



CHAPTER 3

METHODOLOGY

3.1. INTRODUCTION

This chapter deals with the research methodology. The first section deals with the basic research design for the exploratory phase of the research. It provides the basic design which was progressively adapted based on the results achieved with each of the individual case studies. These changes in the approach, research and investigative questions, theoretical framework, associated propositions, rival theories, and techniques will be highlighted with the results of the individual case studies presented in Chapter 4.

3.2. EXPLORATORY RESEARCH DESIGN

The literature research has revealed that the conservative treatment approaches to the condition, is generally not successful (Edwards *et al.*, 2005). The objective with the exploratory research was thus to gain insight into the underlying theoretical framework responsible for the development of the symptoms of Chronic Posterior Compartment Syndrome (CPCS) in order to create an understanding for the lack of success in this regard. As a result of the exploratory nature of this research, it was decided to make use of a case study approach (Holloway, 1997). Due to the exploratory nature of this phase a flexible research design for the first case studies was elected. As the research became progressively more focussed, the research designs were adapted accordingly.

The objective of the first group of case studies was to explore the causal relationships of the condition. As a first step, the adequacy of the current theoretical framework was assessed as basis for the development of a potential treatment approach for the symptoms. If this proved unsuccessful, the next step would be to adapt the current framework or to develop a new one that could be used as basis for replication logic in the research.



In the following sections, the basic design for the case studies used during the exploratory design, will be reflected. This design was progressively adapted based on the insights gained from preceding cases. This typically included changes in investigative questions, the theoretical framework and associated propositions, rival theories and treatment interventions. These changes or modifications to the basic design are not discussed in this chapter, but will be progressively addressed in Chapter 4 as the rival theories are disposed off.

3.2.1. The basis for exploratory research design

The framework (Yin, 2003) which was developed in Chapter 2 for the case study protocol will be used as the basis for research design. This framework included:

General aspects

- Design classification;
- Unit of analysis;
- Subjects;
- Database; and
- Ethical considerations.

Specific issues

- Overview;
- The research question;
- Investigative questions;
- Theoretical framework;
- Propositions;
- Rival theories;
- Data collection;
- Schedule and reviews;
- Criteria for interpreting results;
- Variables and associated measures;
- Instrumentation/procedure;

- Intervention;
- Data recording; and
- Quality assurance measures.

The basic design for the exploratory research will be reflected in the following section.

3.2.2. Design classification (Scholz & Tietje, 2002)

The group of case studies dealing with the exploratory research is classified as a *Type 4: Multi-case; Embedded design* as reflected in Table 3.1. Each of the individual case studies however is classified as a *Type 2: Single-case; Embedded design* in its own right. Table 3.1 provides a brief classification of the exploratory group of research designs based on a number of dimensions that are self-explanatory in the light of the previous literature review in Chapter 2.

Table 3.1: Design classification of Case Study 1

<i>Dimension</i>	<i>Classification</i>
<i>Basic design:</i>	<i>Type 4: Multi-case; Embedded</i>
<i>Motivation:</i>	<i>Instrumental</i>
<i>Epistemological status:</i>	<i>Exploratory</i>
<i>Purpose:</i>	<i>Research</i>
<i>Data:</i>	<i>Qualitative and quantitative</i>
<i>Format:</i>	<i>Unstructured</i>
<i>Synthesis:</i>	<i>Both quantitative as well as qualitative information will be used for a narrative assessment of the current theoretical model</i>
<i>Synthesis strategy:</i>	<i>Pure case or Leibnizian model</i>



3.2.3. Unit of Analysis

The main unit of analysis is the *individual subject* who suffers from CPCS. During the experimentation alternative units of analysis will be explored on a progressive basis and could include aspects such as the *treatment process*, or *events* that trigger positive response.

3.2.4. Subjects

3.2.4.1. Inclusion criteria

For inclusion in the research project the subjects had to meet the following inclusion criteria. All subjects recruited had to:

- Be between 18 and 50 years of age;
- Actively participate in races with a distance of 10 kilometres or more;
- Be willing to run throughout the intervention period;
- Have symptoms of chronic posterior compartment syndrome in one or both lower legs; and
- Pass a subjective examination (interview) and a process of differentiation as described in the literature, to ascertain whether the symptoms were due to CPCS and not a stress fracture, tendonitis, calf muscle sprain, periostitis, spinal stenosis, radiculopathy, entrapment of arteries and nerves, claudication and effort induced venous thrombosis.

3.2.4.2. Exclusion criteria

Such subjects were excluded based on the following criteria:

Stress fractures:

- The subject had to have no pain at night or at rest;
- Percussions all along the length of the tibia with a patella hammer had to be painless;
- Ultrasound therapy applied over the painful posterior-medial aspect of both lower legs had to be painless;

Tendonitis:

- The intensity of pain should have increased and not have improved after warming up;

Lumbar nerve root:

- The subject should not have had any back pain;
- The subject should have had full range of all the lumbar physiological movements (flexion, extension, rotation and side flexion); and
- The neurological assessment should have been normal with regard to sensation, reflexes and motor strength of the L4, L5 and S1 referral/innervated areas.

Spinal stenosis:

- Lumbar spinal extension should have been normal; and
- No correlation should be reported between pain and the gradient of the running surface.

Nerve entrapments:

- The subject should not have experienced any tingling or burning sensation or pain behind the knee.

Vascular conditions (popliteal artery entrapment):

- There should not have been discoloration of the toes;
- The pain should not have increased with elevation of the leg; and
- The dorsalis pedis and posterior tibialis pulses should have been normal.

Exercise-induced venous thrombosis

- The subject should not have/ had any exercise-induced thrombosis.

The rationale for exclusion criteria was to eliminate subjects with conditions which could mimic symptoms of CPCS.

3.2.4.3. Recruitment of subjects

Subjects were recruited by means of an e-mail to all the registered running clubs in Pretoria; as well as through referrals by medical practitioners specialising in sport



injuries. The latter also included a podiatrist known in the running community for assisting runners with symptoms of CPCS. The e-mail described the symptoms of CPCS in detail and was distributed to all the different club members via the individual club's weekly newsletter to members. The e-mail is contained in Appendix 3. The medical practitioners consisted of three orthopaedic surgeons and three general practitioners, specialising in sport injuries.

Seven subjects were recruited over a period of six months from January 2002 to June 2002. One of the seven subjects sprained his ankle's lateral ligament (grade 2 ligament injury) one week after being recruited and was therefore excluded from the study. The subjects recruited were assessed by the researcher to ensure that they complied with the inclusion criteria and were then treated in the facilities of a private physiotherapy practice (i.e. the researcher's facilities) in Pretoria.

