

A COMPARISON OF PHYSIOTHERAPY AND RICE SELF TREATMENT ADVICE FOR EARLY MANAGEMENT OF ANKLE SPRAINS

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Attestation of Authorship

“I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or institute of higher learning.”

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Abstract

Ankle sprains are one of the most common musculoskeletal injuries. Physiotherapy treatment and advice to rest, use ice, use compression, and elevate the ankle (RICE advice) is believed to speed up the functional recovery and enhance healing associated with acute ankle sprains. However, there is limited evidence to support the efficacy of RICE treatment. This study investigated whether physiotherapy (including RICE advice) was as effective as RICE advice alone in improving the time to recovery in a clinical situation.

The evidence for RICE advice was reviewed along with the different treatment modalities currently used by physiotherapists in New Zealand for acute ankle sprain. This review highlighted the low number and poor quality of studies investigating RICE and early intervention physiotherapy management for ankle sprains. RICE principals appear to be relatively inexpensive and somewhat effective for pain relief and may reduce further tissue damage in the acute stage of Grade I and II ankle sprains. Evidence extrapolated from studies investigating the use of post surgical ice appears to support the use of ice in the acute stage of an ankle sprain to minimise bleeding and oedema. The intermittent application of ice is more effective for pain relief in the acute phase than sustained icing. Physiotherapy interventions such as TENS for pain relief and bracing for the support of Grade II – III ankle sprains have been shown to be beneficial for pain relief in the acute phase. A need for further high quality, randomised controlled trials (RCT's) was identified.

Subsequently a RCT was conducted with 28 participants to investigate the difference between (a) early intervention physiotherapy management combined with RICE advice, and (b) self management RICE advice without physiotherapy.

Twenty eight individuals (males $n = 22$, females $n = 6$), between the ages of 16 and 40 with acute ankle sprains, who met the inclusion criteria, were approached by physiotherapists working on this project and invited to participate. Dependant variables were pain, function, swelling, compliance and medication use up to Day 11 post injury. Swelling, pain and function were measured over three assessments on Days 1, 3 and 11, using volumetric analysis, a visual analogue scale (VAS) and a functional question derived from a validated functional questionnaire respectively. Medication use and compliance were elicited from information gathered in a participant home diary.

Both groups were similar on Day 1 in respect to their initial pain, swelling, the number of participants who were referred for X-rays, and the time taken to present to the physiotherapist. However the RICE group had significantly higher function scores ($p = 0.042$). The RICE group also had a significantly higher use of medication on Day 1 ($p = 0.035$) and Day 11 ($p = 0.048$). For both groups there was a statistically significant decrease in swelling ($p = 0.003$), pain scores ($p = 0.000$), and an increase in function scores ($p = 0.000$) in relation to time over the eleven days of assessment. The physiotherapy group had significantly improved function scores ($p = 0.042$) from Day 1 to Day 11 compared to the RICE group. There were no significant differences between groups for swelling, pain scores, and their first day of documented non-compliance. The within day range of error in the volumetric measurements was within 189.9 ml and 1.2 ml. Three trials were conducted per person within a Day session. The first volumetric analysis was significantly less than the subsequent two measurements ($p = 0.040$).

It was concluded that, in the early stage of an ankle injury both physiotherapy and RICE, and RICE advice alone, resulted in significant improvements in swelling, pain and function. Early intervention physiotherapy was significantly better at improving the functional ability of participants by Day 11. Early intervention physiotherapy may also identify complications associated with ankle sprains.

Despite its limitations this research could potentially lead to changes in the standard treatment protocols for soft tissue ankle injuries. Implementation of self management RICE by patients in the acute stage would initially reduce the cost of physiotherapy treatments, and may lead to equal improvements in pain and swelling outcomes. However, it appears that physiotherapy may lead to better functional outcomes which would reduce the costs associated with time off work, and rehabilitation. It is important to note that these findings are based on a small sample size and on Grade I or II ankle ligament sprains, and that treatment for more severe ankle injuries may be better with physiotherapy, or surgery, rather than self management RICE by patients. Findings contribute to the growing body of 'best practice' evidence for health practitioners.

Keywords: Acute soft tissue injuries, ankle, sprain, early intervention, physiotherapy, RICE, volumetric measurement.

CHAPTER 1: INTRODUCTION

Injuries to the medial and lateral ankle ligament complex (ankle sprains) are one of the most common musculoskeletal injuries and account for approximately 10% of all injuries treated in the casualty department (Frey, Bell, Teresi, Kerr, & Feder, 1996; Lynch & Renstrom, 1999). The incidence of ankle ligament sprains in the athletic population ranges from 11% to 15-20% (A.C.C., 2003; Balduini, Vegso, Torg, & Torg, 1987; Lynch & Renstrom, 1999; Safran, 1999a), and ankle sprains have been cited as the most common sporting injuries (Boyce, Quigley, & Campbell, 2005; Gross & Lui, 2003; Stasinopoulos, 2004; Verhagen et al., 2004). Ankle inversion sprains are among the most common of ankle injuries occurring in young sporting populations, accounting for to 85% of all ankle injuries and are often recurrent, adding to the incidence of these, often painful and debilitating injuries.

Injuries to the soft tissue structures around the ankle are a major cause of short term disability and pain; they often result in loss of function, which can have economic consequences due to lost working days. In New Zealand ankle sprains represent a significant cost to the New Zealand public and employers through employees requiring time off work. In addition there is considerable cost to the Accident Compensation Corporation (ACC); ankle injuries accounted for more than 82,000 new claims in the 2000/01 year at a cost of over NZ\$19 million. In the same year 17,200 ongoing claims cost ACC an estimated NZ\$12.8 million (A.C.C., 2005). In addition to the costs of time off work or sport, there are surcharges for medical attention, investigations and materials such as tape and compression bandages and private surgery. Poor management of soft tissue injuries in the acute stage can lead to long term adverse effects, such as early onset degenerative joint disease, chronic instability and chronic pain which can affect lifestyle. Chronic soft tissue injuries of ligaments, tendon and fascia account for the majority of injuries which result in prolonged instability and time of work, therefore finding the most efficacious treatment is a necessity. The goal of early management is to reduce these long term consequences, however if inappropriately applied, these treatments can also cause adverse reactions or outcomes.

The physiotherapist may be the primary medical caregiver who assesses and treats an acute ankle sprain and, as such, has a responsibility to ensure that the injury is treated in a manner that minimises that risk of further damage to the injured structures and to educate the patient on the best means to rehabilitate their injury. Appropriate interventions at the acute stage of the healing process can reduce complications, and appropriate rehabilitation can prevent recurrence. Despite being one of the most common injuries, until recent times there appears to be a low incidence of quality trials that have investigated the optimal early management of Grade I or II ankle sprains. This was highlighted by a recent review by ACC (2005), which recommended conducting well designed RCT's with adequate power and clinically relevant outcomes, and of sufficient duration to assess the effectiveness of physiotherapy techniques including rehabilitation programmes, comprising strength retraining, proprioceptive and flexibility training, and other treatments.

The current study aimed to provide information on whether or not physiotherapy and RICE management is more effective than RICE management in shortening the time to full recovery in a clinical situation for acute (up to Day 11 post injury) ankle sprains, by looking at pain, swelling and functional outcomes. This information allows us to comment on how effective multimodality treatment for ankle sprains is. The hypothesis is that physiotherapy administered in the acute stage of an acute ankle sprain injury will decrease swelling, and pain, and encourage range of movement, promote early function and prevent complications and chronicity better than if somebody just follows RICE advice. We can then document how effective the current standard physiotherapy treatment for this injury is. The sooner the return to normal working and sporting activities the better for the individual, and the more likely it is to reduce costs for public (A.C.C.) and private insurers.

The purpose of this thesis was to: (a) briefly describe the anatomy of the ankle joint, the soft tissue response to healing, and the differential diagnosis for ankle sprains (see Chapter 1); (b) review the literature on commonly prescribed management for acute soft tissue ankle injuries (see Chapter 2) and; (c) conduct and describe a Randomised Controlled Trial (RCT) which compared multimodal physiotherapy and RICE management of acute ankle sprains, to RICE management in isolation (see Chapters 3, 4 and 5).

Anatomy of the ankle joint

The ankle joint is comprised of the articulation of the distal aspect of the tibia and fibula, and the talus bones. These joints are known as the talocrural and subtalar joints. The talocrural joint is surrounded by a synovial joint capsule. Stability is provided by ligaments that surround the ankle joint, including the distal tibiofibular ligaments, the lateral ligament complex and the deltoid ligaments. The inferior or distal tibiofibular joint is stabilised by the interosseous membrane and the anterior and posterior tibiofibular ligaments (see Figure 1).

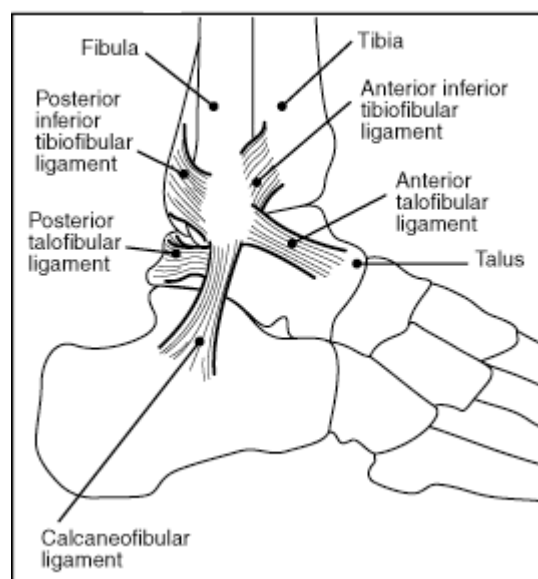


Figure 1: Lateral ankle bones and ligaments, adapted from MedicineNet.com (2007)

The lateral ligament complex is composed of three ligaments; the anterior talofibular ligament (ATFL), the posterior talofibular ligaments (PTFL) and the calcaneofibular ligaments (CFL). Slight variations in the size and attachments of these ligaments have been reported, for example Milner (1997) found that there are variations of the major bands of the ligaments and there can be several variations of minor bands present too. These variations do not appear to affect the ligaments function (Milner & Soames, 1997). The primary function of the ATFL and PTFL is to restrain anterior and posterior displacement (respectively) of the talocrural and inferior tibiofibular joint. The ATFL originates from the anterior rim of the lateral malleolus and inserts into the neck of the talus, mechanically limiting talar tilt in the sagittal plane, especially in plantarflexion. The CFL originates at the tip of the tip of the lateral malleolus and inserts into the calcaneus. It lies between the calcaneous and peroneal tendons, running obliquely,

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superior to inferior, and from anterior to posterior. The CFL mechanically limits talar tilt during dorsiflexion and talocalcaneal adduction (Hochenbury, 2001).

