, et al., 2008). According to Lim et al., shell temperature is “slave” to core temperature,

[6] An organism that maintains its body temperature at a constant level, usually above that of the environment, by its metabolic activity (TheFreeDictionary.com, 2001)

both endo- and ectothermic properties function in synchrony to maintain thermal balance within the body (Lim, et al., 2008).

For this research, details about shell temperature mechanism is important to elaborate on, since we look at the skin temperature captured by thermal imaging.

Heat transfer between the body and the external environment occurs through the following processes (Folk, et al., 1998):

- Convection
- Conduction
- Radiation
- Evaporation

Heat transfer through convection, conduction and radiation is bidirectional, where heat transfer between the skin surface and the environment is driven by the temperature gradient between skin and its surrounding environment (Lim, et al., 2008). Heat is transferred from the skin to the environment if the ambient temperature is lower than shell temperature and vice-versa.

As opposed to the above, heat transfer through evaporation is unidirectional, where heat is dissipated only from the skin surface to the external environment (Lim, et al., 2008). Evaporative heat loss takes place when sweat changes from liquid to gaseous state. This is the main reason why within this study the subjects are being asked to not perform any sports activities on the day of the examination!

2.6 MANUAL PALPATION OF SPRING AND VITALITY OF THE TIBIAL BONE

In order to assess an intraosseous strain, one should test mechanical spring and Vitality of a bone because an intraosseous strain contains decreased Vitality and spring (Laflamme, 2006). Brown (2008) confirms this by saying that an intraosseous lesion is

"... expressed by increased rigidity, altered force transmission, and reduced vitality."

2.6.1 MECHANICAL SPRING OF A BONE

As perceived by the author, a healthy bone feels like a green wooden branch of a tree: Alive, flexible, humid. A bone area which has an intraosseous strain rather feels like a white tree branch picked up from the ground: Dead, rigid, dry (Edward Muntinga, 2011). Heller (2011b) mentions: "Testing for intraosseous restriction is not really about motion, but rather about "give" or "stiffness"". Also Chauffour & Prat (2002) mention the importance of testing a bone through compressing along its longitudinal axis and along the so-called *Lines of Force* which are defined as specific areas within a bone which are more likely to have mechanical loading and thus are more prone to form intraosseous strains in mechanical trauma. Meert (2007) only mentions "intraosseous pumping" techniques, but no tests.

2.6.2 VITALITY

Vitality is the expression of life force in a body, and has many manifestations that can be observed and perceived by the experienced osteopath. Vitality as the expression of life force is at the interface of the union between the tangible, the physical body, and the intangible, the life force. It is the force that maintains health, achieves homeostasis, and accomplishes the work in osteopathic treatment. (Mummery, 2008, p.215)

Usually, if the term *Vitality* is mentioned in osteopathic literature (J. Licciardone, Brittain, & Coleridge, 2002; J. C. Licciardone, et al., 2004; "Osteopathic Manipulative Therapy Helps Patients With Migraines," 2011; Rolf, 1989; Yahnert, Hartmann, Steward, & Kuchera, 2006), the author talks about *global Vitality* of the patient which is being improved or not by osteopathic interventions.

In the teachings of Swiss International College of Osteopathy (Beaulieu, Forget, Laflamme, & Lanthier, 2007; Beaulieu & Muzzi, 2004; Colford, Forget, Laett, Lanthier, & Van Vliet, 2005; Colford & Gauthier, 2004; Evans, 2005, 2006; Forget, Laett, Lanthier, &

Van Vliet, 2006; Muntinga, 2008, 2009, 2010a, 2010b, 2010c, 2010d; E. Muntinga, 2011a, 2011b, 2011c; Muzzi, 2007; Pelletier, Beaulieu, & Van Vliet, 2006; Pelletier & Colford, 2006) and mainly by its director Philippe Druelle, the term *Vitality* is mentioned in a local, regional and global setting. This means that due to an intraosseous strain, an affected bone might express lowered Vitality within the bone but does not necessarily affect the global Vitality of the patient.

Dianne Mummery, a DO from Ontario Canada, graduated from Canadian College of Osteopathy, presented a qualitative thesis with the title "An Analysis and Synthesis of the Concepts of Vitality as they relate to Osteopathy" in the year 2008. Mummery (2008) defined Vitality as follows:

"Vitality can be defined as the expression of life force in a body, and has many manifestations that can be observed and perceived by the experienced osteopath. Vitality as the expression of life force is at the interface of the union between the tangible, the physical body, and the intangible, the life force. It is the force that maintains health, achieves homeostasis, and accomplishes the work in osteopathic treatment." (Mummery, 2008)

"As an interface, Vitality is neither tangible nor intangible but something in between, with the qualities of both also of its own." (Mummery, 2008)

"...it is not static, but is an interface of resonance, which implies an exchange and interaction." (Mummery, 2008)

"The nature of Vitality is something that is perceived through the lens of the individual Osteopath." (Mummery, 2008)

"The view of Vitality is seen through a lens of experience and skill, paradigms, beliefs about the world, and expectations among other things." (Mummery, 2008)

"Vitality is never ill. The perception of the expression of Vitality through the body can be distorted by barriers, blockages or restrictions. In Osteopathy, the removal of restrictions and blockages allows for the free expression of Vitality." (Mummery, 2008)

"The expression of Vitality implies motion. However, the motion that occurs is the result of the effect of Vitality on matter, ..." (Mummery, 2008)

"In the perception of Vitality, the energy of intention of the Osteopath could change the expression of the Vitality just through the act of observation." (Mummery, 2008)

"The perception of Vitality cannot be taught; it must be experienced. The experience of Vitality is a knowing or resonance." *(Mummery, 2008)*

"Vitality is part of the whole expression of the universe with no divisions or boundaries." *(Mummery, 2008)*

According to Druelle (2011), the expression (expansion and retraction of the tissue) of Vitality happens approximately 50% slower than palpated Cranial Rhythmic Impulse[7] (CRI), thus approximately 5-7 cycles per minute. This would correspond to the findings of K.E. Nelson et al. (2006). Much osteopathic research has been done on the *Cranial Rhythmic Impulse* or also called *Primary Respiratory Mechanism*.

Nelson, Sergueef, Lipinski, Chapman & Glonek (2001) compared manual palpation of the CRI and simultaneous measurement of the Traube-Hering-Mayer (THM) oscillation by Laser-Doppler Flowmetry and came to the result that both CRI and THM happen simultaneously, though they may not represent the same phenomenon. Kenneth, Sergueef & Glonek (2006) compared quantified rates for the CRI reported in the literature from 1961-2006. They found that in most publications where manual palpation was used to obtain data, the reported rate of CRI was 3-9 cycles per minute (cpm). In publications where data was obtained by any kind of instrumentation, the rate of CRI was measured 7-14 cpm.

Within a study examining CRI (Nelson, et al., 2006), the conclusion was that CRI palpated manually was 1/2 of the rate of the instrumentally tested THM oscillation, thus indicating that CRI and THM might not be the same phenomenon and more research should be done in this area.

Druelle (2011) teaches that Vitality is being sensed as an expression of expansion and retraction within the tissue. The American Dictionary of the English Language (Dictionaries, 2000) defines the term *Vitality* as such:

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[7] CRI = Cranial Rhythmic Impulse, also called *Primary Inspiratory Mechanism* or *Cranial Motion* (Druelle, 2011; Laflamme, 2006; Nelson, et al., 2006)

- The capacity to live, grow, or develop.
- Physical or intellectual vigor; energy.
- The characteristic, principle, or force that distinguishes living things from nonliving things.
- Power to survive.

The term *Vitality* is derived from the word *vigor* (middle english), which is again derived from the latin word *vigere*, which can be translated as "to be lively" (Dictionaries, 2000). So this concludes that with Vitality, we try to palpate *direct expression of life*. As Rollin E. Becker (1997) quotes:

"Motion is not life. Motion is a manifestation of life."

Furthermore, Andrew T. Still (1899) gives us following important message:

"Every joint of the neck and spine has much to do with a healthy heart and lung, because all vital fluids from crown to sacrum do or have passed through heart and lungs, and any slip of bone, strain or bruise will affect to some degree the usefulness of that fluid in its vitality, when appropriated in the place or organ it should sustain in a good healthy state. To the osteopath, his first and last duty is to look well to a healthy blood and nerve supply."

These two very important sentences reinforce the importance of the expression of local, regional and global Vitality in general and also the importance of the fluids, with which the author wants to indicate in this thesis that it might have an influence on the nature of intraosseous strains.

2.7 FLUID FLOW WITHIN BONE TISSUE

It makes sense to accept the possibility that fluid flow within the bone tissue might affect temperature within itself and the tissue around it. Any increased physiological activity also affects positively tissue temperature (Diadikes & Bronzino, 2008), shown mainly by cancerous processes within bone and other tissue (Farrell, Mansfield, & Wallace, 1971; Farrell, et al., 1968; Farrell, Wallace, et al., 1971) which - next to increased blood flow - also

increases general physiological activity. Julie Brown DO (2011) - the author of a qualitative thesis about intraosseous strains and compactions - believes that intraosseous strains affect fluid flow within the bone tissue. A short literature research on bone tissue fluid flow thus is given:

Hillsley and Frangos (Hillsley & Frangos, 1994) and Fleming et al. (Fleming, et al., 2001) state that optimal interstitial fluid flow directly affects bone cell function and bone remodeling. The composition of bone fluid within the bone fluidic compartment seems to be regulated by a blood-bone barrier, formed mainly by (pre)osteoblastic cells (McCarthy & Hughes, 1987). Within quiescent[8] bone tissue, numerous intercellular small channels (2 nanometers diameter) have been observed (Doty, 1981) which are actually even larger in diameter than in active remodeling bone (Holtrop, 1990). Hillsley and Frangos (1994) state that this bone-blood barrier may regulate the rate of calcium absorption which affects the intercellular channels, and thereby regulate the flow rate within the bone matrix. This increased flow may even influence other bone cells deeper within the matrix.

Hillsley and Frangos (1994) say that a significant and rapid interstitial fluid flow occur through the interstitial spaces of bone. The interstitial fluid is driven from the endosteal[9] toward the periosteal[10] surfaces in cortical bone. The flow appears mainly to be driven by a hydrostatic pressure drop across the cortex, resulting in an outward radial flow (Hillsley & Frangos, 1994). Because lymphatics are absent from the bone marrow (Tavassoli & Yoffey, 1983), this pressure drop towards the exterior surface of the bone is crucial so that all fluids

[8] quiescent = state of absent active remodeling

[9] endosteum = thin layer of connective tissue that lines the surface of the bony tissue that forms the medullary cavity of long bones (Netter, 1987)

[10] periosteum = a membrane that lines the outer surface of all bones, except at the joints of long bones as the tibia (Netter, 1987)

can be drained towards the periosteal surface where the lymphatic system is present (Anderson, 1960).

Kelly & Bronk (Kelly & Bronk, 1990) showed that increased venous and intraosseous pressure resulted in an increase in extracellular fluid and fluid space, thus suggesting that this causes an increase in interstitial fluid flow.

2.8. MECHANOTRANSDUCTION WITHIN BONE TISSUE

Mechanotransduction is a molecular mechanism by which cells sense mechanical forces and convert them into changes in intracellular and gene expression (Ingber, 2008). The concept of mechanotransduction might explain the physiological process which happens during the creation of an intraosseous strain. According to Jerosch, Bader & Uhr (2002), this process helps the bone to adapt to new mechanical demands which is happening through several steps shown here:

1. During mechanical coupling, mechanical forces are being converted into local signals which can be transferred towards bone cells. This process activates certain biochemical reactions within osteocytes and bone lining cells. Accountable for this step are stress-induced lacuno-canalicular fluid flows, respectively shearing forces within fluids of the lacuno-canalicular network in the bone.
2. Following step one, the biomechanical coupling - transduction of a mechanical signal into a biomechanical reaction - takes place. This process is being contributed by some metabolic pathways within the cell membrane and the cytoskeleton.