3.2.4.4. Randomness

The selection process is considered as random. The researcher, other than the pre-specified inclusion and exclusion criteria, had no way of influencing the selection process and the subjects can therefore be viewed as a representative sample of the running population with symptoms of CPCS.

3.2.5. Database

All the data are filed in hardcopy in a manual filing system. Transcribed data onto magnetic media are stored in MS Office formats on hard disc as well as removable hard disc (flash discs and DVD). The latter includes video material which is stored in this manner as well as on video tape.

3.2.6. Ethical considerations

The research was approved by the Student Ethics Committee of the Faculty of Health Sciences and the Postgraduate Committee of the School of Health Care Sciences (at the University of Pretoria) during October 2002 (protocol number: S166/2002; Appendix 1). The informed consent which had to be signed by the individual subjects is contained in Appendix 2.

Specific issues

3.2.7. The research question

The initial research question for Case Study 1 has been formulated as:

“Does the existing theoretical model for CPCS provide for a logical model of proof for predicting replication in experimental results, and does it allow for inference of the causal relationships under investigation?”

3.2.8. Investigative questions

The investigative questions are reflected in the table below.

Note: It is important to keep in mind that these questions are primarily directed towards the researcher as guidance in executing the research.

Table 3.2: Case study questions (Yin, 2003)

<i>Level 1 Questions</i>	<i>Data Source</i>
○ <i>Does the subject qualify for inclusion in the research?</i>	<i>Interview</i>
○ <i>What is the running history of the subject?</i>	<i>Interview</i>
○ <i>Has the subject had any previous injuries?</i>	<i>Interview</i>
○ <i>When were the symptoms experienced for the first time?</i>	<i>Interview</i>
○ <i>Were there any previous treatments for the symptoms?</i>	<i>Interview</i>
<i>Level 2 Questions: Physical examination</i>	<i>Data Source</i>
○ <i>Does the subject have any muscle imbalances?</i>	<i>Isokinetic dynamometer</i>
○ <i>Does the subject have any abnormal movement patterns?</i>	<i>Running gait analysis</i>
○ <i>What is the flexibility/length of the soleus muscle?</i>	<i>Physical measurement</i>
○ <i>Does palpation of the soft tissue in the calf-area reveal any tightness?</i>	<i>Observation</i>
○ <i>What is the impact of the interventions on performance measures?</i>	<i>Observation</i>
○ <i>Why do the measures respond to interventions in the way that they do?</i>	<i>Logical argument</i>

3.2.9. Theoretical framework

The current theoretical framework for the pathogenesis of CPCS as reflected in Figure 3.1 was adapted from the model of Clanton & Solcher (1994) which was discussed in detail in Chapter 2. This theoretical perspective of CPCS sees it as a localised condition in the posterior compartment. The non-compliant fascia boundaries play a crucial role in the perpetuation of the condition. As was seen from the literature review, the only marginal successful intervention is the surgical release of the pressure in the posterior compartment. This is achieved through a surgical insertion in the encapsulating fascia. This allows for increased blood-flow to the area, with associated increase in oxygenation.

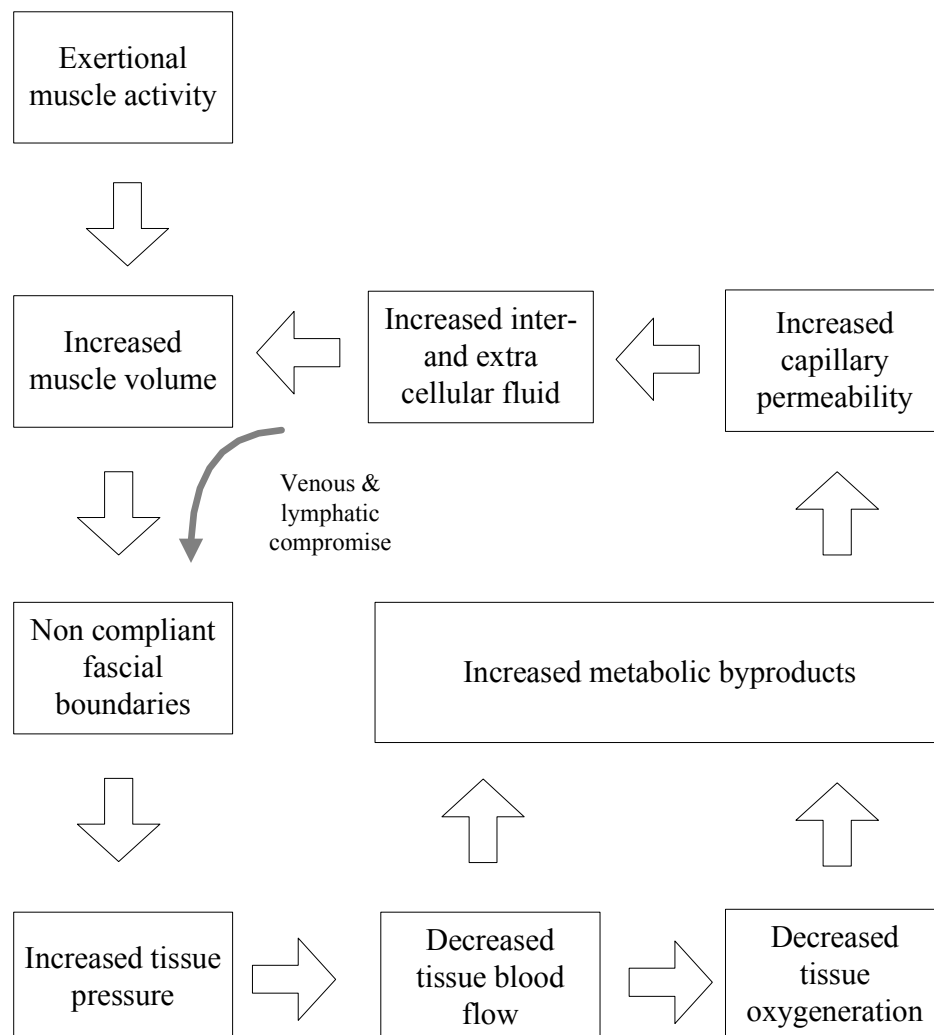


Figure 3.1: Pathogenesis of CPCS (Clanton & Solcher, 1994)

3.2.10. Propositions

The mobilization of soft tissue (myofascial tissue) of the lower leg will lead to a disappearance in symptoms of CPCS through:

- *a reduction in the pressure in the calf area which in turn will lead to the alleviation of the symptoms of CPCS; and/or*
- *an increase in tissue blood flow and associated oxygenation that will reverse the process.*

3.2.11. Rival theories

The following rival theories can be postulated:

- *The rival proposition is that the conventional treatment of the posterior compartment of the lower leg will not lead to the alleviation of the symptoms of CPCS, as a different theoretical framework is responsible for the pathogenesis of the condition.*
- *The alleviation of the symptoms of the condition is purely due to chance and the intervention has nothing to do with it.*
- *The interventions have not been applied long enough in order to generate the required response.*
- *The researcher is incapable of applying the intervention techniques in an effective manner.*

3.2.12. Data collection (Hussey & Hussey, 1997)

The principle data collection methods were:

Participant Observation:

The data was collected by the researcher by means of observation of the response of the subjects to the treatments.