The deltoid (or medial) ligament comprises of deep and superficial fibres. The deep fibres originate at the medial malleolus and insert at the posterior aspect of the medial talus. The superficial portion lies anterior and is thinner, originating from the distal aspect of the medial malleolus, and widening as a fan to insert into the sustentaculum tali, calcaneonavicular ligament and scaphoid. The stability of the joint is maintained by the ligaments from (a) check rein stability reducing excessive motion (b) via proprioceptive feedback loops or dynamic stability, and (c) as a guide to direct motion (Safran, 1999a).

Biomechanics of the ankle joint

Normal biomechanics of the ankle joint

Internal and external rotation of the foot occurs about a vertical axis through the shaft of the tibia, whereas dorsiflexion and plantarflexion occurs perpendicular to the vertical rotational axis, about an axis through the lateral and medial malleoli of the ankle. Supination and pronation occur about an axis described by a line centred on the long axis of the foot and perpendicular to the previous two axes (Bahr, 1996). Inversion and eversion result from movement at the talocrural joint and the subtalar joint. Eversion is a combination of pronation, external rotation and dorsiflexion, whereas inversion combines supination, internal rotation and plantarflexion. The ligaments help control movement around the ankle joint with the ATFL and CFL working synergistically. In dorsiflexion the CFL is strained and the ATFL is relaxed. In plantarflexion the ATFL is strained and the CFL is relaxed. These strain patterns are accentuated by axial loading. The CFL and PTFL offer significant resistance to dorsiflexion and to mediolateral and posterior displacement of the talus (Bahr, 1996).

Biomechanics of inversion sprain

Inversion (lateral ligaments) sprains are more common than medial ankle sprains because the lateral malleolus projects more distally than the medial malleolus and there is less bony obstruction to inversion compared to eversion. Secondly the deltoid ligament is much stronger than the ATFL or lateral ligaments (Attarian et al. cited in Safran (1999a).

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The mechanism of 85 percent of sprains involves excessive plantarflexion and inversion movement, with subsequent damage of the lateral ankle ligament complex (Balduini et al., 1987; Liu & Nguyen, 1999; Safran, 1999a, 1999b), therefore most lateral ankle ligament injuries occur as a result of landing with the foot plantarflexed, internally rotated and supinated (inverted). The stability of the ankle mortise is compromised in this position and, unless the muscular stabilisers can compensate, the ligaments are overloaded as the weight comes down through the ankle. The consequence of this is that the fibres of the AFTL are usually the first to be disrupted resulting in 65% of all ankle sprains being located in the ATFL. If the tearing force continues the CFL is injured next. A further 20% of patients with an ankle sprain also have involvement of the CFL. Lynch and Renstrom (1999) stated that if the force continues the PTFL will also be damaged, though this is rare. Isolated injuries of the PTFL are infrequent, but occur when the ligament is under maximum strain with the foot in dorsiflexion (Lynch & Renstrom, 1999). Functional instability (where a “giving way” or painful sensation is experienced during activity due to the loss of ligamentous integrity) and loss of normal kinematics as a complication of ankle sprains may lead to degenerative changes via recurrent injury mechanisms (Safran, 1999a).

Biomechanics of eversion sprain

Injuries to the medial ligament complex occur during excessive eversion and are rare compared to the lateral ligament complex. The anterior capsule can also be injured during forced plantarflexion of the ankle.

Proprioception and neural dynamics

Proprioception is a sense described in the literature as an awareness of body position and movements of parts of the body (Tortora & Grabowski, 1996). This mechanism is disrupted following lateral ankle sprains due to the stretching of the ligaments and the golgi tendon organs, and if left untreated can contribute to injury recurrence due to the loss of the sense of body position (Boyle & Negus, 1998; Refshauge, Kilbreath, & Raymond, 2003). Furthermore, experiments have shown that muscle spindles are the primary source of information for maintaining balance during upright stance. Spindle output has been reported as the only source of afferent signal that is potentially modifiable by training (e.g., with wobbleboard training), although improvements may also be made due to central mechanisms (Ashton-Miller, Wojtys, Huston, & Fry-Welch,

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2001) which are dependant on many factors including an individuals motor skill learning capacity (Forkin, Koczur, Battle, & Newton, 1996).

The dynamic stability of the ankle joint is maintained by the neural tissues in conjunction with the muscles and tendons that surround the joint and act on the bones of the distal leg and foot. These include the peronei, tibialis, gastrocnemius and soleus, and toe flexor and extensor muscles. Numerous mechanoreceptors are present in the joint capsule, ligaments muscle and skin and provide a proprioceptive role in joint stability by contributing to the co-ordination of motor patterns and contributing to dynamic joint stability. Proprioceptive feedback from the ligaments is important for joint function. Muscle, tendon, joint and cutaneous receptors do not work independently of each other, and proprioceptive deficits may be due to damage to any of the receptors or what the interpretation of the signals is processed (Bernier & Perrin, 1998).

During rehabilitation, proprioception retraining is used to improve the deficits caused by damage to the receptors and signal processing. This is usually done in the sub-acute stage using tools such as a wobbleboard. Functional retraining can also incorporate some proprioception retraining by retraining the co-ordination of the signal processing from the receptors to the cerebellum and back via afferent pathways. This is considered important to reduce the incidence of recurrent sprains.

Soft tissue response to injury and healing times

Injury is the medical term for cellular damage, reducing the bodies' ability to tolerate the demands of functional loading. The body's response to injury, i.e. restoring the tissues ability to cope with functional load, and the healing time of this process, is usually consistent, and dictates management that is required. Management should be based on sound biomechanical timeframes (Hunter, 1998) and knowledge of the optimum method to influence the body's cascade of chemicals and processes that comprise the healing process. Therefore management is dictated by the stage of healing.

Injury

Soft tissue injury or dysfunction occurs when: (a) it is exposed to an excessive load in relation to the mechanical properties of the tissue; (b) the biomechanical properties of

the tissue have decreased in relation to a normal load, and; (c) a combination of the aforementioned processes occur (Hunter, 1998).

Biomechanical properties of tissue including the stress strain curve, hysteresis and creep

Ligaments are made from collagen which can only tolerate a certain amount of load before it is damaged. The process by which this occurs when an excessive load is applied can be illustrated by a stress strain curve (Hunter, 1998). This illustrates the point of fibre failure and ultimate failure point of the tissue, or injury. Viscoelastic properties of ligaments are described with stress strain curves that illustrate hysteresis. Hysteresis is described as a phenomenon exhibited by viscoelastic tissue when it is subjected to loading and unloading cycles, where the curves of the phases are not identical illustrating the energy lost. Creep describes a process where tissue lengthens under constant load until a point of equilibrium is reached (Hunter, 1998).

Swelling

The aetiology of swelling, (also termed effusion or oedema) that occurs post injury is multi-factorial. Subcutaneous bleeding and increased hydrostatic pressure build within capillaries causing fluid seepage into underlying tissue space (Rucinski, Hooker, Prentice, Shields, & Cote-Murray, 1991). There may be also be reduction in the lymphatic drainage due to trauma to lymph vessels (Airaksinen, Partanen, Kolari, & Soimakallio, 1991).

Oedema can limit joint range of movement (ROM) and cause pain, and is an indication of pathology or dysfunction. Persistent oedema can reduce function and lead to musculoskeletal dysfunction. When the ankle joint is not being moved an increase in capillary hydrostatic pressure known as orthostasis occurs, due to the increased gravitational force placed on the calf muscles' musculo-venous pump. This leads to an increase in transcapillary filtration into the interstitial space. Concurrently, re-absorption of interstitial fluid is reduced, slowly increasing lower leg volume. When the calf muscle is engaged during normal walking the calf musculo-venous pump acts to keep venous outflow equal to arterial inflow without undue venous dilation in the lower leg (Man, Lapar, Morrissey, & Cywinski, 2003). When the ankle is injured and painful, not only is there an increase in ankle volume due to the release of fluid, it may not be

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possible to mobilise without an antalgic gait, reducing the effectiveness of the calf musculo-venous pump, contributing to further ankle oedema.

Swelling post ankle injury is often extra-capsular. Swelling or oedema of the ankle joint may inhibit the musculature that surrounds the ankle, in a similar way that an effusion affects the musculature around the knee (Myers, Riemann, Hwang, Fu, & Lephart, 2003). Swelling appears to alter the neural signals post sprain. Simulated ankle effusion has been shown to increase H-reflex and M-wave measurements in the soleus, peroneus and tibialis anterior, although this may not result in changes in strength. The increased facilitation may occur to stabilise the foot and ankle complex during gait and posture in the injured ankle (Verhagen, van Mechelen, & de Vente, 2000).

Healing

There are three phases in the healing process; the inflammatory or lag phase; the proliferation phase and the maturation or remodelling phase. Separate processes occur at each of these phases, however, there is no distinct cut-off point as the chemical cascades and cellular activity at each level appear to overlap slightly. The processes that occur at the time of injury and immediately after (i.e., the lag phase) are those that we try and augment during early management.

During the lag phase, from approximately Day 1 to six, the cardinal signs of inflammation are described as Calor (heat), Rubor (redness), Dolor (pain), and Tumor (swelling). A fifth sign is loss of function. Acute injury causes damage to tiny blood vessels and other soft tissue structures. This bleeding combined with cellular and chemical reactions causes vasodilation of surrounding blood vessels, which allows more blood to enter the damaged area. The heat and redness is caused by the exit of white blood cells from the cellular walls. Chemicals released increase the permeability of local capillaries, allowing protein rich fluid to seep from the bloodstream into the tissue space. The release of chemical exudates causes swelling, which irritates nociceptors, causing pain. Pain is also caused by the release of bacterial toxins, the sensitising effect of the prostaglandins and kinins, and from the lack of nutrition to the cells in the vicinity (Marieb, 1995).