3. Now, sensor cells (most probably osteocytes and bone lining cells) pass on these signals to effector cells (osteoblasts and osteoclasts) through signal molecules (probably prostaglandines and nitrogen peroxide).
4. In the end, we have the actual reaction of the effector cells; bone formation or bone decomposition.

2.9 ANATOMY AND PHYSIOLOGY OF THE TIBIA

It is very important to state that not only gross anatomy of the bone tissue (like morphology, innervation, vascularization, histology and cytology) is important, but specifically the physiology and micro-anatomy of what happens *inside* the bone!

2.9.1 GENERAL ANATOMY OF BONE TISSUE

Much information for this subchapter was taken from Jerosch, Bader & Uhr (2002), a book specifically written about osseous physiology.

Bones are mainly made of extracellular/organic bone matrix[11] and bone cells (osteocytes, osteoblasts and osteoclasts).

2.9.1.1 EXTRACELLULAR MATRIX

Organic bone matrix is 90% to 95% made of Type-I collagen, which is synthesized by osteoblasts and chondrocytes[12] and has following functional characters (van der Rest & Garrone, 1991):

- Mechanical stability
- Compressive strength
- Tensile strength

[11] Note of author: organic bone matrix is also called “osteoid” (Jerosch, et al., 2002)

[12] chondrocytes are only found in cartilage (Jerosch, et al., 2002)

Further proteins in the bone matrix are osteocalcin, osteonektin, bone proteoglycans, proteolipids, sialoprotein and bone morphogenetic protein (Jerosch, et al., 2002).

2.9.1.2 OSTEOCYTES, OSTEOBLASTS AND OSTEOCLASTS

Osteocytes develop from osteoblasts, have a size of 20-60 micrometers and are found in small lacunae amidst mineralized bone substance. They are interconnected with other osteocytes through cellular extensions and create a osteocyte-syncytium[13]. Osteocytes mainly participate in intercellular communication, mineral-matter homeostasis and mechanotransduction (see chapter 2.3.) (Jerosch, et al., 2002).

Osteoblasts create non-mineralized intercellular substance called osteoid within bone tissue. These bone generating cells originate from mesenchymal stem cells. They are about 20 micrometers in diameter and have a single cell nucleus. Osteoblasts line up on the surface of bone lining cells like a string of beads and produce organic bone matrix (see chapter 2.2.1.1.). They also secrete great amounts of alkaline phosphatase which prepares the organic bone matrix for mineralization. Among others, osteoblastic activity is being regulated by bone morphogenetic protein, parathormone, estrogens and steroid hormones. After osteoblasts have fulfilled their function, they either become osteocytes (immured in organic bone matrix) or cover cells on the osseous surface. This conversion process only affects about 30%-50% of all osteoblasts, 50%-70% die through apoptosis[14] (Jerosch, et al., 2002).

Osteoclasts - cells which break down bone tissue - have a size of about 100 micrometers and contain up to 100 cell nuclei. Usually they appear on the surface of bone tissue. Osteoclasts break down bone tissue by secreting strong acids and “dig” tunnels which are

---

[13] syncytium - a mass of cytoplasm containing several nuclei and enclosed in a membrane but no internal cell boundaries (Farlex, 2001)

[14] apoptosis - a natural process of self-destruction in certain cells that is determined by the genes and can be initiated by a stimulus or by removal of a repressor agent. Also called *programmed cell death* (Farlex, 2001)

called Howship-Lacunae. Secretion of special proteases again allow the breaking down of the organic bone matrix (Jerosch, et al., 2002).

2.9.2 TYPES OF BONE AND THEIR SPECIFIC ARCHITECTURE

Within the human bone system there are two types of bone: Woven and lamellar bone.

2.9.2.1 WOVEN BONE

When new bone tissue is being formed in the development of the fetus or after a fracture within the callus, collagenous fibers are being assembled in a seemingly random configuration. Through mineralization of this bone matrix, a mesh of trabeculae is being formed - the woven bone. At time of birth this type of bone predominates (Schünke, et al., 2005).

2.9.2.2 CONVERSION OF WOVEN BONE INTO LAMELLAR BONE

Medullary cavities within the woven bone tissue are relatively large and contain 1-2 capillary vessels, perivascular cells and one nerve fiber. These trabeculae together with medullary cavities are being called *primary osteon*. Within the cortical region, osteoblasts deposit bone substance by creating concentric layers in a lamellar-like form until almost all medullary cavities are filled (Schünke, et al., 2005).

After this process, small canals (Havers-Canals) with a diameter of about 50 micrometer, a small artery, a small venule and one nerve fiber remain. All Havers-Canals are connected with each other by Volkmann-Canals (Schünke, et al., 2005). Now this system is called the *secondary osteon*, respectively the Havers-System. The Havers system consists of 4-20 concentric cylindrical lamellae with a thickness of 3-6 micrometers. Through creation of countless secondary osteons, lamellar bone is being formed. During this transformation

process the medullary cavities are being preserved. Red hematogenous bone marrows are generated from their mesenchymal cells (Schünke, et al., 2005).

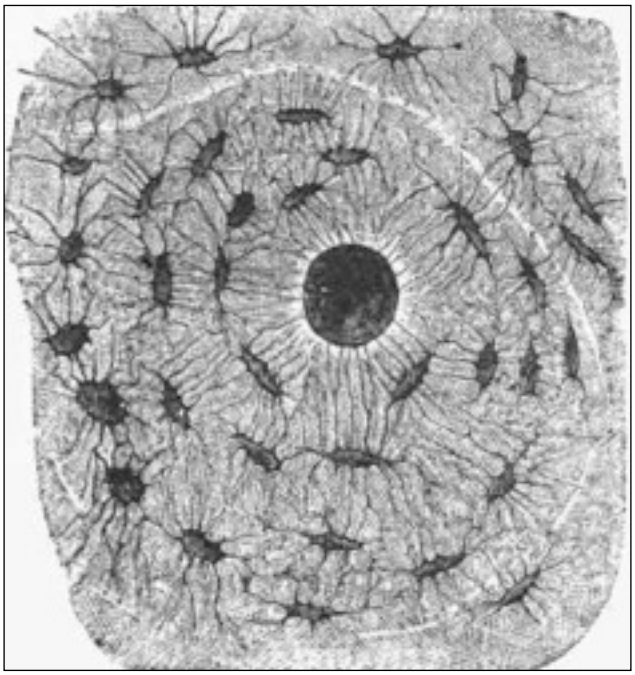


Figure: 2. Transverse section of a system of Havers, showing Haversian canal in centre, with bone cells arranged around it in lacuna (Schünke, et al., 2005).

2.9.2.3 LAMELLAR BONE

Lamellar bone is made of cortical (or: compact) and cancellous (or: spongiosa) bone. Cortical bone is located at the outer area of a bone, cancellous bone is found within.

Cortical bone covers cancellous bone like a shell and is made of lamellar bone tissue which is being formed by the combined effect of endosteal and periosteal bone conversion (Schünke, et al., 2005). Within each lamella of the secondary osteon, the orientation of collagenous fibers and calcium-phosphate crystals changes. This way a complex and plywood-like structure with excellent biomechanical properties is being created (Weiner, Traub, & Wagner, 1999). This structure is predominant within cortical bone and makes 80% of total bone mass of the human skeleton (Schünke, et al., 2005).

Cancellous bone is also made of lamellar bone, it makes 20% of total bone mass of the human skeleton (Schünke, et al., 2005). This complex sponge-like construct is made of with each other connected and intersected, straight and curved trabeculae. Cancellous bone is especially found in the endings of long bones, in the skullcap and in cube-like bones (e.g. vertebrae). Cancellous bone is metabolically more active and reacts faster on mechanical and metabolical stimulations (Schünke, et al., 2005).

Noteworthy is that there is no clear evidence on the close connection between elastic properties of the cancellous bone and the linkage density of its trabecular structure (Kabel, Odgaard, van Rietbergen, & Huiskes, 1999; Kinney & Ladd, 1998). Also bone mineral density (BMD) alone does not reflect its strength, rigidity and elastic property. But according to Kabel et al. (1999), trabecular bone volume showed highest positive correlation with bone strength and rigidity.

2.9.3 GROSS ANATOMY AND PHYSIOLOGY OF THE TIBIA

According to Gray's Anatomy Atlas (Drake, Vogl, Mitchell, Tibbits, & Richardson, 2008), the tibia - or also called shinbone - is commonly recognized as the strongest weight bearing bone in the body. It is the second largest bone in the human body, the largest being the femur. Proximally, it articulates with the femur, the patella and the proximal fibula via art.tibiofibularis (Schünke, et al., 2005). Distally, the tibia articulates with the talus and the distal fibula via syndesmosis tibiofibularis (Schünke, et al., 2005). Between the tibia and the fibula, we find the membrana interossea cruris. This interosseous membrane is made of a tight connective tissue lamina which acts as an anchor for various muscles and stabilizes the malleolar fork (Drake, et al., 2008).

2.9.3.1 ARTERIAL SUPPLY

Main incoming arteries into the periosteum of the tibia are (Menck, et al., 1992):

- Aa.recurrentes tibiales anterior et posterior
- Aa.inferiores medialis et lateralis genus
- Aa.tibialis anterior et posterior
- Semicircular vessels of the a.tibialis anterior
- A.fibularis

These arteries all arise from the following branches (Schünke, et al., 2005), listed from proximal to distal: A.femoralis - a.poplitea - a.tibialis anterior, a.tibialis posterior and a.fibularis.

According to Menck et al. (1992), the tibia can be divided into four segments:

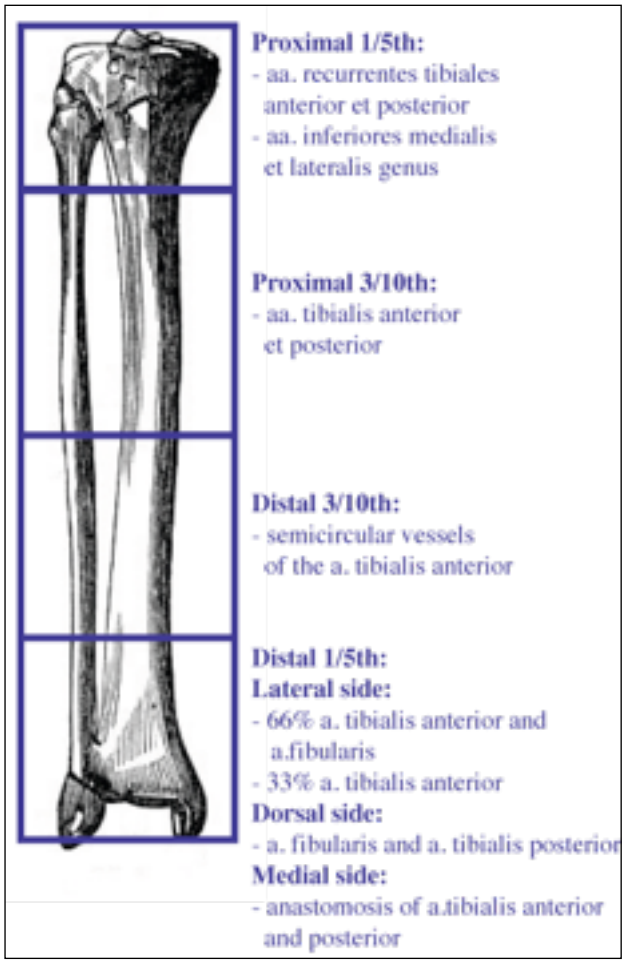


Figure 3. Angioarchitecture of the tibia, adapted from Menck et al. (1992)

From the figure above, it seems that the a.tibialis anterior is of great importance concerning the arterial supply of the periosteum and the outer aspect of the cortex of the tibia (Menck, et al., 1992).