Critical incident technique:

The researcher focused on interventions with a positive effect on the symptoms of CPCS as reflected in the experimental measures used.



Interviews

The researcher obtained both qualitative and quantitative information from the participants by means of interviews. Use was made of both a *positivistic* approach by means of structured questions as a *phenomenological approach* with unstructured “open-ended questions” where the subject could give his own opinion with regard to the investigation.

Records

Where appropriate, use was made of any historical records that the subject may have that had bearing on the condition.

3.2.13. Schedule and reviews

The schedule for the first case study and associated reviews was handled on an ad hoc basis due to the unpredictability of the exploratory nature of the research.

3.2.14. Criteria for interpreting results

The criteria for interpreting results were the degree of conformance to the propositions made from the theoretical framework.

3.2.15. Variables and associated measures

During the exploratory research phase the objective was the search for propositional logic. The identification of the dependant variable, i.e. the symptoms of CPCS, is fairly obvious. With the independent variables, it is however not the case.

The exploratory research process is dominated by the interaction between research question and intervention. The objective is, as stated, to find the causal explanation of the phenomenon under investigation. In this process a proposition is developed from the theoretical framework. The next step is to vary the interventions in order to assess its effect on the dependant variable. If no desired response is obtained, the researcher has to reformulate the theoretical proposition, and redo the iteration. The independent

variables are thus the *research question* and the *treatment intervention*. These variables and associated measures are reflected in Table 3.3.

Table 3.3: Case study variables and associated measures

<i>Dependant variable</i>	<i>Measure</i>
<ul style="list-style-type: none">○ <i>The symptoms of CPCS</i>	<ul style="list-style-type: none">○ <i>Intensity of pain/discomfort prior to running</i>○ <i>Intensity of pain/discomfort post running</i>○ <i>Distance run prior to symptoms</i>○ <i>Total weekly distance run</i>○ <i>Palpation findings</i>
<i>Independent variable</i>	<i>Measure</i>
<ul style="list-style-type: none">○ <i>Research question</i>○ <i>Treatment interventions</i>	<ul style="list-style-type: none">○ <i>Conformance to the proposition and theoretical framework</i>○ <i>Credibility of the rival theories</i>

3.2.16. Research process

3.2.16.1. Subjective assessment - Interview

Running history

A detailed history of each subject's running career was taken. This included:

- number of years that the subject has been running (running experience);
- his detailed training programme (total kilometres per week, quality training session- and cross training detail);
- race participation (frequency, distance and average speed) as well as
- the type of running shoes used.

The training programme was scanned for:

- sudden increases in either distance run per week or quality work such as speed work or hill training which might have precipitated the injury;



- the stability/motion control ability of the running shoe. This was assessed in order to evaluate the compatibility of shoe alignment with the degree of hind foot pronation; and
- the cumulative distance run with the shoes was also determined in order to assess whether the stability/motion control and shock absorption features were still intact.

Previous running injuries

All previous running injuries were noted, together with the treatments received and their outcomes. The rationale for recording previous injuries were, where possible, to determine previous fascia-related injuries such as plantar fasciitis, ilio tibial band syndrome and compartment syndrome. It was also noted whether the injury occurred on the left or on the right side in order to determine whether the current injury could be linked to a previous injury.

Symptoms noted

- Types of symptoms produced by the CPCS;
- Area of symptoms of CPCS;
- Intensity of the symptoms at rest as well as at the end of the training session;
- Duration of the symptoms, once produced; and
- Factors that either eased or aggravated the symptoms.

History of symptoms and any treatment received

- The history with regard to the symptoms as well as the extent of any medical, surgical and conservative treatments received, and the effect thereof.

3.2.16.2. Objective assessment – Physical examination

Muscle strength tests

Muscle strength tests (plantar- and the dorsi flexors), as determined by means of a calibrated Isokinetic dynamometer, using the same testing protocol for each of the subjects.

Analysis of running gait

Analysis of running gait (Perry, 1992) as reflected in Table 2.9 was assessed while running at a calibrated speed of 7, 6 kilometres per hour (km/hr) on a treadmill. This was video-taped from posterior as well as from the right side on a digital Sony video-camera. The right side was chosen for convenience since the room space was limited and the treadmill was placed against the left wall of the room. The camera was set up in the centre, three metres posterior to the treadmill as well as in the centre, one and a half metre to the right side of the treadmill. The video-taped information was then transferred via a frame catcher programme onto the computer. Once on the computer, the information was played through IrfanView (version 3, 92), which allowed for the analysis of movement patterns as well as the measurement of specific biomechanical angles such as the degree of hind foot pronation.

Soft tissue

The soft tissue over the posterior aspect of the lower leg was palpated for muscle spasm, trigger points, swelling and general tissue tension. The palpation was done in a direction from cephalad to caudad on the posterior side of the lower leg. This was done, using the hands and fingers in a general manner over these parts as a circular massage during which a general impression could be gained as to the state of the superficial soft tissues. Thereafter a deeper massage was done, using the tips of the three middle fingers. The purpose was to identify areas of thickness, swelling and tightness in the soft tissue (Maitland, 2006).

Flexibility of the calf muscle (soleus muscle)

The soleus muscle was chosen because it is a deeper muscle than the gastrocnemius muscle and is often indicated in the medial tibial syndrome which is often described as a compartment syndrome (Puranen, 1974; Detmer *et al.*, 1986; Touliopolous & Herschman, 1999). The subject was asked to stand flat footed, the maximum possible distance away from the wall, while still able to bend the knee to touch the wall. The distance between the big toe and the wall was measured with a tape measure. An average was then calculated based on three measurements.

3.2.17. Intervention

Three specific soft tissue mobilizations were selected which will be discussed in the following paragraphs. In order to provide for a better visualisation of these techniques, Figure 3.2 has been included for reference purposes.