Treatment can and should be targeted to affect the processes that occur during the different healing phases of soft tissue, namely creep, plastic deformation and hysteresis which all alter the viscoelastic response and tissue architecture (Hunter, 1998). This may enhance the body's natural healing processes.

Epidemiology of acute ankle sprains

Incidence

Sprain injuries to the medial and lateral ankle ligament complex are one of the most common musculoskeletal injuries and account for approximately 10% of all injuries treated in the casualty department (Frey et al., 1996; Lynch & Renstrom, 1999). The incidence of ankle ligament sprains in the athletic population ranges from 11% to 15-20% (A.C.C., 2003; Balduini et al., 1987; Lynch & Renstrom, 1999; Safran, 1999a), and ankle sprains have been cited as the most common sporting injuries (Boyce et al., 2005; Gross & Lui, 2003; Stasinopoulos, 2004; Verhagen et al., 2004). Ankle inversion sprains accounting for to 85% of all ankle injuries occurring in young sporting populations. Ankle sprains are often recurrent (9% compared to 7% of total injuries) possibly due to damage to the ligament complex and the effect of the sprain on the proprioception pathways, and returning to sport before the ligament has time to heal properly (Woods, Hawkins, Hulse, & Hodson, 2003).

Risk factors for acute ankle injury

The largest risk factor in suffering an ankle sprain is having injured the structure previously. In senior footballers approximately four out of five ankle sprains occur in previously injured ankles (Ekstrand & Topp, 1990), therefore recurrence is a real risk and it is essential that appropriate rehabilitation is undertaken as this may prevent re-injury. Poor proprioception (knowledge of where the body is in space), weakness of the ankle evertors, inappropriate footwear, poor training facilities, poor rehabilitation, uneven terrain and foul play have also been suggested as risk factors (Woods, Hawkins, Hulse & Hodson, 2003).

Most lateral ankle ligament injuries occur as a result of landing with the foot plantar flexed and internally rotated and supinated (inverted). The stability of the ankle mortise is compromised in this position and, unless the muscular stabilisers can compensate, the ligaments are overloaded as the weight comes down through the ankle. The consequence of this is that the fibres of the AFTL are usually the first to be disrupted.

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Sixty five percent of all ankle sprains are located in the ATFL. If the tearing force continues the CFL is injured next. A further 20% of patients with an ankle sprain also have involvement of the CFL. Lynch and Renstrom (1999) stated that if the force continues the PTFL will also be damaged, though this is rare. Isolated injuries of the PTFL are infrequent, but occur when the ligament is under maximum strain with the foot in dorsiflexion (Lynch & Renstrom, 1999).

Signs and symptoms

Often the patient experiences a tearing sensation associated with pain in the lateral or medial aspect of the ankle (depending on the mechanism of injury). The injured ligaments become tender to palpation. Swelling and a localised haematoma may be evident only a couple of minutes after the incident which, if untreated gradually, increases. Ecchymosis (bruising) becomes evident over the next 24 to 78 hours and often travels down into the foot (above the fat pad) due to gravity.

Differential diagnosis

Ankle sprains occur when the ligaments that support the talocrural and subtalar joints are damaged. Symptoms include pain, swelling, and a decreased range ROM of the ankle joint, tenderness to palpation of the damaged ligaments, and a reduction in functional ability and mobility.

As there are multiple different pathologies associated with injury to the ankle region, clinical diagnosis and tests are used to differentiate ankle injuries. A list of possible ankle injuries, separated by their incidence, is presented in Table 1. The anterior drawer test is used to assess the integrity of the ATFL, and the talar tilt test is used to assess the integrity of the CFL. Manual muscle testing is used to assess strength and integrity of the invertors, evertors, plantarflexors and dorsiflexors around the ankle. Timed balance tests, with and without visual cues, can assess a loss of proprioception. Functional questionnaires assess the functional level of the patient and the effect of the injury on their activities of daily living. Passive and active range of movement are assessed using a goniometer and can be recorded as degrees of motion.

Table 1: Differential diagnosis for acute ankle injuries modified from Brukner and Khan (2001)

<i>Common</i>	<i>Less Common</i>	<i>Not to be missed</i>
Lateral ligaments sprain	<p>Medial ligament sprain</p> <p>Peroneal dislocation</p> <p><i>Fractures</i></p> <ul style="list-style-type: none"> -Lateral/medial/posterior malleolus -Potts -Talar dome -Tibial plafond -Base of 5th metatarsal -Anterior process of calcaneus -Lateral process of talus -Posterior process of talus -Os trigonum -Bone bruise -Loose bodies <p>Dislocated ankle (fracture/dislocation)</p> <p><i>Tendon rupture</i></p> <ul style="list-style-type: none"> -Tibialis posterior -Peroneal tendons 	<p>Reflex sympathetic dystrophy (post injury)</p> <p>Greenstick or growth plate fractures (children)</p> <p>Ruptured syndesmosis</p>

Grading ankle sprains

Grading the severity of an ankle sprain in the acute setting has been reported to be difficult and not reliable (van Dijk, 1999) due to local swelling, muscle spasm and limb guarding, and the accuracy of the manual stress tests in the first 24 hours has been questioned (Fujii, Luo, Kitaoka, & An, 2000). It appears that more accurate assessment and grading can be performed four to seven days post injury (Liu & Nguyen, 1999; Lynch & Renstrom, 1999; van Dijk, 1999). It therefore makes no sense to use other expensive diagnostic methods in the acute phase of the injury, unless there is an indication of a fracture under the OTTAWA Ankle Rules for X-ray (Stiell et al., 1995).

The ‘gold standard’ for diagnosis is currently Magnetic Resonance Imaging (MRI), however, it was not considered appropriate for this study due to the expense of the imaging. Clinical subjective and objective assessment by an appropriately trained physician is most often all that is used in the clinical situation to diagnose ankle sprains. Ultrasound imaging using high frequency electronic transducers can provide accurate evaluation of ankle sprains although accurate diagnosis requires the use of high level equipment, which is not easily accessed by physiotherapists in the clinical setting (Morvan, Busson, Wybier, & Mathieu, 2001). Information obtained from diagnostic imaging is still imperfect. It also only indicates the severity of the injury, not the impact

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on the injured person's daily life. The severity of the ligamentous injury cannot be elucidated by X-ray photography or CT scans. Arthroscopy is very invasive and unnecessary in most cases.

Grading system

Grading in the sub acute phase (4-5 day after trauma) according to van Dijk, (1999) is shown in Table 2. These results concur to a large degree with the findings of Liu and Nguyen (1999) who reported that the specificity and sensitivity, of grading four to five days after the injury was sustained, was 84% and 96% respectively.

Table 2: Sensitivity and specificity of grading for lateral ligament sprains in the sub acute phase

Criterion	Sensitivity	Specificity
Anterior drawer	75%	79%
Haematoma	88%	78%
Combination of haematoma and palpation if possible	90%	/
Combination of all three tests positive	99%	77%

(van Dijk, 1999)

Generally ankle sprains are divided into 3 grades. Grade I (mild), Grade II (moderate) and Grade III (severe). The characteristics attributed to each grade vary, and there is a large range of subjectivity during test evaluation. Table 3 shows a summary of the grading descriptions based on the West Point Ankle Sprain Grading System.

Table 3: West Point ankle sprain grading system

Criterion	Grade I	Grade II	Grade III
Location of tenderness	ATFL	ATFL, CFL	ATFL, CFL, PTFL
Oedema, Ecchymosis	Slight local	Moderate local	Significant diffuse
Weight-bearing ability	Full or partial	Difficult without crutches	Impossible without significant pain
Instability-Anterior Drawer Tests	None	None or slight positive	Definite Positive
Instability - Inversion stress test	None	None or slight positive	Definite Positive

Grade I sprain for a lateral ligament is described as; ligament injury without macroscopic tearing, very little functional loss and weight bearing is possible. There is tenderness over the ATFL. The ligaments have been stretched and the Anterior Drawer test is negative. There is no instability of the ankle. Slight local swelling and haematoma may be present.

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Grade II sprain of the lateral ligament of the ankle has a partial macroscopic tear and weight-bearing ability is very limited. Tenderness over the ATFL and CFL is present and there is increased laxity when performing the Anterior Drawer test. No, or slight, instability of the ankle is present and the swelling and haematoma remain largely localised.

Grade III injury to the lateral ligament of the ankle is defined by a complete macroscopic tear. There is complete functional loss and weight bearing is impossible without severe pain. There is tenderness and pain over the ATFL, CFL and the PTFL. The Anterior Drawer Test is positive. There is marked instability and the swelling and haematoma are diffuse.

The Anterior drawer test is performed with the ankle in a neutral position. A stabilising hand is placed on the anterior aspect of the tibia, five centimetres proximal to the joint line. The dynamic hand cups the heel and displaces the foot in an anterior direction, which stresses the ATFL ligament. A positive sign, which indicates a tear of the ATFL, is when there is more than 3mm anterior shift. The sensitivity and specificity for grading lateral ankle sprains is shown in Table 3.

It is important to exclude an avulsion fracture in adolescents and other fractures in severe sprains. Avulsion fractures of the ATFL and CFL are more frequent in adolescents and children as the ligament is stronger than the growth plate at this developmental level. The Ottawa Ankle Rules are used to identify whether radiography is necessary to exclude bony pathology (Stiell et al., 1995; Stiell et al., 1992).

The Ottawa ankle rules

The Ottawa ankle rules are used to give an indication of need to refer for an X-ray, or if a syndesmosis injury is suspected (X-rays requested should include anteroposterior, lateral and mortise views.) Ankle X-rays are indicated if there is bony tenderness in the areas described by the Ottawa guidelines, or if the patient is unable to weight bear four steps or more at the time of injury and at the time of clinical examination. The Ottawa guidelines (see Appendix 3) have a very high sensitivity. From 99.6% for identifying fractures with 48 hours of injury, to 96.4% in combined assessments for detecting clinically significant fracture (Bachmann, Kolb, Koller, Steurer, & ter Riet, 2003).

Prognosis

There is no consensus on how long it takes for a ligament to reach 85-95% of its normal tensile strength, with figures ranging from 16 weeks to 40-50 weeks (Houglum, 1992). The severity of the injury would impact on the recovery time with grade I injuries returning to sport quicker than grade II injuries, and grade III injuries may not resolve, leading to ongoing problems and decreased participation sport. A study by Woods (2003) found that 83% of ankle sprain injuries needed a rehabilitation period of less than one month to return to playing football.