2.9.3.2 VENOUS DRAINAGE

Following veins drain the blood from the tibia (Schünke, et al., 2005):

- Posterior: Vv.tibiales posteriores
- Anterior: Vv.tibiales anteriores, v.saphena magna, vv.geniculares

These veins drain into the following proximal veins, from distal to proximal (Schünke, et al., 2005): Vv.geniculares, vv.tibiales anteriores et posteriores - v.poplitea - v.iliaca externa. The v.saphena magna drains directly into the v.iliaca externa.

2.9.3.3 LYMPHATIC DRAINAGE

Lymphatics are absent from the bone marrow (Tavassoli & Yoffey, 1983), thus lympthatic drainage only starts at the cortical bone.

Superficial and deep lymph vessels drain into v.poplitea and v.saphena parva. Along the v.saphena parva we find lymphatic nodes, the so-called nll.popliteales superficiales. V.poplitea and v.saphena parva drain into the v.femoralis where we find the nll.popliteales profundi. These lymphatic nodes are the main collecting nodes for the tibial region. V.femoralis the drains into v.iliaca externa, then v.cava inferior (Schünke, et al., 2005).

2.10 CONCLUSION

It is strongly indicated that thermal imaging is useful in detecting physiological processes (as breast cancer and osteosarcoma) underneath the human skin. The main blood vessel which nourishes the tibial bone is the a.tibialis anterior which also nourishes most parts of the

skin of the anterior face of the lower leg. Qualitative research has been done to define how an intraosseous strain shows itself - with decreased spring and Vitality.

These facts increase the authors curiousness and leads to the main purposes of this thesis: Can thermography detect any significant changes in skin temperatures with intraosseous strains and are there any relations between osteopathic manual palpation and thermal mapping of the anterior tibia?

3 CHAPTER THREE: METHODOLOGY

3.1 RESEARCH STRATEGY

3.1.1 SAMPLE SIZE

It is planned to achieve a sample size of 40 subjects (N=40). This means this thesis will present a minimum of 20 subjects in the intraosseous group and 20 subjects in the control group.

From a methodological standpoint, we can assume that a sample size as large as 30 has a normal distribution of sample mean score (Huettenmoser Oliva, 2011).

3.1.2 SAMPLE SEARCH

The following methods will be used to search for adequate subjects:

- A search within the authors clinic. In *therapiepraxis muntinga*, many patients seeks help after accidents of any kind, especially due to the reason that the author has specialized in traumatology (Whiplash et cetera). Patients are informed through a leaflet or directly via the author or his assistants.
- A search through two friends which are senior football and ice-hockey club members
- A search through the internet through following platforms:
  - www.muntinga.ch, the website of the authors clinic.
  - www.facebook.com, a well-known and social platform connecting people and groups of interest.
  - www.sacralmusings.com, a well-known social platform within the osteopathic community.

- If needed, a search through advertisement in a local newspaper called “Maurmer Post” (www.maurmerpost.ch).

Randomization of the subjects is given because any healthy person without known pathologies of his or her legs, age 22 and above can be part of this experiment. Because this experiment does *not* use a placebo control group for comparing it to another group which receives a therapeutic intervention, randomization is generally not necessary.

3.1.3 INCLUSION AND EXCLUSION CRITERIA

3.1.3.1 INCLUSION CRITERIA

- Inclusion criteria for the intraosseous group:
  - Age: 22 years and above
  - History of lower leg accidents and repeated mechanical stress
  - IMPORTANT: confirmed intraosseous strain with osteopathic manual palpation by the examiner
- Inclusion criteria for the control group:
  - Age: 22 years and above

The inclusion criterion “age 22 years and above” is important for this study, because the tibial bone ossifies completely until the 21st year of age (Schünke, et al., 2005) and thus physiological activity is markedly decreased within the growth plates, especially the proximal growth plate (Gray, 1918; Schünke, et al., 2005). In relation to subjects age, the author reflected on the possibility that menopause of women might influence skin temperature, but no actual research literature was found on this. And as a search on Pubmed/Medline shows, no literature was found on the influence of osteoporosis on shell and core temperature.

3.1.3.2 EXCLUSION CRITERIA

- Exclusion criteria for the intraosseous group:
  - Existence of bilateral intraosseous strains
  - Known fractures
  - Recent superficial or deep injuries (three weeks or younger) at the site of both tibias due to inability to compare temperatures reliably (active inflammation phase) (Schultz, Ladwig, & Wysocki, 2005)
  - Any arterial, venous or lymphatic pathology
  - Any (sub-)acute skin condition (allergies, eczema, rash, et cetera)
- Exclusion criteria for the control group:
  - Existence of an intraosseous strain
  - Any known superficial or deep injuries (including fractures) of the tibial area younger than 16 weeks
  - Any arterial, venous or lymphatic pathology
  - Any (sub-)acute skin condition (allergies, eczema, rash, et cetera)

Apley & Solomon (1994) give a rough guide of healing times of tubular bones in the lower limb of healthy adults:

- Callus visible 2-3 weeks
- Union 8-12 weeks
- Consolidation 12-16 weeks

The estimate of 16 weeks for complete healing of a fracture of the tibia and/or fibula - if no delay has happened due to complications - is being used as a general limit for excluding a subject. Unwanted increased physiological activity of the bone and its surrounding tissues are

hereby minimized and should help to ensure good infrared image material without any disturbances of unwanted heat patterns.

The time-limit of three weeks for any recent injury is important to include as an exclusion criterion because it usually takes up to three weeks to finish the inflammation phase of wound healing (Schultz, et al., 2005). Scar tissue healing takes actually longer than 3 weeks to heal (Madden & Peacock, 1971), but more on a mechanical load level. They claim that full mechanical load bearing capabilities develop within a full year. This mechanical aspect is not very important for this study because the author measures heat patterns and not mechanical factors of the tissues being examined.

Subjects with fractures of the tibial bone on the side of an intraosseous strain and its contralateral side are excluded from the intraosseous group due to the fact that this research wants to test traumatic strains below fracture threshold, thus strains which aren't detectable with common medical imaging systems (X-ray, MRI, CT-Scan). Consolidated fractures within the intraosseous group might affect the thermal information of the overlying skin and are being excluded to ensure optimal thermal data. Furthermore, consolidated fractures within the intraosseous group might affect osteopathic manual palpation and might falsify intraosseous testing results.

Exclusion of any arterial, venous and lymphatic pathologies make sense because any of these physiological states might influence thermal radiation of the skin.

At last, the author took the possibility into account that some pharmacological medications might influence skin temperature. A Pubmed/Medline search was performed on the following terms:

- Beta blocker (and) temperature
- Aspirin (and) temperature

- NSAID[15] (and) temperature
- Anticoagulant[16] (and) temperature
- Thyroid (and) temperature
- Thyroid (and) hormone (and) temperature

None of the searches above produced any results, even the search for correlation of thyroid hormone intake and body temperature.

3.1.4 VARIABLES

- Independent variables:
  - Age of subject
  - Gender of subject
  - Inglehart Index value
  - Weekly frequency of sport activities
  - Number of known mechanical traumata
  - Suspected age of mechanical traumata
  - Palpatory results: Location, Rigidity and Vitality
- Dependent variables:
  - Skin temperature measured by thermography in degree Celsius

[15] NSAID = Non-steroidal anti-inflammatory drug (WebMD, 2008)

[16] anticoagulant = Any agent used to prevent the formation of blood clots (WebMD, 2008)

3.2 MEASURING INSTRUMENTS

3.2.1 THERMOGRAPHY

In this thesis, the author uses a thermographic device produced and sold by *Trotec*[17], details shown below (as written in technical specification leaflet from trotec24.com):

Figure: 4. EC 060 Infrared Camera, sold by trotec24.com

"EC 060 Infrared Camera - First-Class Thermography

The EC 060 is yet another infrared camera in the hugely-successful infrared camera series from Trotec. The amazingly-priced EC 060 is equipped with a variety of valuable features including a maintenance-free, uncooled image sensor with a detector resolution of 160 x 120 measuring spots and a thermal sensitivity of 0.1 °C. And because the EC 060 is also a fully-radiometric infrared camera which enables you to take thermal images in a temperature range from -20 °C to +250 °C it has already set new standards with regard to price and performance.

An overview of the EC060's many favorable features:

- *Measuring range from -20 °C to +250 °C*
- *Fully radiometric infrared camera in a compact design*
- *High image repetition frequency of 50/60 Hz*
- *Maintenance-free operation due to microbolometer technology*
- *Ergonomic form and extremely light*
- *High thermal sensitivity of 0.1 °C*
- *Automatic cold spot / hot spot detection*

[17] Trotec, see online www.trotec24.com

- *One movable measuring spot*
- *Minimum focal distance of only 10 cm*

The camera's high image repetition frequency ensures permanent real-time image representation of thermal images and the mini SD card included in the scope of delivery can easily save thousands of thermal images."

In order to qualitatively and quantitatively process the thermal images taken, the Trotec EC 060 comes with a computer software called *IC-Report Standard*. Within this software, the author can do the following:

- Open and view thermal images taken by Trotec EC 060
- Show temperatures (exact, maximum, minimum and average in degree celcius):
  - At any location
  - Within in a defined area
  - Along a defined line

The Trotec EC 060 has been used in medical research before (Wolter & Kieselbach, 2011) and was found to be precise and valid for measuring living tissue temperature. Only this one research article was found by the author. The International Academy of Clinical Thermology (Thermology, 2002) doesn't recommend specific infrared camera equipment, it gives a list of minimum specifications the used infrared device should have:

- Detector response with the spectral bandwidth encompassing 8-10 micron region
- Repeatability and precision of 0.1 °C detection of temperature difference
- Accuracy of +/- 2% or less
- Significantly variable contrast (level) settings
- A maximum scanning time of 4 seconds or less with real-time capture
- High-resolution image display for interpretation
- Ability to archive captured images

- Image processing and data capturing software

All above mentioned requirements are given with the Trotec EC 060. Last but not least, the Trotec EC 060 is calibrated to ensure maximum accuracy.

3.2.2 MANUAL PALPATION AS AN IDENTIFICATION AND CLASSIFICATION TOOL FOR INTRAOSSEOUS STRAINS

Little written information is found on a methodology for testing intraosseous strains. The Swiss International College of Osteopathy teaches the existence of intraosseous lesions and defines what they feel like on a palpatory level, but little information is given for exact testing and locating. Instead, Chauffour & Prat (2002) and Heller (2011b) talk about testing the spring or stiffness of the bone in all spacial dimensions and give precise instructions how to locate and define the intraosseous strain in all three dimensions. The author uses this rigidity-testing of the Chauffour/Prat-Method and supplements it with an additional test for global torsion of the tibia and with listening of Vitality (as a consequence of the qualitative thesis from Brown (2008) and lectures from Druelle (2011)). Please see Chapter 3.3.2. for details.