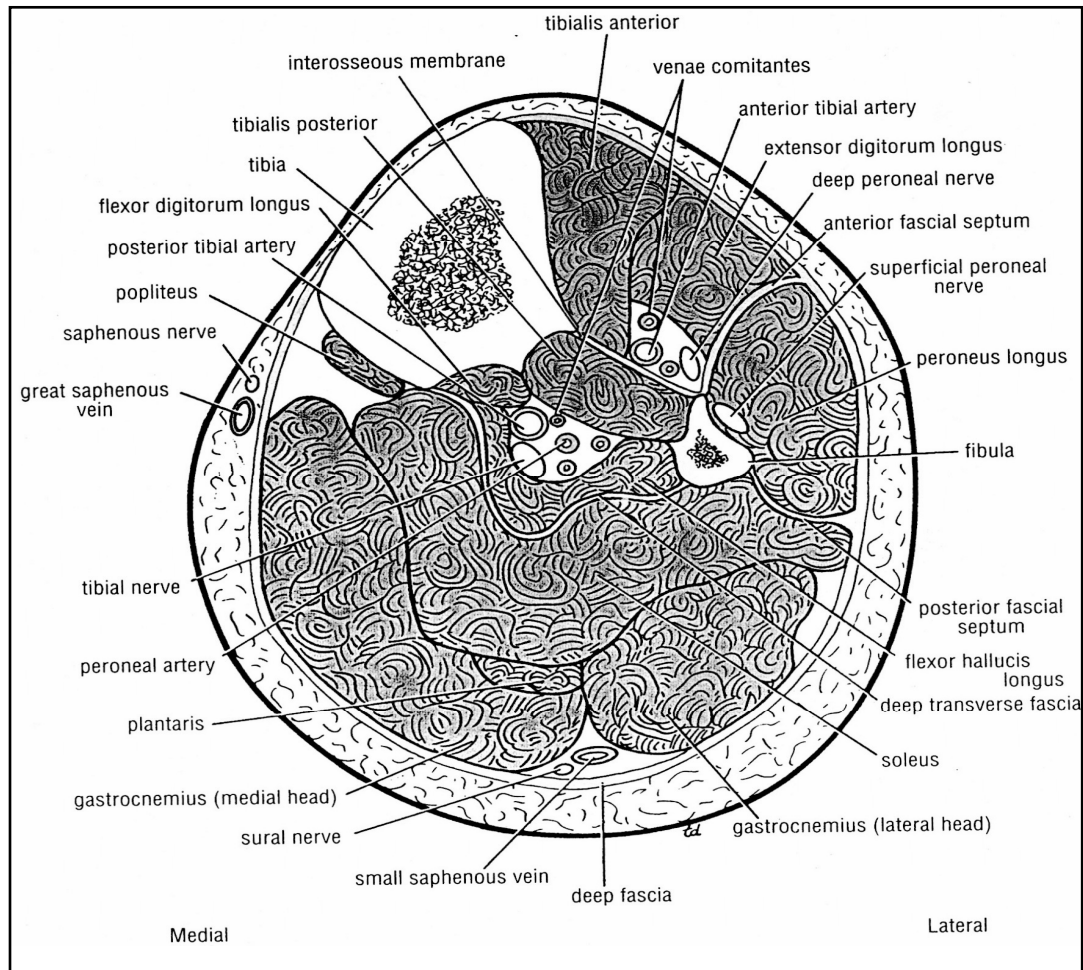


Figure 3.2: Anatomy of the compartments of the lower leg (Clemente, 1996).

- Soft tissue mobilization techniques (Hunter, 1998), aiming at reducing the pressure in the calf area and improving the blood flow to the area were applied (Figure 3.3) to the posterior intermuscular septum (on the posterior-lateral side of the lower leg- through the gastrocnemius muscle). The posterior intermuscular septum separates the superficial posterior compartment from the lateral compartment. A sustained force, aimed at a 90° angle to the posterior intermuscular septum, with slow oscillations into resistance was used in order to promote hysteresis, creep and plastic deformation of the soft tissue. A force

equivalent to a grade three (Maitland, 1991) was used for 30 seconds at a time. This mobilization technique was started proximally at the posterior-lateral part of the knee and the mobilization was repeated in a distal direction, covering an area of two to three centimetres at a time until the length of the posterior lower leg was covered.

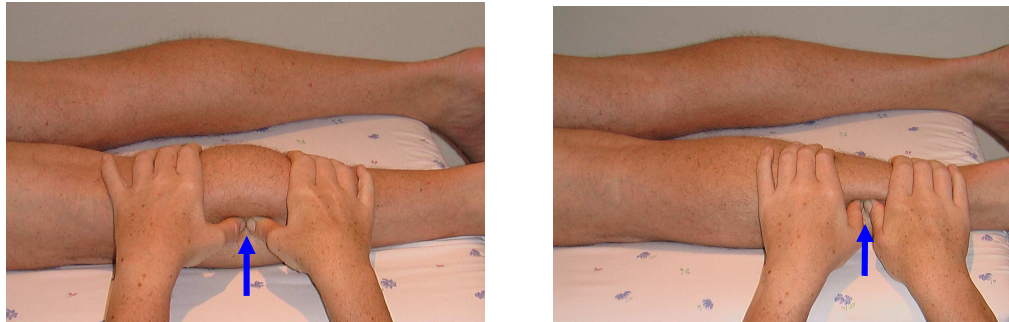


Figure 3.3: Mobilization of the posterior inter-muscular septum

- Whilst the subject was lying supine, the deep transverse fascia which lies between the flexor hallucis longus muscle and the soleus muscle was mobilised. The physical therapist faced the subject with her hand resting on the subject's lower leg with her thumb on the side of the subject's tibia where the soleus muscle is palpable next to the tibia. The therapist's lower hand supported and counteracted the movement that wanted to take place by encircling the gastrocnemius muscle from posteriorly (Figure 3.4). The therapist's upper hand glided the soleus muscle in a superior direction at the place where the soleus muscle was palpable. At the end range of the glide, accessory soft tissue mobilization techniques, equal to a grade three, were again applied for 30 seconds.

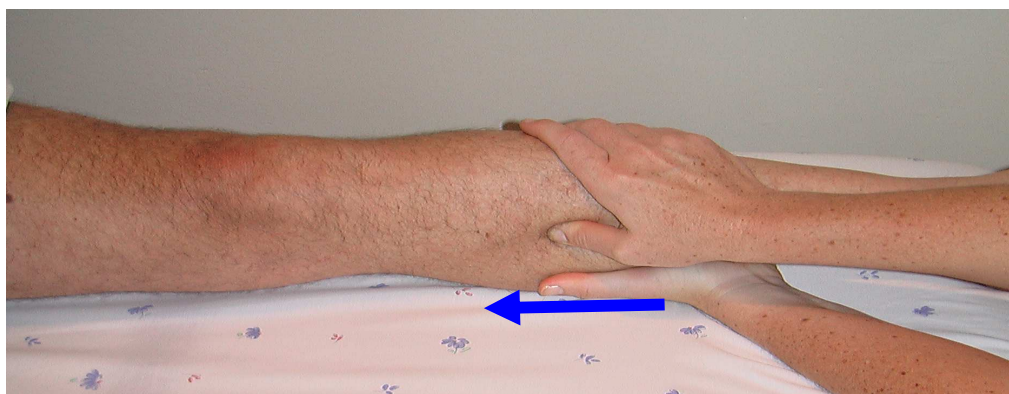


Figure 3.4: Soft tissue mobilization of the deep transverse fascia

- Thereafter the gastrocnemius muscle was glided over a fixated soleus muscle in order to mobilize the fascia of the leg that lies between these two muscles. With the subject lying prone, the researcher's underneath hand fixated the soleus muscle from anteriorly while the upper hand of the researcher rested on the posterior aspect of the gastrocnemius muscle and glided the gastrocnemius muscle superiorly over the fixated soleus muscle (Figure 3.5). At the end range of the glide, accessory soft tissue mobilization techniques, equal to a grade three were again applied for 30 seconds. The posterior lower leg was divided into the upper, middle and lower parts and the glide was applied to each.