CHAPTER 2: LITERATURE REVIEW

A SYSTEMATIC REVIEW OF THE EFFICACY OF PHYSIOTHERAPY AND RICE MANAGEMENT ON SOFT TISSUE INJURIES AT THE ANKLE JOINT

Search strategy

The literature search regarding the efficacy of physiotherapy and also the efficacy of RICE management, on acute soft tissue injuries was completed in the form of a systematic review (SR). Two separate literature searches were conducted; first, on RICE principals, then on physiotherapy management for ankle sprains.

A search to identify RCT's, controlled clinical trials (CCT's) and SR's for each of the RICE principles separately, as a global term, and ankle sprains, was conducted in electronic databases which included EBSCO health databases, Physiotherapy Evidence Database (PEDro), Sport Discus, CINAHL, Cochrane Library, AMED, Blackwell-synergy, Proquest 5000 international and Web of Science.

For RICE principles the following keywords were used: *ankle, sprain, volume, oedema, edema, R.O.M., pain, vas.* In addition, several other keywords were used for each specific principle:

- **Rest:** *rest, immobilisation, immobilization, mobilisation, mobilization, cast, brace, crutches;*
- **Ice:** *cryotherapy, ice;*
- **Compression:** *compression;*
- **Elevation:** *elevation.*

Several limitations for the inclusion of literature in this review were assigned.

Inclusion criteria were:

- Literature from 1990 to 2005;
- Literature which examined pain, functional recovery, ROM or volume measures;

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- Literature which examined lateral ankle ligament sprains.

Note; Some SR's summarised literature from before 1990 in their papers and it was decided to include their summaries of papers where the results were relevant.

Exclusion criteria were:

- Literature where participants had sustained a fracture.

Second, a search was conducted to identify SR's, clinical trials and clinical papers related to physiotherapy modalities including; proprioceptive training, strengthening, mobilisations, physiotherapy and the ankle joint. This search was conducted within electronic databases including CINAHL, EBSCO and MEDLINE. The search was conducted using the keywords: proprioception and ankle, ankle sprains and mobilizations or mobilisations, strengthening and ankle sprains, and physiotherapy or physical therapy and ankle sprains. Limitations were set restricting the search to research in peer reviewed journals, in English, published between 1995 and 2005.

Method of review

From the search, the titles and/or abstracts of the resulting citations were reviewed to identify relevant papers. From each relevant paper, the reference list was inspected to identify other appropriate papers.

Evidence weighting

To critically review the relevant literature, the PEDro scale (See Table 4), was employed (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003). The PEDro scale is a validated eleven point scale rated out of ten because the first criteria is not scored (see Table 4); developed to rate the methodological quality of RCT's evaluating physiotherapy interventions for the PEDro Database. To allow comparison between methodological quality of RCT's and CCT's, the same PEDro scoring system was used for both trial designs. However, it should be noted that, by definition, a CCT is unable to fulfil the criterion related to random allocation of participants (criterion 2).

Table 4: PEDro scale

Criteria		Score	
1.	Eligibility criteria were specified	no	yes
2.	Participants randomly allocated to groups	no (1)	yes (1)
3.	Allocation was concealed	no (1)	yes (1)
4.	Groups similar at baseline regarding the most important prognostic factors	no (1)	yes (1)
5.	Blinding of all participants	no (1)	yes (1)
6.	Blinding of all therapists who administered therapy	no (1)	yes (1)
7.	Blinding of all assessors who measured at least one outcome	no (1)	yes (1)
8.	Measures of at least one key outcome were obtained from more than 85% of initially allocated participants	no (1)	yes (1)
9.	All participants for whom outcome measures were available received treatment or control as allocated, or if this was not the case, at least one outcome measure analysed using 'intention to treat' analysis	no (1)	yes (1)
10.	The results of between-group statistical comparisons are reported for at least one key outcome	no (1)	yes (1)
11.	The study provides both point measures and measures of variability for at least one key outcome	no (1)	yes (1)
TOTAL		/10	

The original developers of the PEDro scale do not recommend specific cut-off scores to indicate the quality of trials. Thus the selected cut-off point, to determine the quality of trials, remains arbitrary. For example, O'Conner and Hurley (2003) used a two category system, where trials scoring six or higher were considered of 'high' methodological quality. On the other hand, Harvey et al. (2002) placed trials into three different categories of quality, depending on their score. In order to strengthen the critique of the papers a quality score was used.

Quality score

In the PEDro scale, each item deals with different aspects of RCT analysis, including internal validity, external validity and statistics. Quantitative analysis is made difficult as RCT's cannot always be directly compared, whereas interventions can be. Therefore where the RCT's reviewed were not clinically heterogeneous, it was appropriate to use a qualitative method of analysis (Reid & Rivett, 2005; van Tulder, Assendelft, Koes, & Bouter, 1997). The qualitative assessment was an adaptation of those used by other authors (Karjalainen et al., 2001).

To quantitatively analyse the methodological quality of each study, the seven items of the PEDro scale that correspond to internal validity were identified and each of these items was allocated a score of one. The seven items corresponding to internal validity are; item numbers 2, 3, 5, 6, 7, 8, 9 (refer to Table 4). The positive score of each of

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these seven items were added together to calculate an Internal Validity Score (IVS) with a possible total out of seven (Reid & Rivett, 2005). Based on the IVS an overall score of methodological quality, or quality score (QS), was determined for each paper.

Using the QS a qualitative assessment was made about the methodological quality of each paper (Karjalainen et al., 2001; Reid & Rivett, 2005). An example is listed below:

- *Level 1:* Strong evidence – when provided by generally consistent findings in multiple RCT's of high quality (IVS = 6-7);
- *Level 2:* Moderate evidence – when provided by generally consistent findings in one RCT of high quality (i.e., IVS = 6-7) and one or more lower quality RCT's (i.e., IVS \leq 5);
- *Level 3:* Limited evidence – when provided by generally consistent findings in one RCT of moderate quality (i.e., IVS = 4-5) and one or more low quality RCT's (i.e., IVS \leq 3);
- *Level 4:* Insufficient evidence – when provided by generally consistent findings of one or more RCT's of limited quality (i.e., IVS \leq 3), no RCT's available or conflicting results.

For this review the total of the seven-item IVS, taken from the initial PEDro score was described as a QS as has been previously described in Ellis (2006). A study of *high* methodological quality was considered to be one with an IVS of between 6-7, *moderate* quality scored between 4-5, and *limited* quality was allocated to the studies that scored between 0-3 (Ellis et al., 2006).

Results of the literature review

The literature review identified the available literature on the management of ankle sprains. The search identified trials that investigated a single intervention, (such as compression using only one type of bandage and a control), trials that investigated two types of intervention (such as two types of compression bandages and a control, or compression compared to ice and a control) and trials that investigated multi-modal physiotherapy (where a combination of more than one type of intervention was compared to a control). Only one multimodal physiotherapy trial was identified (Holme et al., 1999). Considering that most physiotherapists use a combination of treatments to achieve their goals in the rehabilitation of ankle sprains, this is surprising.

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The literature review also identified two guidelines and evidenced based summaries of recent research into RICE, physiotherapy modalities and the treatment of ankle sprains and ruptures. Table 5 illustrates the recommendations and outcomes of the two guidelines for RICE and physiotherapy management for ankle sprains. Note the difference of opinion for immobilisation. ACC (2005) discourages the use of cast immobilisation for any grade of ankle sprain, yet the BMJ Clinical evidence concise guidelines (2006) suggest that immobilisation is likely to be beneficial, however, not as effective as functional treatment. Functional treatment by definition involves some sort of bracing to allow for early mobilisation. The difference in opinion of these two recent guidelines illustrates some of the problems associated with interpreting the literature. There was few good quality RCT's providing strong evidence for either RICE or physiotherapy management, which means that the benefit of applying these modalities has not been proven beyond doubt.

Table 5: Summary evidence from guidelines for management of ankle sprain

Treatment	Beneficial	Likely to be beneficial	Equivocal	Unknown	Unlikely to be beneficial	Discouraged
Ice				A.C.C	BMJ	
Contrast Baths						A.C.C
Elevation		A.C.C				
Surgery			BMJ			
Immobilisation		BMJ				A.C.C
Manual therapy			A.C.C			
Functional treatment	A.C.C. & BMJ					
Electrotherapy			A.C.C			
Diathermy				BMJ		
Ultrasound					BMJ	
Laser						A.C.C
Acupuncture				A.C.C		

References

A.C.C. (2005). Managing soft tissue injuries: A summary of recent research [Electronic Version], 12.8.05.

BMJ. (2006). Clinical Evidence Concise (15th ed.). London: BMJ Publishing Group.

The continuum of treatment

Treatment techniques for ankle sprains used by physiotherapists in New Zealand may be divided into acute and sub-acute techniques and rehabilitation. Treatments modalities include, but are not limited to:

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Acute: RICE, palliative techniques, strapping, bracing, gait re-education, active exercises, walking aids, maintenance exercises for lower limb, and proprioception exercises;

Sub-acute: frictions, stretches, muscle balance programmes, proprioception, palliative techniques, manual therapy, intrinsic strengthening, full rehab, functional rehab and retraining, ongoing braces and strapping as required, and mobilisations with movement (MWM's) of the joint (A.C.C., 2000).

Treatment for ankle sprains is not standardised, however, there are treatment profiles and guidelines developed for physiotherapists practising in New Zealand, based on available literature (A.C.C., 2000). The techniques that individual therapists administer would depend on their training, the signs and symptoms of the presenting patient and the phase of the healing process. Not every clinician uses all the available modalities in every treatment session and the combinations of different modalities could change at each session depending on the clinician's clinical reasoning of what is appropriate at that session. This is the inherent multimodal nature of treatment that physiotherapists use as there is usually more than one problem or deficit that requires attention and more than one option or method to address the problem.

RICE

RICE is often recommended as a management protocol for acute soft tissue injuries to reduce the inflammatory response (A.C.C., 2000, 2004). RICE is cheap, readily available to the general population and, if the correct advice is issued, does not require the presence of a medical professional. Recommendations for RICE management in the acute phase of healing is purported to quicken the time to return to sport and activities of daily living. At present this appears not to be supported by all the literature. There is surprisingly little evidence to support RICE management. The following section is devoted to investigating the recent literature on the RICE principals.