3.3 EXPERIMENTATION METHOD AND DATA COLLECTION METHOD

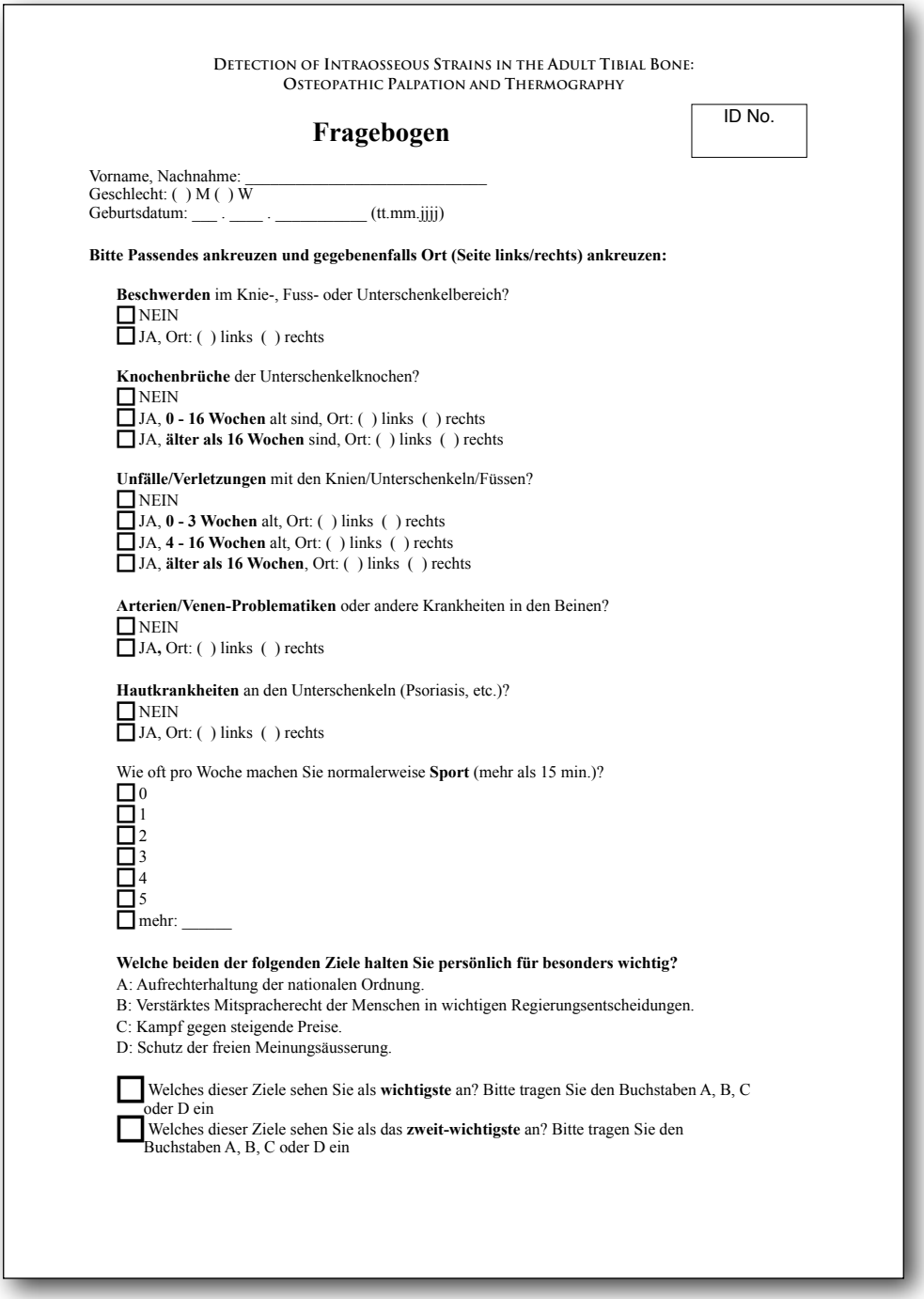
3.3.1 FILLING OUT THE QUESTIONNAIRE AND SIGNING THE FORM OF CONSENT

Each subject has to sign the form of consent and fill out a short questionnaire before examination. This examination form will be given in an envelope (blinded) and will not be shown to the examiner until after manual osteopathic examination. In the following paragraph, you find an English translation:

Questionnaire:

- Name, Gender, Birth Date
- Please tick appropriate and eventually the location (left/right):

- Complaint(s) in knee, foot or lower leg? NO, YES (left/right)
- Fracture(s) of the lower leg(s)? NO, YES 0-16 weeks old (left/right), YES 16+ weeks old (left/right)
- Accident(s) / Injury(ies) in knee, foot or lower leg? NO, YES 0-3 weeks old (left/right), YES 4-16 weeks old (left/right), YES 16+ weeks old (left/right)
- Any arterial/venous pathology in the leg(s)? NO, YES (left/right)
- Any skin disorders in the lower leg(s)? NO, YES (left/right)
- How many times per week do you perform sport activities (more than 15 min): 0/1/2/3/4/5/ more
- Inglehart Index questions (see chapter 3.4.3)



DETECTION OF INTRAOSSEOUS STRAINS IN THE ADULT TIBIAL BONE:
OSTEOPATHIC PALPATION AND THERMOGRAPHY

Fragebogen

ID No.

Vorname, Nachnahme: _____
Geschlecht: ( ) M ( ) W
Geburtsdatum: ___ . ____ . _____ (tt.mm.jjjj)

Bitte Passendes ankreuzen und gegebenenfalls Ort (Seite links/rechts) ankreuzen:

Beschwerden im Knie-, Fuss- oder Unterschenkelbereich?
☐ NEIN
☐ JA, Ort: ( ) links ( ) rechts

Knochenbrüche der Unterschenkelknochen?
☐ NEIN
☐ JA, **0 - 16 Wochen** alt sind, Ort: ( ) links ( ) rechts
☐ JA, **älter als 16 Wochen** sind, Ort: ( ) links ( ) rechts

Unfälle/Verletzungen mit den Knien/Unterschenkeln/Füssen?
☐ NEIN
☐ JA, **0 - 3 Wochen** alt, Ort: ( ) links ( ) rechts
☐ JA, **4 - 16 Wochen** alt, Ort: ( ) links ( ) rechts
☐ JA, **älter als 16 Wochen**, Ort: ( ) links ( ) rechts

Arterien/Venen-Problematiken oder andere Krankheiten in den Beinen?
☐ NEIN
☐ JA**,** Ort: ( ) links ( ) rechts

Hautkrankheiten an den Unterschenkeln (Psoriasis, etc.)?
☐ NEIN
☐ JA, Ort: ( ) links ( ) rechts

Wie oft pro Woche machen Sie normalerweise **Sport** (mehr als 15 min.)?
☐ 0
☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ mehr: _____

Welche beiden der folgenden Ziele halten Sie persönlich für besonders wichtig?
A: Aufrechterhaltung der nationalen Ordnung.
B: Verstärktes Mitspracherecht der Menschen in wichtigen Regierungsentscheidungen.
C: Kampf gegen steigende Preise.
D: Schutz der freien Meinungsäusserung.

☐ Welches dieser Ziele sehen Sie als **wichtigste** an? Bitte tragen Sie den Buchstaben A, B, C oder D ein
☐ Welches dieser Ziele sehen Sie als das **zweit-wichtigste** an? Bitte tragen Sie den Buchstaben A, B, C oder D ein

Figure: 5. Questionnaire. To be filled out by each test subject of both sample groups.

3.3.2 CAPTURING THERMAL IMAGES

First, there is a thermal image taken of the anterior side of both tibias with the Trotec EC 060 camera. It is mounted on a commercially available camera tripod (EF digital star 700, sold by hama). The construct camera-tripod looks like the following:

Figure: 6. Infrared camera and its tripod

Average temperature of the whole anterior side of both tibias will be collected in each subject. The examiner doesn't see the heat pattern of the infrared image, because the Trotec EC 060 has a double-image mode where one only sees a normal picture and at the same time the camera records a infrared image without showing it. This mode ensures that the examiner is single-blinded before and during the osteopathic manual palpation examination.

International standards defined by Diadikes & Bronzino (2008) and Ring et al. (2004) will be used to ensure proper infrared imaging:

- **Examination room type:**
  - Minimum size of 2x4 meters. Actual examination room size is 16 square meters.
- **Room climate:**
  - Relative humidity: It is recommended to have a dry environment to avoid sweating of the skin, thus approximately 35-55% - ideally 45%.
  - Room temperature: To avoid vasoconstriction of the skin due to cold temperature and to also avoid sweating of the skin due to hot temperature, a 20-25 ˚C ambient room temperature will be used. This is no problem in this research project, because the planned examination room has floor heating with a precise thermostat.
  - Air conditioning: No air conditioning equipment is recommended and overall low air speed within the examination room. The actual examination room has no air conditioner and its door and windows are airtight.
- **Test person information before examination:** Before the infrared picture(s) will be taken, the subject has to sign a form of consent (see Appendix C) at least 24 hours before examination. This form also states requests by the author to ensure that the measured temperature during examination will be as precise as possible:
  - No usage of cosmetics (skin lotions, ointments et cetera) on the day of examination.
  - No alcohol intake on the day of examination.

- No smoking approximately 1 hour before examination.
- No large meals and excessive tea/coffee intake on the day of the examination.
- Avoid tight fitted clothing on the day of examination.
- Avoid physical exertion on the day of the examination.
- Avoid any manual/physical therapy on the day of the examination.
- Drugs affecting the cardiovascular system (blood pressure medication et cetera) should be reported to the examiner.

- **Pre-imaging equilibration:** On arrival at the examination, the subject will be informed of the examination procedure, instructed to remove appropriate clothing (in this study: pants, both socks or any stocking which could cover the foot and the tibia), and asked to sit or rest in the examination room for a fixed time of 15 minutes.
- **Position for imaging:** A standard view of the tibias will be used, see Figure 3 below. The complete anterior view of the tibias will be pictured, including feet and knees. Distance between toes of the subject and mid-foot of the tripod is 240 cm and the height of the midpoint of the camera lens from the ground will be 51 centimeters.

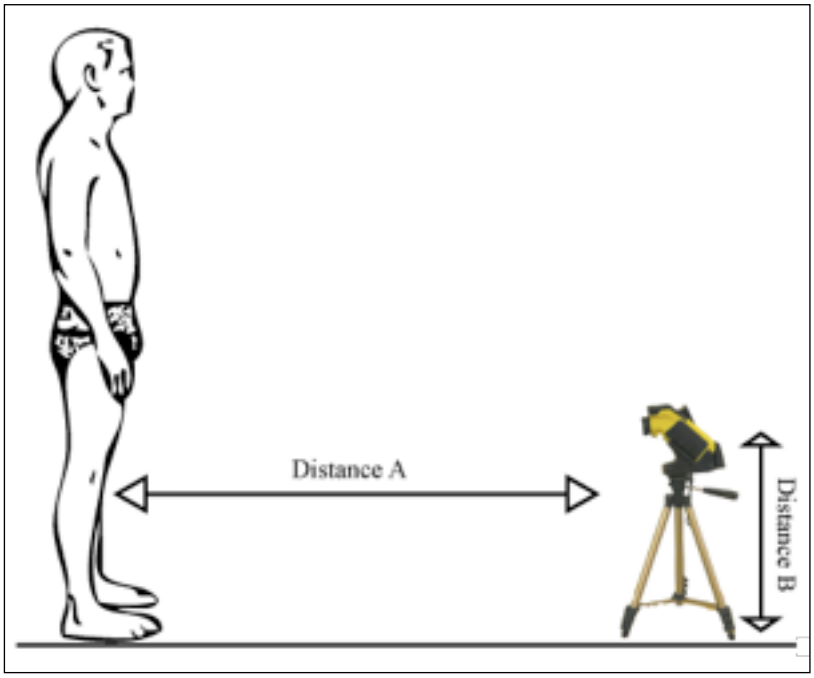


Figure: 7. Distance A between tibia and IR Camera: 240 centimeters. Distance B between ground and midpoint of camera lens: 51 centimeters.