Figure 3.5: Mobilization between the soleus- and the gastrocnemius muscles

Thereafter the gastrocnemius muscle was glided over a fixated soleus muscle in order to mobilize the fascia of the leg that lies between these two muscles. The intervention was followed with daily stretches of the gastrocnemius- and the soleus muscles. The stretches were taken to the point where a mild tension was felt and the stretch was held for 30 seconds (Hunter, 1998). Stretches were done bilaterally and each stretch was repeated twice.

The following stretches were included:

- *Gastrocnemius muscle (Travell & Simons, 1999):*
 - Wall standing;
 - Point both feet forward with legs apart;



- Keep back knee straight;
- Push hips forward;
- Press heel to ground, keeping it flat;
- Hold the stretch; and
- Repeat stretch on each leg.

➤ *Soleus (Travell & Simons, 1999):*

- Wall standing;
- Legs apart and both feet pointing forward;
- Lower the hips and bend knee of back leg;
- Push back heel flat to ground;
- Hold the stretch; and
- Repeat stretch on each side.

The intervention was scheduled for once a week. End of range treatment grades were used (grades three) and more time was needed in between treatment sessions to allow the soft tissue to recover from treatment tenderness/soreness. Since the condition treated was chronic, a treatment period of three months was decided on (this totalled approximately 12 treatment sessions).

3.2.18. Data recording

The following data were recorded during the treatment interventions:

- The intensity of pain / discomfort at rest (if present) as well as the intensity of pain/discomfort at the end of every training session was plotted on a 100 mm visual analogue scale (VAS);
- The distance run (measured in kilometres) before the commencement of the symptoms was noted at every training session;
- The total weekly distance run (measured in kilometres) was noted for the duration of the study;
- Muscle strength of the dorsi- and plantar flexors of the ankle were tested on the Isokinetic dynamometer before commencement of the intervention;

- Running gait and movement patterns were assessed, as described above, before the intervention as well as three months thereafter;
- Flexibility of the calf muscles (soleus muscle) was assessed, as described above, before and three months after the intervention; and
- The tightness on palpation of the soft tissue of the posterior lower leg was assessed before and after every treatment session.

3.2.19. Quality assurance measures

With regard to ensuring the quality of the research, the measures reflected in Table 3.4 was used to ensure the quality of the research design. The reviews of the case study designs were however not limited to peer-reviews. The designs were also reviewed by members of the running club as well as peer physiotherapists who provided a multi-disciplinary perspective. The members included physicists and an engineer. The same approach was followed with draft case study report reviews.

Table 3.4: Quality assurance measures (Olivier, 2004; Yin, 2003)

<i>Test</i>	<i>Case Study Measures</i>	<i>Research Phase</i>
<i>Construct Validity</i>	<i>Peer review of the design</i>	<i>Research design</i>
	<i>Use multiple sources of evidence</i>	<i>Data collection</i>
	<i>Establish a chain of evidence</i>	<i>Data collection</i>
	<i>Key informant reviewing draft case study report</i>	<i>Composition</i>
<i>Internal Validity</i>	<i>Pattern matching</i>	<i>Data analysis</i>
	<i>Explanation building</i>	<i>Data analysis</i>
	<i>Addressing rival explanations</i>	<i>Data analysis</i>
	<i>(Arguments based on) logic models</i>	<i>Data analysis</i>
<i>External Validity</i>	<i>Use of theory</i>	<i>Research design</i>
	<i>Use of replication logic</i>	<i>Research design</i>
<i>Reliability</i>	<i>Use of case study protocol</i>	<i>Research design</i>
	<i>Develop a case study database</i>	<i>Data collection</i>

3.2.20. Modification of the exploratory research design

The nature of the exploratory process implies that the research design be adapted progressively in line with the research outcomes. The process that has been followed is depicted in Figure 3.6. In terms of this process the outcomes of the interventions were progressively compared to the expected outcomes as reflected by the propositions that were deducted from the then ruling theoretical framework. In the event of a deviation from this expectation, the first action was to change the intervention that was applied to the subject. If the options with regard to the available treatment interventions were depleted, the researcher was forced to conclude that the proposition did not hold true. In other words one of the rival theories or a derivative thereof applied to the case study under review.

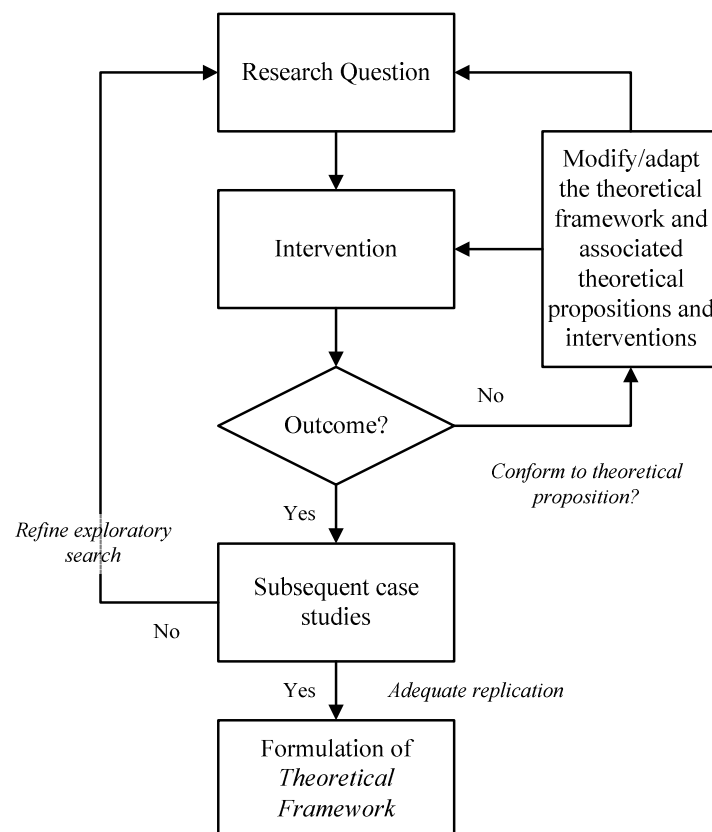


Figure 3.6: Modification of exploratory designs



The next step was thus to adapt or modify the theoretical framework and to postulate a new proposition and rival theories. This iterative approach was followed till convergence of the outputs with the expectations was reached. This implied that some degree of credibility existed in terms of the postulated theoretical framework. In such an event, the researcher proceeded with the subsequent case studies with research objectives aligned with the indications from the preceding case.