Rest

When searching for the principal of 'rest' the list of words used were; rest, immobilisation, immobilization, mobilisation, mobilization, cast, brace, and crutches. This is because rest is on a continuum from immobilisation to mobilisation, and may require braces, taping or a reduction in activity. The trials offering evidence for the

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principle of immobilisation were sub-grouped into two types of treatment comparisons; a) trials which compared different types of braces with immobilisation; b) trials comparing immobilisation with functional treatment protocols. The latter will be further discussed in the functional treatment section later on in the review (It must be remembered that immobilisation and functional treatment are on opposite ends of a continuum).

According to the American Academy of Orthopaedic Surgeons, cited in ACC (2005), the principle of rest involves the avoidance of movement of the injured part, as soon as possible, to limit further injury. With this description in mind, avoidance of ankle movement could be achieved with the implementation of interventions such as bracing, strapping or use of crutches to avoid weight bearing, by restricting walking on the affected limb or actively reducing activity that would stress the ankle. ACC's description of the how to rest advises that "rest reduces further damage – stop activity as soon as the injury occurs. Avoid as much movement of the injured part as soon as possible to limit further injury. Don't put any weight on the injured part of the body (A.C.C., 2002).

There were no studies that specifically dealt with rest as a treatment option for acute ankle sprains. It is sensible to avoid activity on an acute injury as the tensile strength in the ligament could be compromised and the risk of further injury is likely to be increased. Rest is commonly prescribed and, in the acute phase, it would appear to be appropriate, as it may allow for more consolidated healing. However, there are no set parameters as to what precisely is involved in rest advice (besides not participating in the activities of daily living). Therefore, there is a need for studies to investigate the optimum time period that rest may be prescribed, as this is not clear from the available literature. Although the strength of evidence is weak, rest may be appropriate in the early acute phase, however, functional treatment appears to be more efficacious than rest for grade one and grade two injuries in the sub-acute phase. Rest is on the continuum with immobilisation, and they have many commonalities, in that immobilisation could be considered enforced rest for a prolonged period. Both require as little weight bearing as possible to allow structural bonds to strengthen. Evidence for rest in the acute stage could be extrapolated from the research into immobilisation.

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Immobilisation differs somewhat from rest. Immobilisation requires the use of a bracing device such as an ankle brace, cast or heavy strap that restricts all movement at the ankle joint, whereas 'rest' would simply be achieved by not walking or using the affected limb. There are adverse effects to immobilisation that are directly related to the duration of the immobilisation; these include wastage of muscles and de-conditioning of skin. There appears to be a consensus that immobilisation is more effective than no treatment, however, the results from immobilisation studies appear not to be as good as functional treatment (BMJ, 2006).

Seven studies pertaining to immobilisation and ankle sprains met the inclusion criterion; six RCT's and one CCT. Table 6 presents the studies in hierarchical order based on their methodological scores. Three SR's also provided evidence. Studies were generally methodologically sound in their reporting of results of between-group statistical comparisons, for at least one key outcome (criterion 10). This was the only criterion that all trials scored well globally. Common methodological flaws among the trials concerned blinding of participants (criterion 5), blinding of all therapists who administer therapy (criterion 6) and the 'intention to treat' analysis (criterion 9).

Table 6: PEDro scale, internal validity scores and quality score results for immobilisation

Study	Author	1	2	3	4	5	6	7	8	9	10	11	Tot	IVS	QS
RCT's															
Immobilisation vs functional treatment	Ardèvol et al. (2002)	yes	1	1	1	0	0	0	1	0	1	0	5	3	Limited
Cast immobilisation vs air-stirrup vs elastic wrap	Dettoni et al. (1994)	yes	1	0	1	0	0	1	1	0	1	0	5	3	Limited
Early mobilisation vs immobilisation	Eiff and Smith (1994)	yes	1	0	0	0	0	0	1	0	1	1	4	2	Limited
Immobilisation vs functional treatment	Konradsen, Holmer, and Sondergaard (1991)	no	1	0	1	0	0	0	1	0	1	0	4	2	Limited
Dynamic orthopaedic brace vs immobilisation	Regis et al. (1995)	no	1	0	0	0	0	0	1	0	1	1	4	2	Limited
CCT's															
Semi-rigid vs rigid cast immobilisation.	Avci (1998)	no	0	0	0	0	0	0	1	0	1	1	3	1	Limited

Note: QS = Quality Score; IVS = Internal Validity Score; Criterion 1 not scored

The RCT's scored from three to five, out of ten possible points on the PEDro scale. The CCT received a score of three, of the possible ten points. Two studies received scores of five out of ten (Ardèvol et al., 2002; Dettori & Basmania, 1994). The remaining studies received a score of four out of ten or lower (Eiff & Smith, 1994; Konradsen et al., 1991; Regis et al., 1995; Scotece & Guthrie, 1992). All the studies had Internal Validity Scores (IVS) scores of less than three, therefore the Quality Score (QS) of all the studies were again considered 'limited'. These results indicate an overall weakness in the methodological quality of the current literature for the principal of 'immobilisation'.

The most contemporary of the three SR's, compares immobilisation and functional treatment for acute lateral ankle ligament injuries in adults (Kerkhoffs et al., 2002). The review included randomised and quasi-RCT's comparing different types of immobilisation and functional treatments. Trials that investigated the treatment of chronic instability or post-surgical treatment were excluded. Twenty-one trials were included in the review. The same authors also conducted an earlier review, assessing the effectiveness of various methods of immobilisation for acute ankle sprains (Kerkhoffs, Rowe et al., 2001). This earlier review included twenty-two trials. The third review by Pijnenburg (2000) examined the treatment of lateral ankle ligament ruptures, with treatments consisting of cast immobilisation, functional and operative interventions. Twenty-seven RCT's published between 1966 and 1998 were included in Pijnenburg's review.

The trials reviewed varied in methodological quality, as demonstrated by their PEDro scores, however, they were all considered to be of limited quality when they were described using the quality score. These results indicate an overall weakness in the quality of current literature.

Based on the results of the identified trials, it appears that cast immobilisation results in a slower functional recovery, less ROM and more persistent ankle swelling, than treatment with functional treatment. Trials that investigated these outcome measures unanimously found significantly better results with functional treatment for grade one and two injuries. Four of the five trials that investigated pain as an outcome measure found that functional treatment was superior than immobilisation (Ardèvol et al., 2002;

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Boyce et al., 2005; Eiff & Smith, 1994; Konradsen et al., 1991). However, one trial found no significant difference in pain scores between groups treated with cast immobilisation or functional semi-rigid cast immobilisation (Avci & Sayli, 1998). The results of this trial should be interpreted with caution, as the trial received the lowest methodological quality score of all the literature pertaining to the principle of immobilisation.

The three SR's identified, appear to show that functional treatment results in faster functional recovery, greater ROM, less persistent ankle swelling (Kerkhoffs, Blankevoort, van Poll, Marti, & van Dijk, 2001; Kerkhoffs et al., 2002) and less residual pain than treatment with cast immobilisation (Pijnenburg et al., 2000).

Therefore, despite the benefits of immobilisation compared to no treatment, functional treatment appears to be more efficacious than immobilisation for grade I and II ankle ligament injuries. More research is needed to clarify whether early immobilisation is beneficial for grade III injuries and, if so, what type and duration of immobilisation is most appropriate.

Ice

The theoretical basis for the use of ice (cryotherapy) on soft tissue injuries is that the cold may; a) reduce nerve conduction, and/or b) reduce muscle spasm, and/or c) have an antinociceptive effect on the gate control mechanism (Bleakley, McDonough, MacAuley, & Bjordal, 2006). Ice has been shown to reduce blood flow, and the inflammatory response, oedema production, haemorrhage, and pain sensitivity (Smith, 2003). There is however, a risk of adverse reactions such as cold burn, or neuropraxia in superficial nerves with the application of ice.

No contemporary RCT's or CCT's were identified in the literature review that met the inclusion criteria that investigated the effect of ice on ankle sprains. Literature does exist published prior to 1990, but was not considered in this review, due to exclusion criterion for trials published before 1990 (Basur, Shephard, & Mouzas, 1976; Hocutt, Jaffee, Rylander, & Beebe, 1982; Laba & Roestenburg, 1989).

Support for the use of ice comes from two SR's, examining the effect of ice on soft tissue injuries in general; and a SR which examines several treatment modalities for soft

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tissue injuries to the ankle. These reviews suggested that ice promotes a faster functional recovery (Hubbard, Aronson, & Denegar, 2004; Ogilvie-Harris & Gilbert, 1995); less persistent pain, less persistent swelling and greater ankle ROM (Bleakley, McDonough, & MacAuley, 2004) when used in the acute phase for lateral ligament ankle sprains.

The efficacy of ice has been extensively studied in the post-surgical population; particularly patients whom have undergone knee joint surgery. Ice post operatively results in greater ROM, less pain and faster return to function in this population (Barber, 2000; Glenn, Spindler, Warren, McCarthy, & Secic, 2004; Martin, Spindler, Tarter, Detwiler, & Petersen, 2001; Morsi, 2002; Ohkoshi et al., 1999; Raynor, Pietrobon, Guller, & Higgins, 2005; Sanchez-Inchausti, Vaquero-Martin, & Vidal-Fernandez, 2005; Smith, Stevens, Taylor, & Tibbey, 2002). This literature is not immediately applicable to the ankle sprain population, due to the different mechanism of trauma, and location of injury; however, it would appear to lend support to the theory that ice would improve outcome in the acute ankle injury population.

There are no CCT's that investigate ice post ankle sprain injury, which fit the inclusion criteria outlined for this review. However, a RCT was conducted for 6 weeks post ankle sprain by Bleakley et al. (2006) who compared an intermittent ice protocol (where ice was applied for ten minutes, taken off for ten minutes, then reapplied for ten minutes), with a constant protocol where the ice was left *in situ* for twenty minutes. Both options were repeated every two hours for 72 hours post injury. Their results suggested that the intermittent method was significantly better ($p < 0.05$) pain on activity in the first week than the constant method, however, both groups were even after the second week. They postulated that the intermittent method of ice application provided more efficient short term pain relief as the ten minute applications maintain tissues at optimal levels of 10–15°C for longer than standard twenty minute treatments (Bleakley et al., 2006).