The reason why the whole anterior side (superior border: inferior margin of the patella, inferior border: horizontal mid-line between lateral and medial malleolus) of the tibia will be taken for calculating the average temperature and not only the exact location of the intraosseous lesion is that thermal imaging quantitatively shows current state of skin blood flow (Diadikes & Bronzino, 2008; Plaugher, 1992; Ring, unknown; Ring & Ammer, 2000; Ring, et al., 2004) and the tibia is mainly nourished by the anterior tibial artery (see chapter 2.2.2.1 for details) which also vascularizes the anterior skin surface of the lower leg (Schünke, et al., 2005).

The logical assumption to this anatomical fact is that an intraosseous strain might alter skin temperature globally at the anterior surface of the lower leg and not only its local spot. Standing position of the subject is chosen to ensure exact distance between the camera and the subject. According to Roy, Boucher & Comtois (2010) there are no differences between

prone and standing temperature measurements if symptom-free subjects are given 8 minutes to acclimate (in this study, 15 minutes are being used) before performing thermal imaging.

3.3.3 PERFORMING THE OSTEOPATHIC MANUAL EXAMINATION

After having the thermal image taken of both tibias in one image and annotation of the infrared image number on the examination form, palpation tests (see Chapter 3.2.2 for details) are performed and their result will be noted in an examination form:

DETECTION OF INTRAOSSEOUS STRAINS IN THE ADULT TIBIAL BONE:
OSTEOPATHIC PALPATION VERSUS THERMOGRAPHY

EXAMINATION FORM

ID No.

Date of examination: (dd.mm.yyyy) _____
Room temperature: _____ degrees celcius
Room air humidity: _____ %

Location(s) of intraosseous strain(s): Mark with a circle and number with "area 1/2/3"

Side + ☐ RIGHT ☐ LEFT ☐ **NONE**

IR Image number(s):

_____

_____

Notes:

Spring tests:

Area 1	Area 2	Area 3
anterior-posterior spring: 0 / 1 / 2 / 3 medial - lateral spring: 0 / 1 / 2 / 3 CW/CCW spring: 0 / 1 / 2 / 3 torsion test: 0 / 1 / 2 / 3	anterior-posterior spring: 0 / 1 / 2 / 3 medial - lateral spring: 0 / 1 / 2 / 3 CW/CCW spring: 0 / 1 / 2 / 3 torsion test: 0 / 1 / 2 / 3	anterior-posterior spring: 0 / 1 / 2 / 3 medial - lateral spring: 0 / 1 / 2 / 3 CW/CCW spring: 0 / 1 / 2 / 3 torsion test: 0 / 1 / 2 / 3

Vitality tests:

Area 1	Area 2	Area 3
0 / 1 / 2 / 3	0 / 1 / 2 / 3	0 / 1 / 2 / 3

Definitions:
spring: 0, 1, 2, 3 (0= none, 1 decreased, 2 normal, 3 increased)
vitality: 0, 1, 2, 3 (0= none, 1 decreased, 2 normal, 3 increased)

Figure: 8. Examination form

Precise methodology of the manual palpation tests are as following:

- Spring of the tibial bone localization and classification testing method:

  a) **Position testing subject**: Lying supine on the treatment table, legs extended.

  b) **Position Osteopath**: Standing next to the table at the site of the tested tibia.

  c) **Action 1**: The Osteopath glides the palm of his hand slowly over the anterior surface of the tibia and seeks a sensation of "magnetic pulling in" (Heller, 2005).

  d) **Action 2**: At the given location, the Osteopath palpates that spot with both palms over each other and sinks down towards the table into the level of the bone.

  e) **Action 3**: When at the level of the bone, the Osteopath performs a spring test towards the table and registers normal or abnormal "give" and "spring" of the bone. This action tests the tibia's ability to bend within one direction; from anterior to posterior.

  f) **Action 4**: The Osteopath changes the hand position to the antero-lateral and antero-medial side of the tibial bone and performs a spring test from medial to lateral and vice versa. This action tests the tibia's ability to bend within the medial to lateral plane.

  g) **Action 5**: The Osteopath performs a torquing action by adding a rotational pressure, both clockwise and counterclockwise. This action tests the tibia's ability to bend along an anterior-posterior axis.

  h) **Action 6**: To supplement the spring testing, the Osteopath takes the proximal and distal end of the tibia into his hands and performs a torsion of the tibia globally by rotating the distal end into one direction and the proximal end

into the opposite direction. This tests gives an additional information of the global longitudinal torsion capacity of the tibia and additionally confirms the finding of an intraosseous strain.

Furthermore, if the spring tests above are positive on a specific location, the Osteopath continues with the tests below to additionally confirm an intraosseous strain:

- Vitality listening of the tibia:

  4.a) **Position testing subject and Osteopath**: Subject is lying supine, a pillow under the knee of the side being tested. The Osteopath encompasses the area with an intraosseous strain proximally and distally with each hand.

  4.b) **Action**: Both hands of the Osteopath encompass the area of the found intraosseous lesion and perform a listening for expansion and retraction, which normal palpation should have a good amplitude and force[18] with an approximate rate of 5-7 per minute (Druelle, 2011).

Table: 3. FINDINGS NOTED WITHIN MANUAL EXAMINATION

Spring tests:	Vitality listening:
0 (none)	0 (none)
1 (decreased)	1 (decreased)
2 (normal)	2 (normal)
3 (increased)	3 (increased)

The testing results of each sub-spring-test (anterior-posterior spring test, medial-lateral spring test, rotation spring test, longitudinal torsion spring test) are being used to calculate an average spring test result. As an example, if the sub-spring-tests give results like “0,1,1,0”,

[18] same as footnote 11: these parameters are palpated very subjectively and are a consensus of the author professional experience and with the comparison to the contralateral side in each subject being tested.

the average spring test result will be “0.5” which describes the intraosseous strain as “decreased to no spring at all”.

78% of the Osteopaths from all over the world interviewed by Mummery (2008) use descriptive palpation, 40% used visual observation of Vitality, 34% use palpation results Vitality or No vitality, 34% use patient’s verbal description of their own Vitality and 19% use a number scale from 1 to 10. The author chose the scale 0/1/2/3 to be able to statistically utilize the received palpatory data form the examination.

3.4 BIAS

3.4.1 SAMPLE BIAS

- All subjects have to avoid a list of activities and things on the day of the examination (see chapter 3.3.1). The examiner cannot control if all recommendations have been followed by the subjects or not and has to trust that they tell the truth.

3.4.2 METHODOLOGY BIAS

- The examiner performs all steps of examination himself. Although he doesn’t know the result of the questionnaire and the infrared image taken (both are blinded), he still has personal contact with the subjects and preliminary information could be given before manual osteopathic examination. Thus blinding is not 100% ensured.
- Dividing all subjects into both groups solely depends on the palpation capabilities of the examiner. So if the examiner doesn’t palpate well, subjects might get categorized into the wrong group.

- The used camera type (Trotec EC 060) has only been used for one medical research before (Wolter & Kieselbach, 2011), thus its validity is not 100% ensured, although all standard requirements are given (see Chapter 3.2.1) and strict image taking standardization is being used to ensure similar infrared images.
- Definition of the exact area of the anterior skin surface of the lower leg within the software used to read out temperature values. This area is being drawn manually on the computer-screen with computer-mouse movements, thus 100 percent exact definition of all lines which form this area is not possible.

3.4.3 BIAS CONTROL METHODS

To control the to be avoided activities of the subjects before examination is not possible. The examiner has to trust the information given by each subject. The examiner will be single-blinded before and during manual osteopathic palpation procedure. The subjects will be told to tell no information about their symptoms and problematics (if there are any) until after the manual osteopathic palpation procedure.

3.4.3 THIRD VARIABLES CONTROL METHOD: INGLEHART INDEX

As advised by Hüttenmoser Oliva (2011), a third variable control method should be used to exclude spurious correlation results.

"A confounding variable, also known as a third variable or a mediator variable, can adversely affect the relation between the independent variable and dependent variable. This may cause the researcher to analyze the results incorrectly. The results may show a false correlation between the dependent and independent variables, leading to an incorrect rejection of the null hypothesis." (Bauer, 2009; Shuttleworth, 2008)

In order to control spurious correlations, each subject will be asked to answer two additional questions which will collect data for a third variable, the Inglehart Index:

"The Inglehart index of post-materialism is measured by people's priority for low inflation and order. We use regression analysis to correct national averages of the Inglehart index for the effects of observed inflation and (violent) crime rates for selected European, Asian and South American countries. Low inflation and low crime rates significantly increase the Inglehart index, but we also observe a trend towards post-materialistic values. This trend cannot be explained by economic growth alone." (Oliver & Richard, 2003)

The text used for creating the form to determine the Inglehart-Index of each subject is being taken from Bortz & Döring (2006).

Table: 4. QUESTIONS TO DETERMINE INGLEHART INDEX

If you had to choose among the following things, which are the **two** that seem the most desirable to you?
A: Maintaining order in the nation.
B: Giving people more say in important political decisions.
C: Fighting rising prices.
D: Protecting freedom of speech
Which one of the mentioned things above do you classify as MOST IMPORTANT: Please mark letter A, B, C or D.
Which one of the mentioned things above do you classify as SECOND IMPORTANT: Please mark letter A, B, C or D.

3.5. LIMITATIONS

1. Definition of the exact area of the anterior skin surface of the lower leg within the software used to read out temperature values. This area is being drawn manually on the computer-screen with computer-mouse movements, thus 100 percent exact definition of all lines which form this area is not possible.
2. Time limitation: This thesis has to be finished within two years. In-depth literature research and sample size will be limited.

3. Methodology: Due to time and financial restrictions, all examinations will be performed by the author itself. The author will perform self-blinding strictly.
4. Osteopathic palpation: Due to time and organizational limitations, manual palpation will be solely performed by the author without control of inter-reliability through one or more third-party Osteopath(s).

3.6 ETHICAL CONSIDERATIONS

This research will performed in such a way that anonymity of each subject is given at all times. After data collection, examination protocols will be anonymized by not showing the subjects name.

Each infrared image will be numbered with the number of the corresponding subject. Image anonymization is not necessary because thermal images have a low resolution in thermal coloring (“rainbow coloring”) and can’t be matched to a person.

The thermal image will be owned by the author (see appendix, chapter 9.3.) but a copy will be offered to each subject if requested.

4 CHAPTER FOUR: DATA ANALYSIS

First, all data is being collected (questionnaire data, thermal image data in degree Celsius and palpation data) and put into a data matrix within an Excel sheet.

Within that sheet, measurement of central tendencies are being calculated (location- and distribution parameters) to describe distribution of the collected data:

- Mean
- Median
- Mode
- Standard deviation
- Minimum
- Maximum
- Range

It is planned to use descriptive statistics (cross tables), correlational analysis (correlation values) and mean score analysis (mean score comparison and variance analysis). The analyzed data will be presented within tables, histograms and bar diagrams.

All measured central tendencies mentioned in the list above will be directly calculated within the excel sheet, all other calculations will be performed with a professional statistics software.

5 CHAPTER FIVE: TIMELINE

Table: 5. TIMELINE OF THESIS

Jan 2012 - April 2012	May 2012 - Nov 2012	Dec. 2012
- Search for subjects - Examination of subjects - Data collection	- Data analysis - Further research - Thesis writing	- Deposit thesis for first pre-reading
Apr. 2013	**May 2013**	**Jun 2013**
- Deposit thesis for second pre-reading	- FINAL deposit thesis	- Presentation of thesis to an international jury in Hertenstein, CH

6 CHAPTER SIX: CONCLUSION

Quantitative infrared image detection and classification of intraosseous strains could help to show the medical and osteopathic world that there *are* stages in between "not-fractured" and "fractured" bone contradicting common medical opinion (Keaveny & Bouxsein, 2008). It would be a benefit to the osteopathic world if the actual existence of intraosseous strains is proven by this research. The author is very well aware that this thesis is only the starting point in trying to understand testing, treating and classifying intraosseous strains. Further research on how the left-right temperature difference will change after certain treatment protocols is then possible and will give more precise and quantitative information on the nature and effectiveness of treatment.