3.2.21. Conclusion

In this section the basic design for the exploratory phase of the research project was presented. This design is based on the findings of the literature research on the subject contained in Chapter 2. It also contained the rationale for as well as the process for the adaptation of this design throughout the exploratory design phase.

In the following section, the research design for the explanatory phase of the research will be covered.

3.3. THE EXPLANATORY RESEARCH DESIGN

The research design framework developed in Chapter 2 as applied to the design of the exploratory research will again be used as the foundation for the research design covered in this section. Elements of the design which are common to the exploratory research design are not repeated in this section. This includes elements such as the database, ethical considerations, and data recording.

Although the objective of pressure reduction in the posterior compartment and the normalisation of the blood micro circulation remained the same, the focus of the explanatory research phase shifted to the validation of the concept that this could be achieved through interventions aimed at the so called “*clinically significant muscles*”.

3.3.1. The research question

The research question is whether the revised theoretical model developed as a result of the exploratory research is adequate to explain the phenomenon of the pathogenesis of CPCS; and whether it can be used as a general framework for the development of conservative treatment interventions for the condition.

The main proposition of this explanatory phase of the research is that the root cause of CPCS lies outside the posterior compartment and this manifests through tightness in the clinically significant muscles. The mobilization of these tight “*clinical significant muscles*” will lead to a disappearance in symptoms of CPCS through:

- a reduction in the pressure in the calf area which will lead to the alleviation of the symptoms of CPCS through:
 - the normalisation of the length of the myofascial chain;
 - which in turn will lead to a reduction in the stresses exerted in the chain;
 - which will lead to a reduction in the radial stresses induced on the calf-area;
 - which will reduce the pressure in the posterior compartment; and
- the normalisation of the blood micro circulation and associated oxygenation which will enable final healing.

3.3.2. Theoretical framework

The revised theoretical model which was developed based on the research findings of the exploratory research phase is reflected in Figure 3.7 for the ease of reference.

3.3.3. Propositions

The mobilization of soft tissue (myofascial tissue) of the lower leg will lead to a disappearance in symptoms of CPCS through:

- a reduction in the pressure in posterior compartment which in turn will lead to the alleviation of the symptoms of CPCS; and/or
- an increase in tissue blood flow and associated oxygenation which will reverse process.

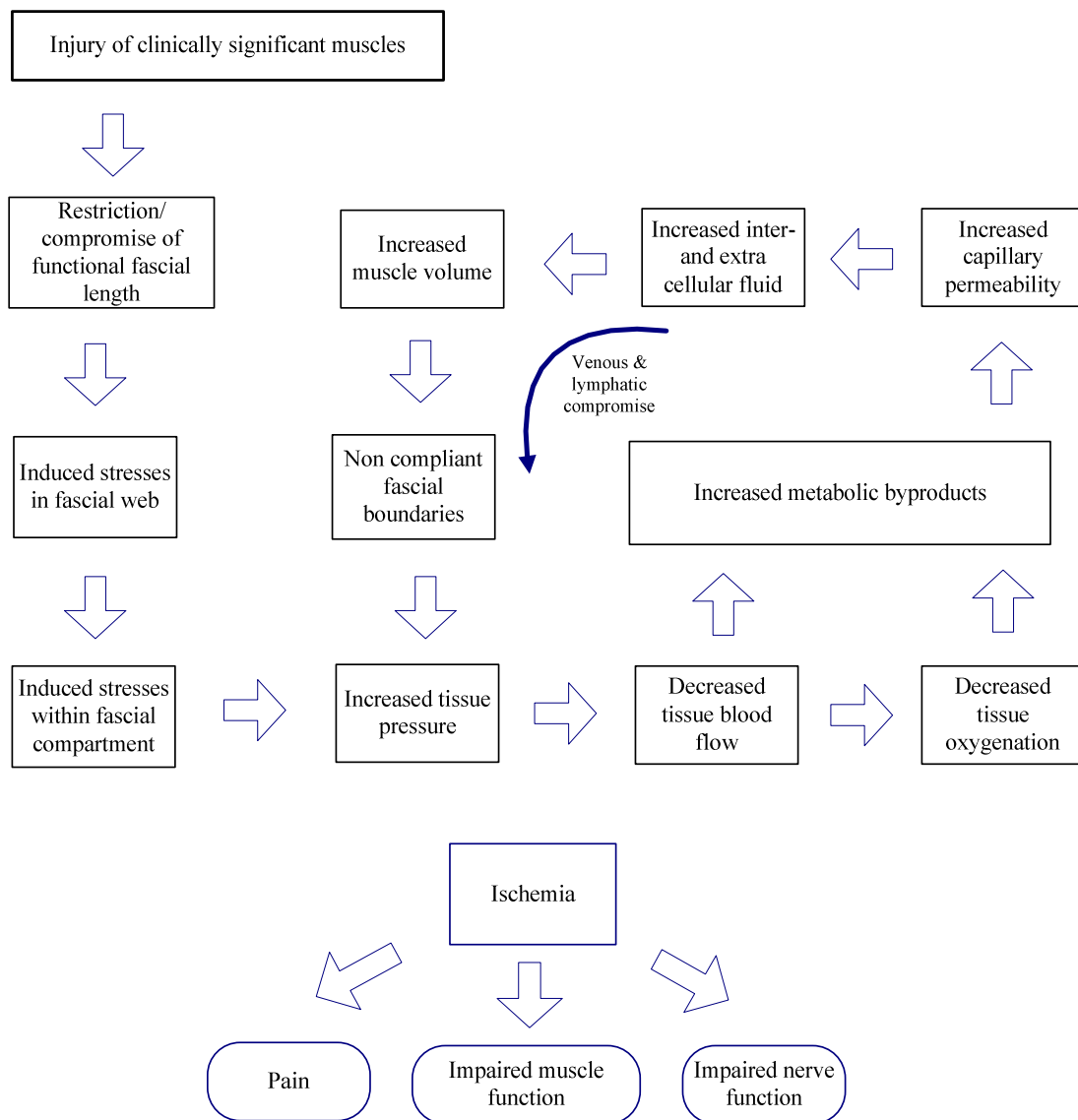


Figure 3.7: Modified model for the pathogenesis of CPCS (adapted from the model of Clanton & Solcher (1994))