The best available evidence comes from two SR's, examining the effect of ice on soft tissue injuries in general; and a CR, which examines several treatment modalities for soft tissue injuries to the ankle. One of the SR's, assessed the use of ice in the treatment of acute soft-tissue injuries (Bleakley et al., 2004). The review included RCT's published before April 2002, resulting in the inclusion of twenty-two trials. The second SR examined a more specific outcome measure, the influence of ice on return to work

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or sport (Hubbard et al., 2004). RCT's published between 1976 and 2003 were investigated, resulting in the inclusion of four studies. The third review was a CR of 84 studies published between 1966 and 1993 (Ogilvie-Harris & Gilbart, 1995). This review examined several treatment modalities for soft tissue injuries to the ankle, including ice, active mobilisation, electrotherapy modalities, topical gels, joint aspirations and injections. Only five of the 84 studies included in the trial included evaluated the principle of ice.

The first of these SR's examined ice on the outcome measures of function, pain, swelling and ROM (Bleakley et al., 2004). With regard to these outcome measures, it was found that there was marginal evidence that ice plus exercise is most effective, after ankle sprain and post ankle surgery. There was little evidence to suggest that the addition of ice to compression had any significant effect, but this was restricted to hospital inpatients. The authors also found that there are few studies that assess the effectiveness of ice on closed soft-tissue injury; and that there is no evidence of an optimal mode of duration of treatment.

The second SR examined the single outcome measure of functional recovery, in the form of time to return to participation at work or sport (Hubbard et al., 2004). The authors found that there is positive evidence to suggest that ice speeds up functional recovery. It is interesting to note that although the authors intended to examine soft tissue injuries in general, all four trials included in the review investigated participants with ankle sprain, adding to its relevance to this review.

The final CR, by Ogilvie-Harris and Gilbart (1995) examined treatment modalities for soft tissue ankle injuries. They concluded that ice helps reduce the length of time to recovery; however, it did not appear to help with the overall outcome post ankle sprain.

Despite the positive outcomes of the previous reviews, the BMJ Clinical Evidence Concise edition concluded there was more evidence to the contrary for ice. There were two RCT's cited in the BMJ Clinical Evidence Concise edition (2006) pertaining to ice. One RCT found no significant difference in symptoms between cold pack placement and placebo (simulated treatment) and another RCT that found less oedema with cold pack placement compared with heat or contrast bath at 3-5 days post treatment. They

considered that the current evidence suggested that ice was unlikely to be beneficial (BMJ, 2006).

Ice is often recommended in the acute phase for ankle injury, however, there is a substantial shortfall of evidence for its effectiveness in the contemporary literature. It is strongly recommended by the developers of guidelines for treatment of ankle sprains that more contemporary, high quality studies, be conducted to investigate the efficacy of ice on ankle sprains (A.C.C., 2002; BMJ, 2006).

Compression

Compression involves the use of bandages or a device which applies pressure to the injured limb. These are wrapped or placed over the injured area. There is no internationally recognized classification system for compression and a lot of research has been conducted into compression for the treatment of ulcers. A variety of methods of compression for acute injuries have also been investigated, including intermittent compression, constant compression and U-shaped compression devices using various materials and protocols. Compression for injuries is purported to increase the hydrostatic pressure of the interstitial fluid, counteracting some of the force that causes fluid to move out of the tissue following damage. Compression is hypothesised to stop bleeding, inhibit fluid seepage into underlying tissue spaces and help disperse fluid (oedema) thereby minimising the secondary damage to surrounding tissue that often occurs post injury (Rucinski et al., 1991). Six studies pertaining to compression and ankle sprains met the inclusion criteria, five RCT's and one CCT. No SR's have been published in this area.

The RCT's ranged in quality from three to five, of the possible ten points on the PEDro scale. The CCT identified achieved a score of three out of ten points. Table 7 presents these studies in hierarchical order based on their methodological scores and therefore quality. Only one study received a PEDro score of five out of ten (IVS = three) and is therefore still considered limited. (Leanderson et al., 1999). The remaining six studies received a score of four out of ten or below (Airaksinen, Kolari, & Miettinen, 1990; Guskiewicz, Riemann, & Onate, 1999; Rucinski et al., 1991; Tsang, Hertel, & Denegart, 2003; Wilkerson & Horn-Kingery, 1993). These results, once again, indicate poor methodological quality of literature.

Table 7: PEDro's Scale, internal validity score and quality score results for compression

Study		1	2	3	4	5	6	7	8	9	10	11	Total	IVS	Quality score
RCT's															
Air-cushioned brace vs compression bandage	Leanderson et al. (1999)	Yes	1	1	0	0	0	0	1	0	1	1	5	3	Limited
Compression and elevation vs elevation	Tsang et al. (2003)	No	1	0	0	0	0	0	1	0	1	1	4	2	Limited
Elastic wrap vs intermittent compression vs elevation	Rucinski et al. (1991)	No	1	0	1	0	0	0	1	0	1	1	4	2	Limited
Elastic bandage vs elastic bandage & intermittent compression	Airaksinen et al. (1990)	No	1	0	1	0	0	0	0	0	1	1	4	1	Limited
	Guskiewicz et al. (1999)	No	1	0	0	0	0	0	0	0	1	1	3	1	Limited
Comparison of 3 methods of compression															
Controlled clinical trials															
Comparison of 3 methods of compression	Wilkerson & Horn-Kingery (1993)	Yes	0	0	0	0	0	0	1	0	1	1	3	1	Limited

Note: QS = overall quality score; IVS = internal validity score; Criterion 1 not scored

Common methodological flaws among the studies concerned blinding of participants (criterion five), blinding of all therapists who administer therapy (criterion six), blinding of all assessors who measure at least one outcome (criterion seven) and the lack of ‘intention to treat’ analysis (criterion nine). Studies were generally methodologically sound in the areas of reporting results of between-group statistical comparisons for at least one outcome (criterion ten) and providing point measures of variability for at least one key outcome (criterion eleven).

The six trials offering evidence for the principle of compression can be sub-grouped into four types of treatments. First, trials that investigate compression bandages; second, trials that investigate intermittent compression combined with elevation; third, trials that investigate intermittent compression combined with elastic bandages; and fourth, trials that investigate U-shaped functional compression devices.

Two of the identified trials examined the use of an elastic bandage or wrap (Airaksinen et al., 1990; Rucinski et al., 1991). The latter found that elevation without compression resulted in the greatest reduction in oedema (Rucinski et al., 1991). The former finding intermittent compression resulted in faster reduction and less persistent oedema, greater ROM and less short and long term pain, than treatment with a bandage (Airaksinen et al., 1990). Thus, the evidence for use of compression bandages appears not to be valid.

It has been suggested that external compression of an elevated limb can impede blood flow (Wiger & Stuf, 1998). Although impeding blood flow is thought to be desirable after acute injury (Brukner & Khan, 2001), it is also possible that compression could impede blood flow away from the affected area. This may have been the case in Rucinski, Hooker, Prentice, Shields, and Cote-Murray’ study (1991) which found that elevation without any form of compression resulted in the greatest reduction of oedema. Thus, although the indication is that RICE is suggested in the early management of an injury, specific instructions need to be given to the patient to take off the compression bandage when they elevate the limb, as they would be reducing the effectiveness of the elevation itself.

U-shaped focal compression device

Several authors have advocated the use of U-shaped focal compression devices (Bonci, 1982; Guskiewicz et al., 1999; Weiker, 1984; Wilkerson & Horn-Kingery, 1993). Only two trials were contemporary enough to be included in this review (Guskiewicz et al., 1999; Wilkerson & Horn-Kingery, 1993). One of the trials found that for pain and ankle volume measures, the compression intervention was of no greater benefit than treatment with non-focal compression devices (Guskiewicz et al., 1999). However, Wilkerson & Horn-Kingery (Wilkerson & Horn-Kingery, 1993) found that U-shaped focal compression resulted in faster functional recovery than elastic taping with no compression. As the results of these trials are somewhat contradictory, the true efficacy of treatment with focal compression is in question. One possible explanation for the contradictory results may be that the trials investigated differing outcome measures, and used different compression bandages/techniques, for example intermittent compression elastic bandages versus tubigrip.

Compression bandage

Compression bandage intervention for ankle sprains has been examined previously (Guskiewicz et al., 1999; Wilkerson & Horn-Kingery, 1993). The Guskiewicz trial found no significant difference between groups treated with a compression bandage and an air-stirrup brace.

Intermittent compression and elevation

Two trials have investigated the effect of intermittent compression and elevation (Rucinski et al., 1991; Tsang et al., 2003). The later trial found that intermittent compression and elevation resulted in a reduction in ankle volume, however, the reduction did not differ from elevation alone (Tsang et al., 2003), whereas the earlier trial found that intermittent compression and elevation resulted in a smaller reduction of ankle volume than elevation alone (Rucinski et al., 1991). Both these trials appear to lend more support to the principal of elevation than intermittent compression.

Intermittent compression and elastic bandage

Only one trial has investigated intermittent compression and elastic bandage treatment (Airaksinen et al., 1990). The trial found that intermittent compression and elastic bandage was superior with regard to pain, functional ability, ROM and ankle volume than elastic bandage treatment alone.

There is only poor research to substantiate the claim that compression is beneficial for acute injuries. It appears that focal compression is no better than general compression and that intermittent compression is superior to elastic bandage in isolation. There is limited evidence that compression may in fact reduce the effectiveness of elevation for reducing in oedema in acute ankle sprains.

Elevation

Elevation of the affected limb utilises the influence of gravity. It results in an increase in venous and lymphatic drainage (Tsang et al., 2003), reduction in oedema (O'Brien, Chennubhotla, & Chennubhotla, 2005) and can diminish local bleeding (Wiger & Stuf, 1998). ACC stated that “elevation helps to stop the bleeding and reduce swelling” and recommends to “raise the injured area on a pillow for comfort and support and keep the injured area raised as much as possible.

There were no RCT's, CCT's or SR's pertaining to elevation alone and ankle sprains, which meet the inclusion criteria and a substantial gap exists within the literature, regarding the effects of purely elevation on ankle sprains. Thus, it is impossible to determine the effect of the elevation principle, with regard to current literature. It was recommended by ACC (2005) that future research evaluate the efficacy of elevation on sprains to the lateral ligament complex of the ankle joint.