Although the assessment of intraosseous strains is not thoroughly described in literature, the author tries to scientifically underline all methods being used, such as manual palpation of the bone's spring and its expression of Vitality. Expression of intraosseous strains, its rigidity and its expression of Vitality is still a vaguely described and researched area, even within the osteopathic community. Thanks to qualitative research done by Brown (2008) and Mummery (2008) and to research and lecturing performed by Chauffour & Prat (2002), a large foundation to this research is given.

The author hopes that this fundamental research helps to understand a little more about the true nature of intraosseous strains, whether it might be of mechanical, fluidic or energetical nature - or maybe a mix of all?

It will be a great journey, to delve into the realm of the bone, driven by its fluids.

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APPENDICES

APPENDIX A: PILOT STUDY

This pilot study was performed during spring/summer 2010 with five subjects which matched the listed prerequisites below. The aim of this small study was to actually determine if it is actually possible to detect an indication of intraosseous strains on thermal images. Internationally accepted standards were used during infrared image capturing (Ring & Ammer, 2000) and all subjects fulfilled the following prerequisites:

- Age: above 22 years
- History of accidents (falls, hits, et cetera)
- *No* fractures at the site of intraosseous strain found by palpation (ideally confirmed with X-ray/MRI)
- *No* recent injuries (three weeks or younger) at the contralateral site of the tested area due to impossibility to compare temperatures reliably
- *No* recent injuries (three weeks or younger) at the intraosseous strain site due to the fact that the local site might be warmer through inflammation processes

STUDY DESIGN

First of all, suitable subjects were found by publishing this Pilot Study in the authors clinic. Patients were chosen which had not been treated by the author before. Then the author had them sign the form of consent (see appendix 9.2. and 9.3.) and performed the examination as follows:

1. Another health professional (an authors employee) took the thermal images, not showing them to the author before manual osteopathic examination.
2. Immediately after the thermal images were taken, the author performed a manual osteopathic examination and filled in the examination protocol (see appendix 9.4.).

3. After this, the thermal images were processed by the author as follows:
    3.1. At every site where the author found an intraosseous strain, the average temperature of the affected tibia was compared with the healthy not affected side.
4. All intraosseous strains of all subjects were treated immediately after finishing the complete examination. No follow-up appointments were given - if not desired by the patient.

RESULTS

Although the sample size used in this pilot study is very small, the results are pretty clear: **Three of five subjects have an average temperature *decrease* of 0.47 degree celcius on the intraosseous-affected tibia. Two (subject 4 and 8) of five subjects have an average temperature *increase* of 0.33 degree celcius on the intraosseous strain-affected side.** Subject 4 had recent trauma - three weeks before examination. Subject 8 just had a run in the morning before examination.

The author concludes that older intraosseous strains are clearly visible in thermal imaging by an average temperature decrease on the affected side. On the other hand, “fresh” (less than 3 weeks old) intraosseous strains might still be in its inflammation phase, thus its average temperature will be increased. Subject 8 “stressed” the tibia with the intraosseous strain at the same day as the examination - this might explain the minimal temperature increase on the affected tibia.

Table: 6. AVERAGE TEMPERATURE OF ANTERIOR TIBIA'S IN DEGREE CELCIUS

Subject	Intraosseous Strain Tibia (average degree Celsius)	Healthy Tibia (average degree Celsius)	Temperature Difference Intraosseous Strain -> Healthy Side (degree Celsius)
Subject 1	29,72	30,27	- 0,55
Subject 4	33,46	32,95	+ 0,51
Subject 5	28,42	28,69	- 0,27
Subject 6	29,53	30,12	- 0,59
Subject 8	31,38	31,23	+ 0.15

APPENDIX B: FORM OF CONSENT FOR PILOT STUDY, GERMAN VERSION

Einwilligungserklärung

und Informationen betreffend Vorbereitung zur Pilotstudie
"intraossäre Restriktionen ohne Knochenbruch"

Geschätzte Testperson,

vielen Dank für Ihre Bereitschaft zur Teilnahme an dieser Studie. Ihre Teilnahme wird sehr geschätzt und diese Studie könnte nicht ohne Sie stattfinden!

- Alle persönlichen Informationen von Ihnen werden **streng vertraulich** behandelt und sind nur zugänglich durch Edward Muntinga.
- Sie können nicht durch die Wärmebilder erkannt werden; Ihre **Anonymität** wird stets gewährleistet.
- Die Bilder werden für Studienzwecke genutzt und sind Eigentum von Edward Muntinga.

Falls Sie irgendwelche Zweifel oder Fragen haben, wenden Sie sich bitte an:
Edward Muntinga, Tel. 043 810 81 80, edward@muntinga.ch

Ich, _____ , bestätige:

1. Ich werde am Tag der Untersuchung aufgefordert, in das Behandlungszimmer von Edward Muntinga (in der Therapiepraxis Muntinga, CH-8122 Binz) zu kommen, um **Wärmebilder** von mir aufnehmen zu lassen und darauffolgend eine **manuelle Untersuchung** an meinen Beinen durchführen zu lassen.
2. Ich werde versuchen, ca. 2-3 Stunden vor der Untersuchung
   2.1. keine großen Mahlzeiten zu essen,
   2.2. **keinen Alkohol** zu konsumieren,
   2.3. und nicht unmittelbar vorher zu rauchen.
3. Ich werde am Tag der Untersuchung **möglichst keine Kosmetika oder Salben** auf die Haut meiner Beine auftragen.
4. Vor den Wärmebildkamera-Aufnahmen wird es notwendig sein, für ca. 15 Minuten im Untersuchungszimmer zu verweilen, um mein thermisches Gleichgewicht zu erreichen (dies ergibt präzisere thermische Bilder).
5. Ich bin frei, während der gesamten Untersuchung eine Begleitperson dabei zu haben.
6. Ich bin frei, mich jederzeit aus dieser Studie zurück zu ziehen.
7. Ich habe dieses Formular gelesen und gebe meine Zustimmung, an dieser Studie teil zu nehmen.

Unterschrift Edward Muntinga (Studienleiter) Unterschrift untersuchte Person

_____ _____

Im unwahrscheinlichen Fall einer medizinischen Unregelmäßigkeit in Ihren thermischen Bildern, wollen Sie dass wir Sie darüber informieren?
(__) Ja (__) Nein

APPENDIX C: FORM OF CONSENT FOR PILOT STUDY, ENGLISH VERSION

Form of Consent

and information concerning preparation for the pilot study
"Intraosseous strains without without fractures"

Dear test person,

thank you for your willingness to participate in this study. Your participation is greatly appreciated and this study could not happen without you!

- All personal information will be kept strictly confidential and is only accessible by Edward Muntinga.
- You can not be detected by the infrared images, so your anonymity is always guaranteed.
- The images taken are used for study purposes and are the property of Edward Muntinga.

If you have any doubts or questions, please contact: Edward Muntinga, Tel 043 810 81 80, edward@muntinga.ch

I, _____ , hereby confirm:

1. I am being asked on the day of investigation to come into the treatment room by Edward Muntinga (in therapy practice Muntinga, CH-8122 Binz) to have taken thermal images of me and to undergo a short manual examination on my legs.
2. I'll try about 2-3 hours before the examination
   2.1. to not eat large meals,
   2.2. to not consume any alcohol,
   2.3. and to not smoke immediately before.
3. On the day of investigation, I will wear no cosmetics or ointments applied to the skin of my legs.
4. Before the thermal imaging camera recordings, it will be necessary to wait for about 15 minutes in the examination room, to reach my thermal equilibrium (this yields more accurate thermal images).
5. I am free during the entire examination to have an attendant there.
6. I am free to draw back from this study at any time.
7. I have read this form and give my consent to take part in this study.

Edward Muntinga signature

_____

Examined person signature

_____

In the unlikely event of a medical anomaly in your thermal images, do you want us to inform you?
(__) Yes (__) No

APPENDIX D: PILOT STUDY TESTING PROTOCOL

Pilot Study "POSTTRAUMATIC NON-FRACTURED INTRAOSSEOUS STRAINS OF THE TIBIA IN ADULTS: OSTEOPATHIC PALPATION CONFIRMED BY THERMOGRAPHY" by Edward Muntinga, CO SICO, 2011-2013

Testing Form

Subject No.

Subject Details:

Surname, Name: ( ) MALE ( ) FEMALE

Year of Birth:

Email address (if IR images wanted):

Date of testing: (DD/MM/YYYY)

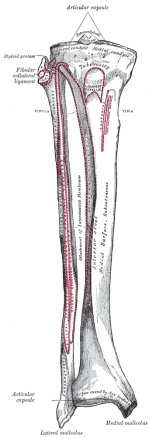
Room temperature: (in degree celcius)

Room air moisture: (in %)

Known accidents:

Pictures taken: (image name from IR camera)

Location of found PNISA's:



1:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

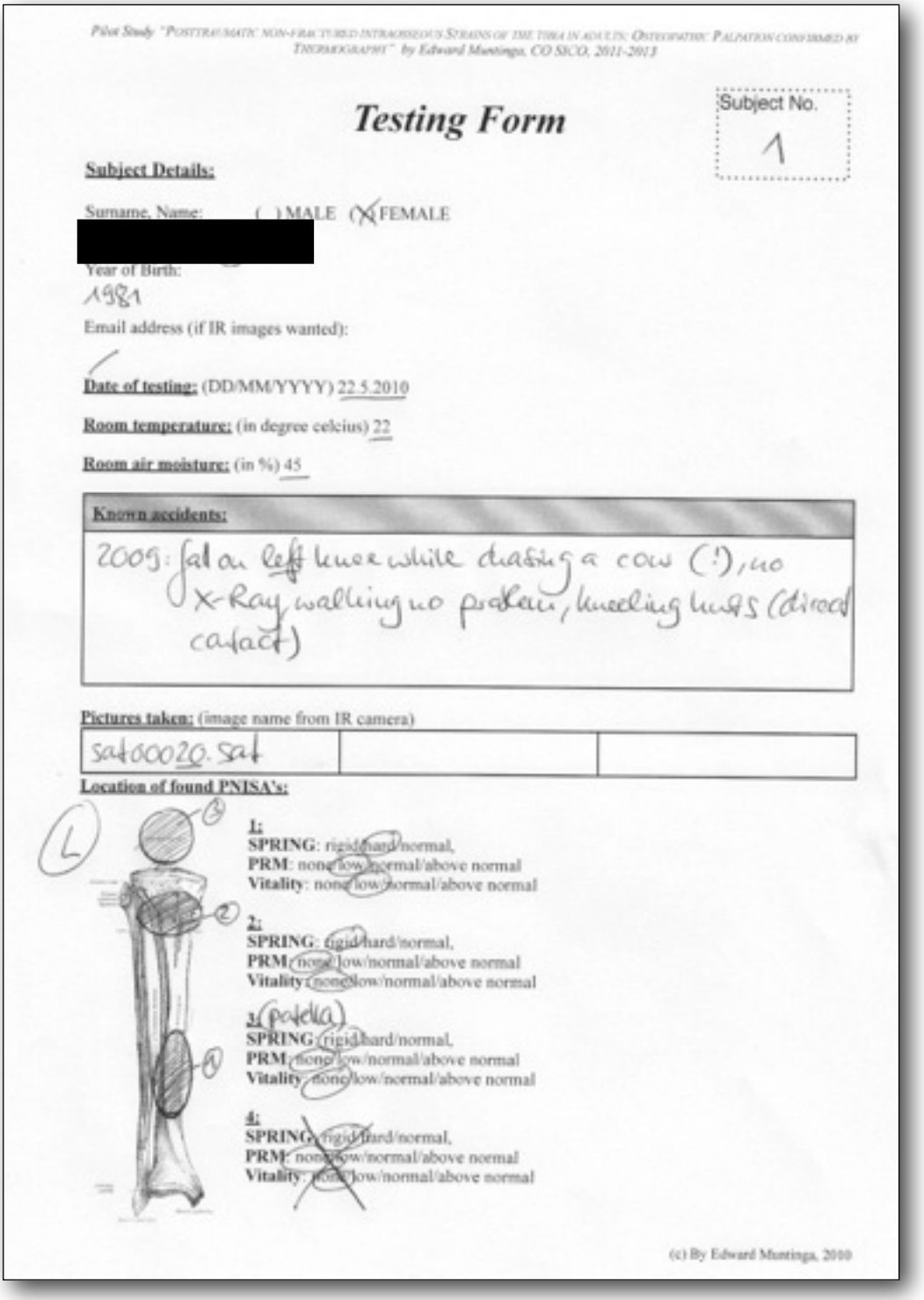
2:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

3:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

4:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

APPENDIX E: PILOT STUDY SUBJECTS

SUBJECT 1 DETAILS



Pilot Study "POSTTRAUMATIC NON-FIBRATURED INTRAOSSEOUS STRAINS OF THE TIBIA IN ADULTS: OSTEOPATHIC PALPATION CONFIRMED BY THERMOGRAPHY" by Edward Muntinga, CO SICO, 2011-2013

Testing Form

Subject No. 1

Subject Details:

Surname, Name: [redacted] ( ) MALE (X) FEMALE

Year of Birth: 1981

Email address (if IR images wanted): ✓

Date of testing: (DD/MM/YYYY) 22.5.2010

Room temperature: (in degree celcius) 22

Room air moisture: (in %) 45

Known accidents:

2009: fall on left knee while chasing a cow (!), no X-Ray, walking no problem, kneeling hurts (direct contact)

Pictures taken: (image name from IR camera)

sat00020.sat		

Location of found PNISA's:

1:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

2:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

3 (patella)
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

4:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

SUBJECT 4 DETAILS

Pilot Study "POSTTRAUMATIC NON-FRACTURED INTRAOSSEOUS STRAINS OF THE TIBIA IN ADULTS: OSTEOPATHIC PALPATION CONFIRMED BY THERMOGRAPHY" by Edward Muntinga, CO SICO, 2011-2013

Testing Form

Subject No. 4

Subject Details:

Surname, Name: [redacted] ( )MALE (X) FEMALE

Year of Birth: 1964

Email address (if IR images wanted): /

Date of testing: (DD/MM/YYYY) ~~22.5.2010~~ 29.5.2010

Room temperature: (in degree celcius) ~~22~~ 24

Room air moisture: (in %) ~~35~~ 47

Known accidents:
3weeks ago: hit the knee frontal on hard surface (table corner) right side.

Pictures taken: (image name from IR camera)

SAM0041.SAF		

Location of found PNISA's:

1: (subpatellar fat body)
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

2:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

3:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

4:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

SUBJECT 5 DETAILS

Pilot Study "POSTTRAUMATIC NON-FRACTURED INTRAOSSEOUS STRAINS OF THE TIBIA IN ADULTS: OSTEOPATHIC PALPATION CONFIRMED BY THERMOGRAPHY" by Edward Muntinga, CO SICO, 2011-2013

Testing Form

Subject No. 5

Subject Details:

Surname, Name: (X) MALE ( ) FEMALE

[redacted]

Year of Birth: 1973

Email address (if IR images wanted): —

Date of testing: (DD/MM/YYYY) ~~22.5.2010~~ 1.6.2010

Room temperature: (in degree celcius) ~~22~~ 24

Room air moisture: (in %) ~~45~~ 42

Known accidents:
4 weeks ago: fell on his knee (left) (also older falls on knee, years ago) - no fracture

Pictures taken: (image name from IR camera)

Sat00047.sat	Sat00048.sat	

Location of found PNISA's:

1:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

2:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

3:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

4:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

SUBJECT 6 DETAILS

Pilot Study "POSTTRAUMATIC NON-FRACTURED INTRAOSSEOUS STRAINS OF THE TIBIA IN ADULTS: OSTEOPATHIC PALPATION CONFIRMED BY THERMOGRAPHY" by Edward Muntinga, CO SICO, 2011-2013

Testing Form

Subject No. 6

Subject Details:

Surname, Name: [redacted] ( ) MALE (X) FEMALE

Year of Birth: 1985

Email address (if IR images wanted): ✓

Date of testing: (DD/MM/YYYY) ~~22.5.2010~~ 23.6.2010

Room temperature: (in degree celcius) ~~22~~ 24,5

Room air moisture: (in %) ~~45~~ 43

Known accidents:

severe car accident 5yrs ago, right leg compressed between dashboard and seat.

Pictures taken: (image name from IR camera)

sid00050.sid		

Location of found PNISA's:

1:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

2:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

3:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

4:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

SUBJECT 8 DETAILS

Pilot Study "POSTTRAUMATIC NON-FRACTURED INTRAOSSEOUS STRAINS OF THE TIBIA IN ADULTS: OSTEOPATHIC PALPATION CONFIRMED BY THERMOGRAPHY" by Edward Muntinga, CO SICO, 2011-2013

Testing Form

Subject No. 8

Subject Details:

Surname, Name: [redacted] (X) MALE ( ) FEMALE

Year of Birth: 1973

Email address (if IR images wanted): /

Date of testing: (DD/MM/YYYY) 29.8.11

Room temperature: (in degree celcius) 23,5

Room air moisture: (in %) 48

Known accidents:

-old accidents (no fr. X-Ray ©), has trouble with knee while running after 0-15min. (triathlon runner!) left side ↓

Pictures taken: (image name from IR camera)

SAM00058.sat		

Location of found PNISA's:

1:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

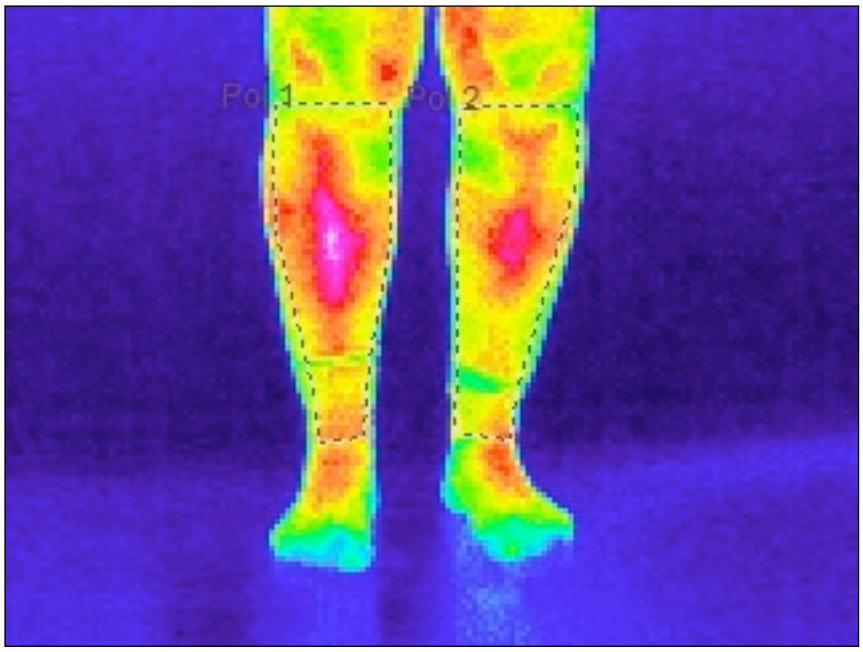
2:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

3:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

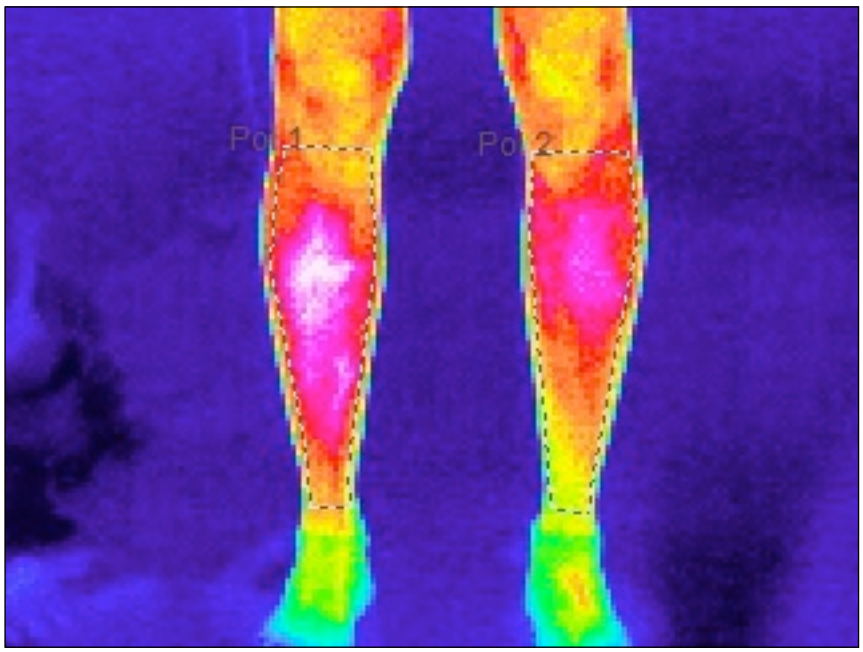
4:
SPRING: rigid/hard/normal,
PRM: none/low/normal/above normal
Vitality: none/low/normal/above normal