3.3.4. Rival theories

The following rival theories can be postulated:

- *The rival proposition is that the release of the tightness in the clinically significant muscles will not lead to the alleviation of the symptoms of CPCS, as a different theoretical framework is responsible for the pathogenesis of the condition.*



- *The alleviation of the symptoms of the condition is purely due to chance and the intervention has nothing to do with it.*
- *The interventions have not been applied long enough in order to generate the required response.*
- *The researcher is incapable of applying the intervention techniques in an effective manner.*

3.3.5. The Research Process

In terms of the process the same process as followed during the exploratory phase will be used. The focus is however now on the application of the techniques and approaches developed based on the propositional logic as developed during the exploratory phase. The process in terms of the subjective assessment by means of interviews and the objective assessment through physical examination are the same.

Interventions

The following intervention techniques will be used to release the tightness in the clinically significant muscles:

- Trigger point releases;
- Myofascial releases;
- Specific mobilizations; and
- Interventions followed up by stretches.

3.3.6. Conclusion

In this section the basic design for the explanatory phase of the research project was presented. The actual case study research results which flowed from both the exploratory and the explanatory research will be presented in Chapter 4.

In the next section the approach and rationale for the supplementary experimental research will be presented.



3.4. EXPERIMENTAL RESEARCH

3.4.1. Introduction

This section covers the experimental design for the research on the effects of interventions on the extension at the first metatarsophalangeal joint as well as on hind foot pronation. As mentioned in Chapter 2, the FDL and the FHL muscles are important in preventing extreme plantar to dorsi flexion movement at the metatarsophalangeal joints when the foot is in contact with the ground. This implies that measurements of the metatarsophalangeal joints might provide further important information with regard to the running gait and muscles involved.

3.4.2. Degree of extension at the metatarsophalangeal joint during terminal stance

During the assessment of the video-clips of the first three subjects it was noted that these subjects appeared to rise abnormally high onto their forefeet. It was decided to investigate the phenomena. Two injury free runners were selected as a basis for comparison. Their extensions at the first metatarsophalangeal joints during the terminal phase were video-taped and compared with that of the subjects with symptoms of CPCS.

3.4.2.1. Aim of the study

The primary aim of this pilot study was to determine whether the subjects with symptoms of CPCS rose higher onto their forefeet during the terminal phase of their running gait in comparison to normal runners without symptoms.

3.4.2.2. Hypothesis

Runners with symptoms of CPCS rise higher onto their forefeet during the terminal phase of the running gait than injury-free runners.

3.4.2.3. *Research design*

The dimensions and classification of the experiment are reflected in Table 3.5.

Table 3.5: Dimensions and classifications of the experiment

Dimension	Classification
Design	Holistic multiple case, single unit (Type 3)
Motivation	Instrumental
Epistemological status	Exploratory followed by explanatory
Purpose	Research
Data	Quantitative
Format	Structured
Synthesis	Formative or method driven

3.4.2.4. *Sample selection*

Six subjects with symptoms of CPCS recruited for the research programme were included, as well as two controls from a regular morning training group. This pilot study was conducted during the therapeutic intervention applied to subjects one and two; and before the therapeutic intervention applied to subjects three to six.

3.4.2.5. *Inclusion and exclusion criteria for the controls*

Inclusion criteria of the controls

- Age: 18 – 50 years of age
- Runners participating in races with a distance of 10 km or further
- Male or female
- Had to be running at the time of the pilot study
- No injuries at the time of the study. Had to be running symptom free for at least the previous 12 months.



Exclusion criteria of the controls

- Any injuries during the last 12 months.
- Not running at the time of the pilot study.
- Not currently participating in road races.

3.4.2.6. Inclusion and exclusion criteria for the subjects

The inclusion and exclusion criteria for the runners with CPCS were covered in detail in Chapter 4.

3.4.2.7. Outcome measures

The outcome measure was the range of extension at the first metatarsophalangeal joint, measured in degrees during terminal stance of the running cycle.

3.4.2.8. Procedure

The degree of extension at the 1st metatarsophalangeal joint will be measured as follows:

- Markings will be made on the medial side of both feet. Dots will be made over the head of the first metatarsophalangeal joint and at the central-inferior border of the medial malleolus.
- Thereafter, the subjects will run barefoot on a treadmill with a calibrated running speed of 7.6 km/h.
- The subject's lower legs will be video-taped with a Sony digital video-camera whilst running.
- This video material will be copied to a specific software programme (TV 2000 combined with Corel Draw version 11) which will be used to measure the degree of extension at the first metatarsophalangeal joints.
- The dots over the centre of the inferior border of the medial malleolus and the head of the first metatarsophalangeal joint must be connected with a straight line using Corel Draw.



- A straight connecting line will also be drawn with Corel Draw between the head of the first metatarsophalangeal joint and the tip of the first toe.
- Every measurement must be taken three times at different intervals of the terminal stance of the running gait and the average of the three measurements must be calculated.

3.4.3. The effect of soft tissue mobilization on subtalar over pronation in sportsmen

3.4.3.1. Introduction

During the treatment of the subjects in case studies 4 to 6, it was noted that a release of tightness in the '*clinical significant muscles*' reduced the degree of hind foot pronation in all three runners. These observations were supportive of the revised or new theoretical model for the pathogenesis of CPCS that was beginning to take shape. In terms this framework one can argue that the stresses that are induced in the fascial web as a result of restricted fascial movement in the clinical significant muscles would also have an effect on the alignment of the feet with the rest of the body. It was thus decided to investigate the effect of soft tissue mobilization of the clinically significant muscles in subjects with abnormal pronation. Abnormal hind foot pronation as was seen in Chapter 2 is defined as in excess of 12° (Hoppenfield, 2000).

3.4.3.2. Aim of the study

The aim of the study was three-fold. The objectives were to:

- establish whether subjects with CPCS symptoms had excessive hind foot pronation (if the stresses in the fascial web were sufficient for the pathogenesis of the condition, it should also reflect in biomechanical abnormalities);
- establish whether the release of the tightness in the clinical significant muscles would normalise such biomechanical abnormalities (if these were indeed the effect of tightness, one could argue that the elimination of the root cause would lead to the normalisation of the phenomena); and
- establish whether these intervention techniques could be successfully applied by less skilled physiotherapists.