Some evidence for elevation can be extrapolated from the literature that explores the principle of compression (refer section page 31). Although attempting to investigate the efficacy of intermittent compression, (Rucinski et al., 1991) found that elevation alone was more effective, with regard to the reduction of oedema, than intermittent compression and elevation, or elastic wrap and elevation. A more recent study by Tsang, Hertel, & Denegart (Tsang et al., 2003) found that treatment with intermittent compression and elevation, or elevation alone, both resulted in a significant reduction in ankle volume. However, the effect was found to be somewhat short, lasting less than five minutes. Thus, it would seem that elevation is indeed of benefit for reducing ankle volume, although its effect may be brief.

Literature also exists, which substantiates the use of elevation for swelling of venous, non-traumatic origins (Giudice, 1990; Lemley, 1992; Xia, Hu, Wilson, Cherry, & Ryan,

2004). This literature has found that elevation resulted in a reduction in extremity volume. However, its applicability to the ankle sprain population is limited due to the different pathologies and mechanism of swelling in these injuries.

Summary of the evidence for RICE management

There appears to be a paucity of quality evidence for the RICE principals. RICE principals are relatively inexpensive, somewhat effective for pain relief, and may reduce further tissue damage in the acute stage of grade I and II ankle sprains. More evidence is needed into the effect of RICE on acute ankle sprains, specifically investigating the mechanisms by which these principals work, the best means of delivering these to the patient, and the optimum timeframes (or dose) for each principal.

Rest: The principle of 'rest' involves the avoidance of as much movement of the injured part in the acute stage to limit further injury. In the acute stage this reduces the chance of further injury to compromised tissue. In the sub-acute stage it appears that functional treatment is superior to immobilisation for the treatment of ankle sprains, and functional adjuncts (e.g., braces) do not appear to be of significant benefit.

Ice: Most commonly used in the acute phase of healing, for pain relief and vasoconstriction to reduce oedema. Evidence extrapolated from studies investigating the use of post surgical ice appears to support the use of ice in the acute stage of an ankle sprain to minimise bleeding and oedema. It has been shown that intermittent application of ice (ten minutes on, ten minutes off, repeated every two hours in the acute phase) is more effective for pain relief than constant 20 minute icing, which leads to improved function (Bleakley et al., 2006). However, it should be noted that there are very few studies investigating the effect of ice specifically for ankle sprains, and the strength of the evidence in general is limited. There are risks associated with using ice, including cold burn, frostbite and nerve palsy. Further research in this area is necessary.

Compression. There are a variety of different means of compression investigated including U-shaped compression devices, intermittent compression, compression bandages, intermittent compression combined with elevation, and intermittent compression combined with elastic bandages. Intermittent compression appears to be better than compression using an elastic bandage. Focal compression using a U-shaped device was no better than general compression, but was better than taping. It appears

that in the acute stage of an ankle sprain compression may minimise secondary tissue trauma that can occur post-injury. Compression should not be applied whilst the body is supine as this may impede venous return.

Elevation. Elevation of the injured ankle appears to reduce ankle volume by the process of gravity, however, the reduction in volume appears to be short acting (less than 5 minutes). Elevation appears to be more effective than compression for reducing the volume of the ankle.

Overall there is limited evidence for using RICE as illustrated by the QS scores for the studies that were identified by the literature review, and not all of the principals were supported by the literature. The strongest evidence appears to be support for elevation as a means of reducing oedema in acute ankle sprains in the short term due to the effect of gravity.

Physiotherapy modalities

A variety of physiotherapy modalities can be used in the management of ankle sprains including, but is not limited to; electrotherapy (ultrasound, TENS, interferential), proprioception retraining, strengthening, exercise prescription for range of movement and strengthening, mobilisations, bracing and taping, soft tissue therapies and functional treatment. A combination of treatment options (termed multimodal physiotherapy) is often used depending on the diagnoses, severity, clinician experience and patient choice. Some treatment options such as mobilisations and electrotherapy require patients to be passive, whereas some require very active participation, as in strengthening or proprioception programmes where the participant is often required to do activities independent of the physiotherapist. Some of these modalities were investigated for the review. Three RCT's were identified regarding treatment utilising proprioceptive training, two RCT's were identified regarding treatment utilising talocrural mobilisations, three clinical trials were identified investigating the use of strengthening in the absence of RCT's on this topic, and one RCT was identified regarding multi-modality physiotherapy (see Table 8).

Table 8: Summary of physiotherapy modalities investigated in this systematic review

Author	Study	1	2	3	4	5	6	7	8	9	10	11	Total	IVS	QS
Proprioception RCT's															
Bernier and Perrin, (1998)	Co-ordination training on functionally unstable ankles	No	1	0	0	0	0	0	1	0	1	1	4	2	Limited
Eils and Rosenbaum (2001)	Multistation exercise programme on unstable ankles	Yes	0	0	1	0	0	0	1	1	1	1	5	2	Limited
Bracing RCT's															
Boyce, Quigley, and Campbell (2005)	Elastic support bandage vs Aircast ankle brace	Yes	1	1	1	0	0	0	0	0	1	1	5	2	Limited
Dettori and Basmania (1994)	Cast immobilisation vs air-stirrup vs elastic wrap	Yes	1	0	1	0	0	1	1	0	1	0	5	3	Limited
Johannes, Sukul, Spruit, and Putters (1993)	Semi-rigid bandage (scotchrap) vs adhesive tape	Yes	1	0	1	0	0	0	1	0	1	0	4	2	Limited
Regis et al.(1995)	Dynamic orthopaedic brace vs immobilisation	No	1	0	0	0	0	0	1	0	1	1	4	2	Limited
Scotece and Guthrie (1992)	Strapping vs gel cast	Yes	1	0	0	0	0	0	1	0	1	1	4	2	Limited
Talocrural Mobilisations RCT's															
Green Refshauge and Adams (2001)	Passive Accessory joint mobilisations	Yes	1	1	0	1	0	0	1	0	1	1	6	4	Moderate
Collins, Teys, & Vicenzino (2004)	Mulligans' mobilisations	Yes	1	0	1	1	0	0	0	0	1	1	5	2	Limited
Strengthening (CCT's)															
Hoiness, Glott, and Ingjer (2003)	Bi-directional bicycle pedalling	Yes	1	0	1	0	0	0	1	0	1	1	5	2	Limited
Powers, Buckley, Kaminski, Hubbard and Ortiz (2004)	Strengthening and proprioception	No	1	0	0	1	0	0	0	0	1	1	4	2	Limited
Kaminski, Buckley, Hubbard. and Ortiz (2003)	Strength and proprioception training	No	1	0	0	0	0	0	0	0	1	1	3	1	Limited
Multimodal Physiotherapy															
Holme et al. (1999)	Supervised rehabilitation	Yes	1	0	0	0	0	0	0	0	1	1	3	1	Limited

Ultrasound and electrotherapy

The BMJ Clinical evidence concise edition (2006) cites a SR that found no significant difference between ultrasound and sham ultrasound in the general improvement of symptoms or the ability to walk or weight bear at seven days, and two RCT's that provided insufficient evidence to compare ultrasound and immobilisation or electrotherapy. The conclusion from this review was that ultrasound was unlikely to be beneficial for acute ankle sprains based on the current literature (BMJ, 2006).

Mobilisations

Mobilisations involve stretching a joint capsule in order to increase a joint's ROM in a particular direction. The theoretical basis for manual movements was explained in 2002 by Kaltenborn's concave-convex theory. According to this concept, a convex moving joint partner, such as the talus in the talocrural joint, should be mobilised in the opposite direction of the restricted movement to stretch shortened joint structures (Kaltenborn, 2002). A progression or alternative to this treatment involves a passive physiological glide combined with a patient generated movement called "mobilisations with movement" (MWM's). This type of mobilisations were developed by Brian Mulligan (1999), who postulated that minor positional faults occur following an injury and result in pain and restricted movement (Mulligan, 1999). According to Mulligan when the correct MWM is applied and repeated several times a joint's tendency to track smoothly and without pain seems to return.

Two recent RCT's involving the interventions of mobilisations and MWM's respectively were identified and their results are summarised in Table 8. In one study (Collins et al., 2004) found that a relative anteroposterior (AP) weight-bearing MWM of the talus within the ankle mortise resulted in an immediate and significant increase in ROM in dorsiflexion, but had no influence on either thermal or mechanical pain thresholds, suggesting a mechanical realignment as opposed to a neuromodulatory effect. Similarly, Green, Refshauge, Crosbie, and Adams (2001) found AP talar glides in addition to a RICE protocol, compared to a control group receiving RICE alone, resulted in improvements in ROM leading to fewer required treatments to achieve pain-free dorsiflexion (DF). These improvements translated into functional improvements in stride speed, but no improvements in step length in the swing phase of gait or single-leg support time in the stance phase (Green et al., 2001). This study was one of the very few studies whose QS was moderate rather than limited which strengthens the validity

of this study. The limited quality of the QS scores for both these RCT's deters from the reliability of the results (see Table 8).

There were only two RCT's examining the effects of mobilisations and MWM's at the talocrural joint, which highlights the need for high quality RCT's to be conducted in this area. Methodology in the two studies examined varied greatly in participant population either being very acute, within 72 hours of sprain (Green et al., 2001) or within an average of 40 days prior to testing (Collins et al., 2004). Other large variations included different outcome measures examined and methods of measurement. A summary of Green (2001) is in Table 9.

Further research involving MWM's and ankle sprains has been conducted to examine the clinical observation made by some researchers that a positional fault often exists in the distal tibiofibular joint following an inversion mechanism, injury leading to an anteroinferior displacement of the fibula (Hetherington, 1996; Kavanagh, 1999; O'Brien & Vicenzino, 1998). The theorised positional fault in these studies is treated with a MWM applied to the distal fibula in a posterior direction, often sustained with tape. The research suggests increased DF and inversion ROM's in addition to pain reductions may result from this treatment. This research includes only one clinical study and two case studies, thus providing limited evidence to support the prevalence of anteroinferior fibular displacement, and the efficacy of treatment of this condition with mobilisations and MWM's. There were no recent review articles examining the effects of manual mobilisations on the talocrural joint or the inferior tibiofibular joint located in the literature search.