IR average ant. tibia:
Re 31,23°
Li 31,38°

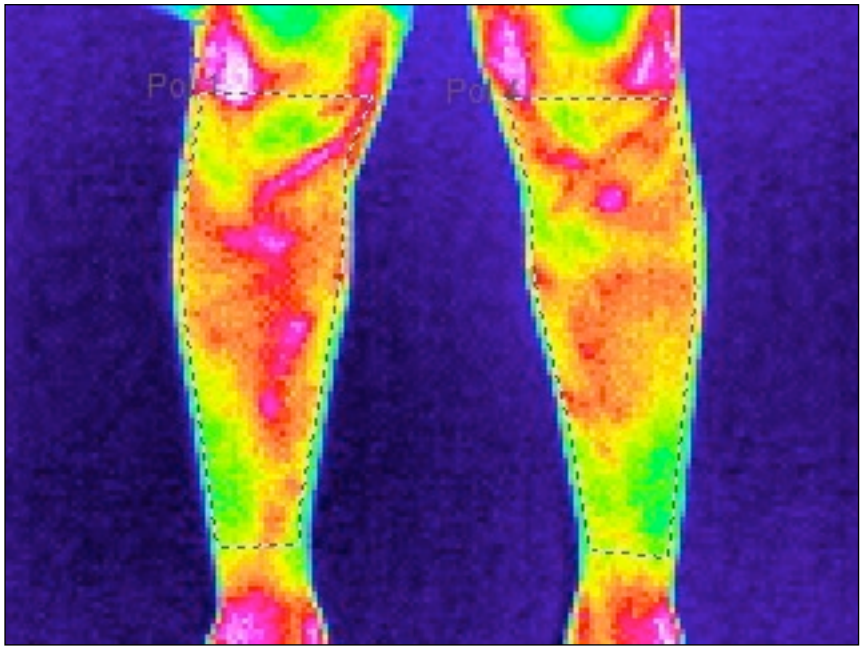
APPENDIX F: PILOT STUDY IR IMAGES



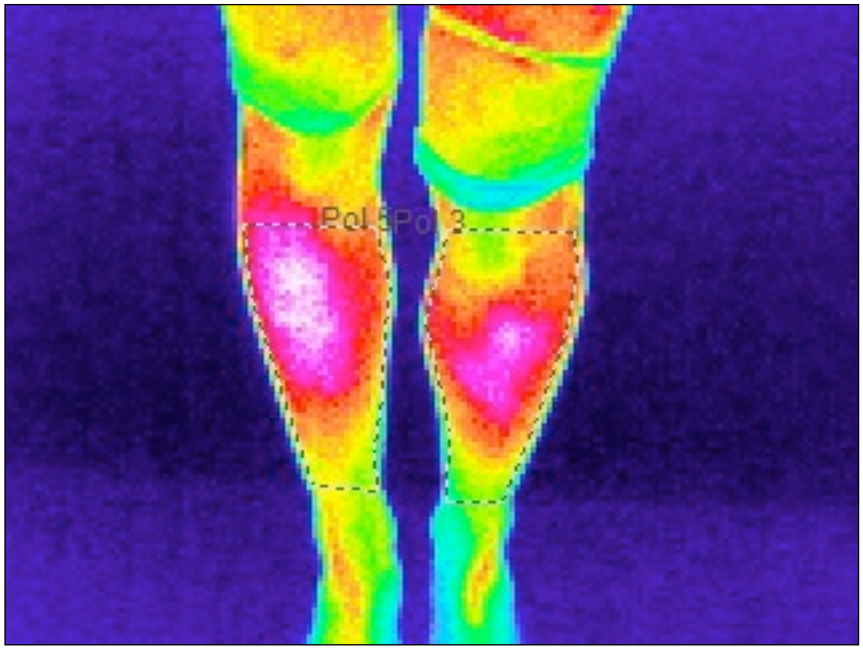
IR image of Subject 1



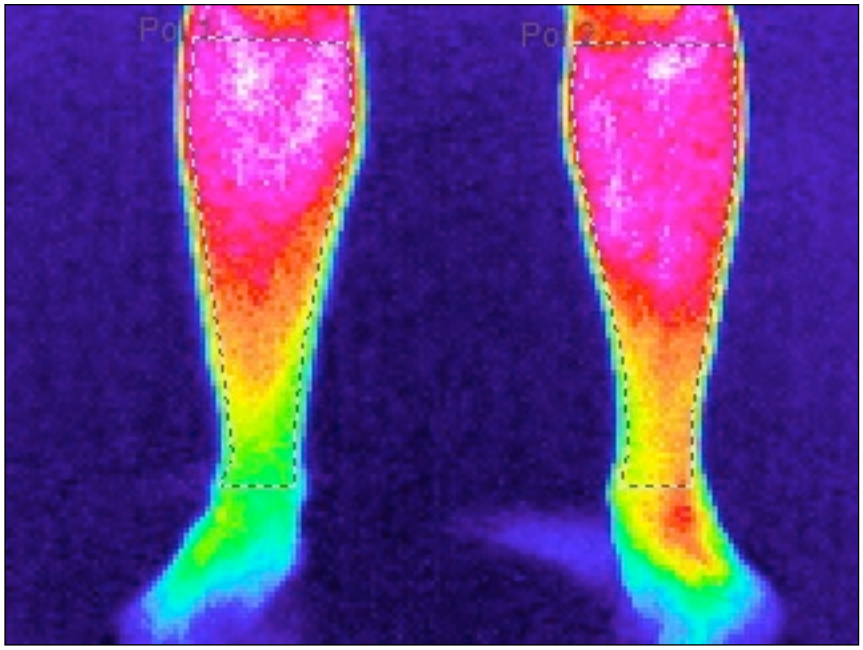
IR image of subject 4



IR image of subject 5

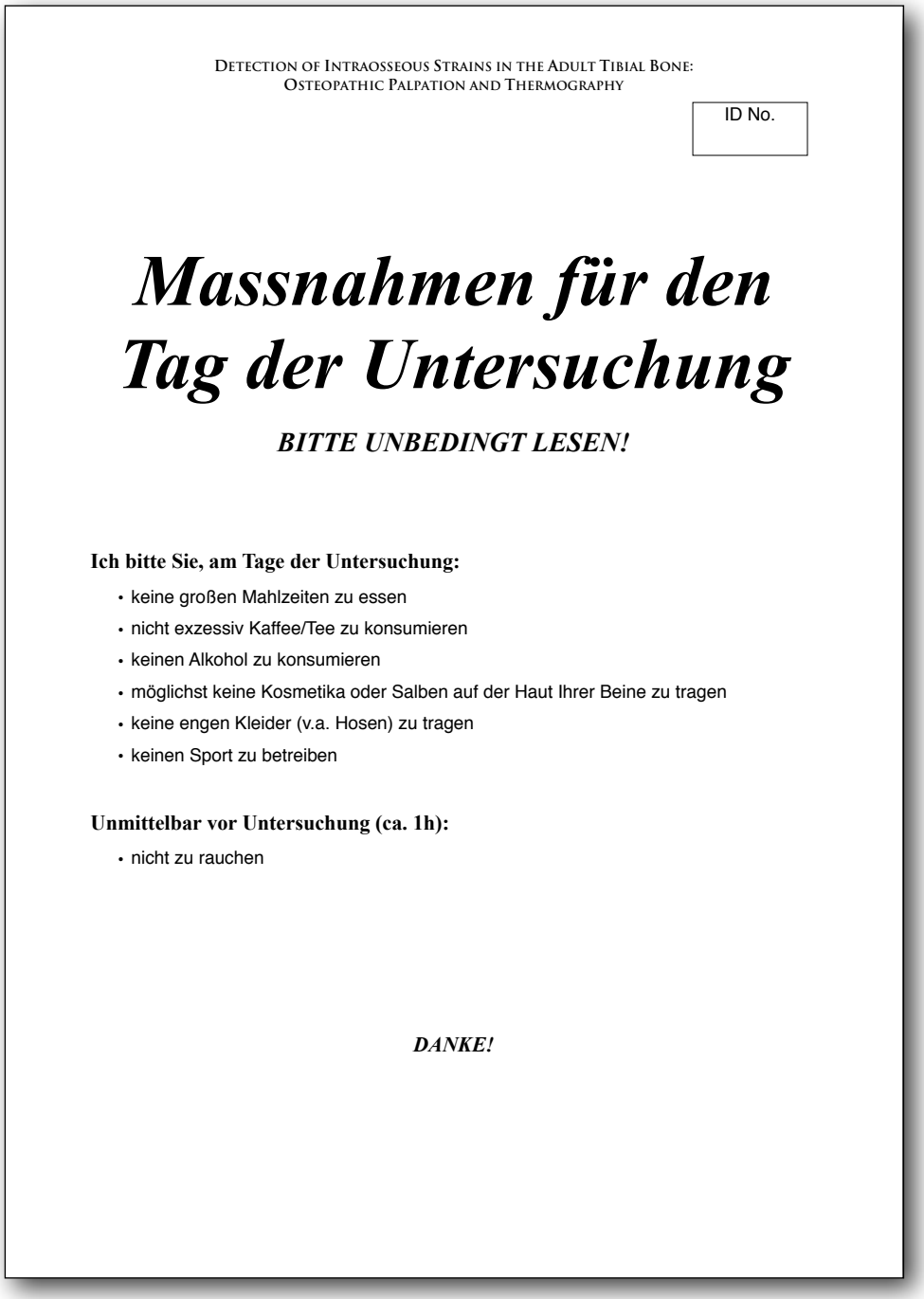


IR image of subject 6



IR image of subject 8

APPENDIX G: THINGS TO AVOID ON EXAMINATION DAY LEAFLET



DETECTION OF INTRAOSSEOUS STRAINS IN THE ADULT TIBIAL BONE:
OSTEOPATHIC PALPATION AND THERMOGRAPHY

ID No.

Massnahmen für den Tag der Untersuchung

BITTE UNBEDINGT LESEN!

Ich bitte Sie, am Tage der Untersuchung:

- keine großen Mahlzeiten zu essen
- nicht exzessiv Kaffee/Tee zu konsumieren
- keinen Alkohol zu konsumieren
- möglichst keine Kosmetika oder Salben auf der Haut Ihrer Beine zu tragen
- keine engen Kleider (v.a. Hosen) zu tragen
- keinen Sport zu betreiben

Unmittelbar vor Untersuchung (ca. 1h):

- nicht zu rauchen

DANKE!

English translation:

Activities to avoid on the day of examination:

- On the day of the examination, please avoid
  - Intake of large meals.
  - Intake of excessive coffee or tea (esp. black/green tea).

- Intake of alcohol.
- Application of any cosmetics or creams on the lower legs.
- Wearing any tight pants.
- Performing sport activities.

- Approx. 1 hour before examination:
  - no smoking

APPENDIX H: FORM OF CONSENT

DETECTION OF INTRAOSSEOUS STRAINS IN THE ADULT TIBIAL BONE:
OSTEOPATHIC PALPATION AND THERMOGRAPHY

ID No.

Einwilligungserklärung

Geschätzte Testperson,

vielen Dank für Ihre Bereitschaft zur Teilnahme an dieser Studie. Ihre Teilnahme wird sehr geschätzt und diese Studie könnte nicht ohne Sie stattfinden!

- Alle persönlichen Informationen von Ihnen werden **streng vertraulich** behandelt und sind nur zugänglich durch Edward Muntinga.
- Sie können nicht durch die Wärmebilder erkannt werden; Ihre **Anonymität** wird stets gewährleistet.
- Die Bilder werden für Studienzwecke genutzt und sind Eigentum von Edward Muntinga.

Falls Sie irgendwelche Zweifel oder Fragen haben, wenden Sie sich bitte an:
Edward Muntinga, Tel. 043 810 81 80, edward@muntinga.ch

Bitte bestätigen:

1. Ich werde am Tag der Untersuchung aufgefordert, in das Behandlungszimmer von Edward Muntinga (in der Therapiepraxis Muntinga, CH-8122 Binz) zu kommen, um **Wärmebilder** von mir aufnehmen zu lassen und darauffolgend eine **manuelle Untersuchung** an meinen Beinen durchführen zu lassen.

2. Vor den Wärmebildkamera-Aufnahmen wird es notwendig sein, für ca. 15 Minuten im Untersuchungszimmer zu verweilen, um mein thermisches Gleichgewicht zu erreichen (dies ergibt präzisere thermische Bilder).

3. Ich bin frei, während der gesamten Untersuchung eine Begleitperson dabei zu haben.

4. Ich bin frei, mich jederzeit aus dieser Studie zurück zu ziehen.

5. Ich habe dieses Formular gelesen und gebe meine Zustimmung, an dieser Studie teil zu nehmen.

Datum, Ort und Unterschrift Testerson

_____

Name in Blockschrift: _____

English translation:

Dear test person, thank you very much for your willingness to participate in this research. Your participation is highly appreciated and this research could not proceed without you!

- All your personal information will be kept strictly confidential and only Edward Muntinga will be able to access it.
- Nobody will be able to recognize you on the infrared images.
- The images are property of E.Muntinga and will only used for this research.

If you have any questions, please do not hesitate to contact E.Muntinga via telephone or email.

Please confirm:

- I am being asked on the day of investigation to come into the treatment room by Edward Muntinga (in therapy practice Muntinga, CH-8122 Binz) to have taken thermal images of me and to undergo a short manual examination on my legs.
- Before the thermal imaging camera recordings, it will be necessary to wait for about 15 minutes in the examination room, to reach my thermal equilibrium (this yields more accurate thermal images).
- I am free during the entire examination to have an attendant there.
- I am free to draw back from this study at any time.
- I have read this form and give my consent to take part in this study.

Place, date and signature of test person: _____