3.4.3.3. Hypothesis

The hypothesis was that abnormal pronation is as a result of tightness in the clinical significant muscles of the subjects which distorts the fascial web which in turn induces stresses in the fascial structures that leads to abnormal pronation. Such abnormal pronation could be normalized by the soft tissue mobilization techniques. It was argued that the tightness in one or more of the ‘clinical significant’ muscles compromise the effective length of the myofascial chain which in turn induces stresses along the fascial web which in turn affects the alignment of the foot and movement patterns which increase the degree of hind foot pronation. This argument is graphically reflected in Figure 3.8.

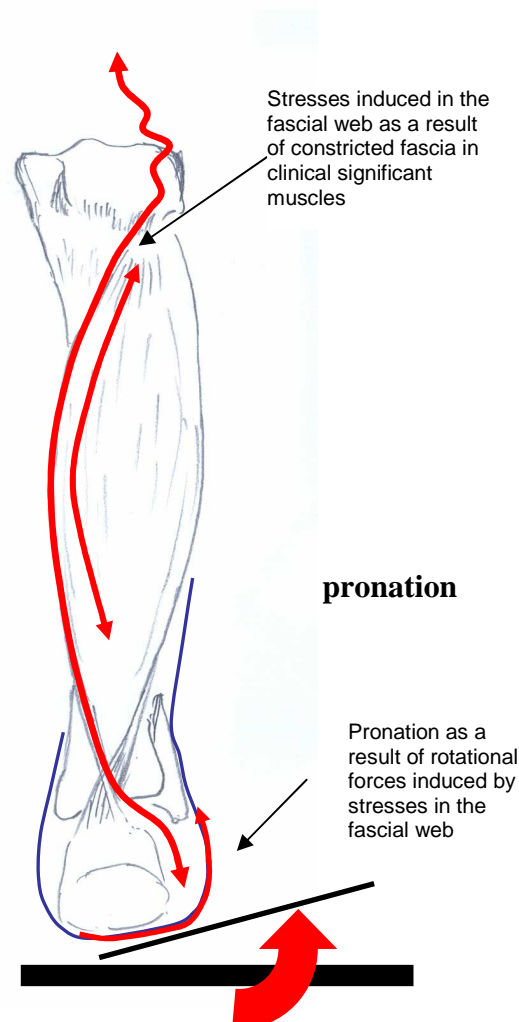


Figure 3.8: Fascial stress induced pronation



3.4.3.4. *Experimental design*

The design for the experiment involving hind foot pronation can be described as follows:

Single group design

The subjects were subjected to observation of their behaviour with the *unmodified* system, which in this case represents the degree of pronation prior to intervention, and then subsequently after the application of the intervention. The subject thus becomes its *own control*. In the broader context the results from the literature provide an additional control.

Blind experiment (application by others)

The experiment was conducted by five research assistants. These were all final year physiotherapy students at the Pretoria University.

3.4.3.5. *Subjects*

Fifteen subjects consisting of seven males and eight females, between the ages of 18 and 45 years complied with the inclusion criteria. To be included into the study, the subjects had to participate actively in a sport or activity that involved a minimum of one hour's training three times a week, live in the Pretoria area and with a hind foot pronation angle of more than 12°. The subjects were requested to continue their participation in the sport or activity whilst participating in the study.

During the interview, it was noted that ten of the subjects experienced occasional symptoms at the time of inclusion into the study but none of them had requested any form of treatment for their symptoms until then. Five subjects complained of medial shin pain, four subjects complained of lateral thigh pain and one subject complained of plantar foot pain. These symptoms were merely noted and did not influence the application of the intervention in any way.

After being briefed on the procedures, all subjects agreed to participate in the study. Subjects who had undergone surgery of the lower extremities within the previous six months, as well as subjects who had had any connective tissue disease, were excluded from the study. During the intervention period, two male subjects dropped out of the study due to work obligations. A third subject's (female) final measurements of hind foot pronation angles were lost and her results were therefore not included. Ethical clearance was obtained from the relevant ethics committee at the University of Pretoria, and informed consent was signed by all the participants.

3.4.3.6. Procedure

The degree of hind foot pronation in each subject was measured by the same podiatrist. It was measured by marking the reference landmarks in the frontal plane bisection of the posterior calcaneus, as it relates to the frontal plane bisection of the posterior aspects of the distal one-third of the lower leg (Hunt, 1998).



Figure 3.9: Measurement by means of Corel Draw software

Dots representing the axis of motion, as well as distal points of the bisections, were drawn with a pen. Skin lines connecting the dots were drawn (Gould & Davies, 1985). Thereafter, the subjects ran barefoot on a treadmill with a calibrated running

speed of 7.6 km/h. The subjects' lower legs were videotaped with a Sony digital video camera while running. This video material was copied to a specific software program (TV 2000 combined with Corel Draw version 11) which was used in turn to measure the degree of hind foot pronation. Figure 3.9 provides an example of a video frame that has been frozen and the angle measured with the Corel Draw software program.

The 'clinical significant' muscles were assessed in all the subjects prior to and after every intervention session to determine whether any tightness existed in the muscles. All the tight 'clinical significant' muscles were subsequently released by means of myofascial release techniques (Manheim & Lavett, 1989), trigger point release therapy (Travell & Simons, 1999) or specific soft tissue mobilization techniques (Hunter, 1998). For the sake of standardization, the main researcher and author demonstrated the assessment and intervention techniques to the five research assistants (fourth year physiotherapy students). The 15 subjects were divided into five groups and each of the five research assistants was responsible for the assessment and treatment of three subjects. The treatment sessions were scheduled once weekly for each of the subjects and were conducted over eight weeks. A treatment session lasted for 45 to 60 minutes, depending on the number of tight 'clinical significant' muscles. The weekly assessment and treatment sessions of all five research assistants were supervised by the main researcher. Each patient was assessed and treated by the same researcher throughout the intervention period. Each subject received the same home muscle stretching programme (mm. trapezius mid fibres, levator scapula, pectoralis major, rectus abdominus, iliopsoas, piriformis, hamstring, soleus and gastrocnemius) in order to maintain the soft tissue mobilization releases that had been achieved during the treatment session. The subjects' hind foot pronation angles were re-assessed directly after the eight-week intervention period, in the same manner as with the initial assessment.

3.4.3.7. Data management and analysis

In terms of the experimentation the independent variable was the application of the soft tissue mobilization techniques with the dependant variable being the degree of hind foot pronation.



A significant improvement in the dependent variable was defined as a change in the degree of hind foot pronation to such an extent that the subjects' measurements would fall within the range considered to be normal for the broad population.

In order to establish a confidence interval for normal pronation, it is necessary to know what the standard deviation for the pronation distribution would be. Based on the work of Hurlburt (1993) one can estimate the standard deviation based on information available on the range of observations. He has developed conversion tables with conversion factors that could be used for this purpose. The range is then divided by the conversion factor which then provides an estimate for the standard deviation.