Table 9: RCT examining the effect of talocrural mobilisations on lateral ankle sprain participants

Author	Purpose	Intervention & Control	Results	PEDro Score	IVS	QS
Green et al. (2001)	Examined effect of anteroposterior talar glides and a RICE protocol as compared to the RICE protocol alone on determining pain-free dorsiflexion, gait speed, step length, and single-support time in 41 participants with acute ankle inversion sprains.	For both groups treatment occurred over a maximum of two weeks with treatments every second day (not including weekends) resulting in a potential maximum of 6 treatment sessions. <u>Control group:</u> Participants received a standardized protocol of RICE treatment per session including: affected foot elevation for 20 minutes with crushed ice applied to the anterolateral aspect of the ankle, ice application for 20 minutes was instructed at least twice a day while not at physiotherapy. For compression participants wore an elastic tubular bandage daily until completion of testing. During the third session participants were taught to tape their own ankles using a standardized technique and this was reassessed during session 4 to ensure proper application. Oral and written instructions on the protocol were given, rest was defined as avoidance of pain provocation and participants were instructed to elevate the foot above their hearts for at least 25% of the day. <u>Intervention group:</u> Were given the same RICE treatment and instructions as the control group plus passive joint mobilisations before the application of RICE. A participants' affected foot was placed in the end of pain free range DF, and a gentle small amplitude anteroposterior glide was applied without producing pain or spasm. The technique was performed for 3x 60 seconds with 10 second rests between repetitions. Treatments progressed by increasing dorsi-flexion range over time as allowed within pain free dorsi-flexion.	The intervention group accomplished pain-free DF in fewer treatments than the control group ($p < 0.01$). In addition the intervention group showed greater ROM before ($p < 0.02$) and after ($p < 0.01$) each of the first three treatment sessions. Improvements in step length symmetry and single-support time were similar between groups.	6	4	2

Proprioceptive training

The effectiveness of proprioceptive training in improving joint positional sense and for reducing the incidence of ankle sprains is summarised in this section. There was literature evident for and against the use of proprioceptive retraining post ankle sprain, however, all studies were considered limited and therefore there is a need for further research in this area. There were trials investigating participants with history of ankle sprains (Bernier & Perrin, 1998; Eils & Rosenbaum, 2001; Forkin et al., 1996) and on normal participants (Waddington, Adams, & Jones, 1999). In the studies examining proprioceptive training in an ankle sprain population, two trials indicated a significant increase in the ability of participants to discriminate joint positional sense (Eils & Rosenbaum, 2001; Forkin et al., 1996) following completion of ankle-disc (wobble board) training, or a multi-station proprioceptive training programme. The third trial showed a lack of significant improvement in joint positional sense following proprioceptive intervention including single-leg stance, and wobbleboard training.

Eils (2001) investigated the efficacy of six week multi-station proprioceptive exercise programme on positional sense, postural sway, and muscle reaction times in tibialis anterior, peroneus longus and peroneus brevis in thirty participants with chronic ankle instability (defined by repeated inversion sprains and a subjective feeling of instability or giving away). Twenty participants were allocated to receive a six week proprioception training programme, and ten participants received no intervention. The intervention group showed significant improvement in joint position sense, postural sway, and muscle reaction times. After one years time the intervention group reported a 60% decrease in sprains ($p < .001$). Caution is recommended however, as the results are considered of limited quality because the study scored 5 on the PEDro scale, with an IVS of 2 (see Table 10).

Table 10: Summary of proprioception RCT's on participants with a history of ankle sprains

Author	Purpose	Intervention	Control	Results	PEDro Score	IVS	QS
Bernier (1998)	To determine the effects of a 6-week coordination and balance treatment programme on the proprioception of participants with functional ankle instability.	17 participants were treated with a balance and coordination training regiment 3x/week for 10 minutes per day. All participants (n = 45) were assessed for postural sway and active and passive joint positional sense.	14 participants served as a control and were asked not to participate in any strengthening or balance type activities over the 6-week period. All 14 participants received a sham electrical stimulation treatment to the peroneal muscles in which no electrical current was actually conducted.	There was a lack of significant improvement in joint position sense for the intervention group. Postural sway however was significantly improved in the intervention group compared to the control group.	4	2	Limited
Eils (2001)	To examine the efficacy of a 6-week multi-station proprioceptive exercise programme on positional sense, postural sway, and muscle reaction times in tibialis anterior, and peroneus longus and brevis.	20 participants with chronic ankle instability defined by repeated inversion sprains and a subjective feeling of instability or giving away, were allocated to receive a 6-week proprioception training programme.	10 participants with chronic ankle instability defined by repeated inversion sprains and a subjective feeling of instability or giving away, were allocated to no intervention.	Intervention group showed significant improvements in joint position sense, postural sway, and muscle reaction times. Furthermore, after one years time intervention participants reported a 60% decrease in sprains ($p < 0.001$).	5	2	Limited

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Forkin et al. (1996) conducted a trial which scored nine on the PEDro scale to determine if collegiate level gymnasts with unilateral, and multiple ankle sprains have a decreased ability to detect passive plantarflexion from one to twelve months post-injury, and secondly, to determine if balance deficits existed during single-leg stance on the affected ankle. Collegiate level gymnasts (two male and nine female) participated in the study. Eight participants had a history of multiple unilateral ankle sprains. Three had history of bilateral ankle sprains, with one ankle that had not been sprained for two years prior to the study start-date. Each participant completed 30 passive movement trials randomly performed on both the injured and uninjured ankles, and a 30-second trial of bilateral single-legged standing with eyes open and closed. The control was as for the intervention group. Subjects were significantly better at detecting the degree of movement during trials of the uninjured ankle (95.75%) compared to the injured ankle (86.06%) based on correct answers to positional changes. Furthermore, participants had significantly better standing balance on their uninjured legs compared to their injured legs with 63% displaying a balance deficit on the injured side with eyes closed as rated by independent observers.

A study to determine the effects of a six-week coordination and balance treatment programme on the proprioception of participants with functional ankle instability was conducted by Bernier (1998) on 45 participants (see Table 10). The intervention group of 17 participants were treated with a balance and coordination training regiment three times a week for ten minutes per day, 14 participants served as a control who were asked not to participate in any strengthening or balance type activities over the six-week period, and 14 participants received a sham electrical stimulation treatment to the peroneal muscles in which no electrical current was actually conducted. All participants were assessed for postural sway and joint positional discrimination. There was a lack of significant improvement in joint position sense for the training group, however, postural sway was significantly improved in the experimental group. This study scored 4 on the PEDro scale, with an IVS of 2 which again meant this studies QS was considered limited.

Proprioception training has been shown to have a positive effect on joint position discrimination in healthy participants as well as those with unstable ankles (see Table 11). Waddington (1999) examined the effects of five-week wobbleboard programme on discrimination of discrete ankle inversion movements in healthy individuals with no

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history of ankle pain for six weeks prior to entering the study and who had no history of vestibular or visual disturbances. Ten first grade rugby league players were randomly allocated to ten minutes of wobble board training three times per week for five weeks, with a control of ten players who performed no wobble board training for the same period. The intervention group were found to have significantly greater ability to discriminate ankle inversion movements in dominant and non-dominant ankles compared to the control group. This study scored 4 on the PEDro scale, with an IVS of 1 and therefore again was considered of limited quality.

Table 11: Summary of proprioception RCT on normal participants

Author	Purpose	Intervention	Control	Results	PEDro Score	IVS	QS
Waddington (1999)	To examine the effects of a 5 week wobble board training programme on discrimination of discrete ankle inversion movements in healthy individuals	10 first grade rugby league players, with no history of ankle pain for 6 weeks prior to entering the study and no history of vestibular or visual disturbances, were randomly allocated to 10 minutes of ankle disc training 3x per week for 5 weeks.	10 first grade rugby league players, with no history of ankle pain for 6 weeks prior to entering the study and no history of vestibular or visual disturbances, performed no wobble board training for 5 weeks.	The intervention group was found to have significantly greater ability to discriminate ankle inversion movements in dominant and non-dominant ankles compared to the control group.	4	1	Limited

Discrepancies in the ability to detect joint positional sense between the three examined studies may be attributable to the testing position. One study tested in the supine position, non weight-bearing (NWB) position, while Waddington, Adams, and Jones (1999) tested in a functional upright weight bearing (WB) position and Eils and Rosenbaum (2001) tested in a partial WB sitting position.

Other methods of indirectly testing for proprioception were also employed in the studies reviewed. These included postural sway in two studies, and muscle reaction times in one study. Postural sway significantly improved in both studies (Eils & Rosenbaum, 2001) while muscle reaction times were found to be significantly slower following training in the peroneal muscles. The authors attributed this result to a possible improvement in muscle synergies employed following training (Eils & Rosenbaum, 2001). It is difficult to make general conclusions based on these studies due to the limited quality of the studies (see Table 8), the heterogeneity of the participant populations, and differences between intervention and control exercise prescriptions. Differences in methods of measurement and testing procedures detract from the ability to draw comparative conclusions from these studies. Furthermore, the quality of the studies, as evaluated by QS and summarised in Table 8, was found to be limited in all cases.

Three reviews investigated proprioception (Ashton-Miller et al., 2001; Baltaci & Kohl, 2003; Verhagen et al., 2004). In the first literature review the evidence for physiological proprioceptive change due to exercise, and the processes by which these changes occur were investigated (Ashton-Miller et al., 2001). According to the authors, the relatively slow postural movements involved in wobbleboard training are unlikely to be optimal in the prevention of ankle ligament injury which occurs in as little as 40 milliseconds. By the time the muscles are activated the force through the ligament complex would have disrupted some of the fibres. The functional gains obtained through wobbleboard training are more likely attributable to central mechanisms, including increased attention paid to proprioceptive stimulation, and an increased neuronal representation of proprioception in the sensory cortex (Ashton-Miller et al., 2001). The positive results seen in this review may be indicative of this phenomenon.

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Another recent review on ankle and knee proprioceptive treatment (Baltaci & Kohl, 2003), found that proprioceptive training improved muscle reaction times, increased postural stability, decreased functional instability, and decreased the incidence of re-injury. Wobbleboard training and closed kinetic chain exercises were found to be appropriate methods of proprioceptive training.

An additional SR (Verhagen et al., 2000) examined the efficacy of preventative measures to reduce lateral ankle ligament injuries by investigating 14 studies relating to proprioception and ankle sprain. From these, two studies met a quality cut-off score and contained incidence rates of lateral ankle ligament injuries as study outcomes. The review found that proprioceptive training reduced the incidence of ankle sprains in athletes with recurrent sprains to the same level as participants without any history of ankle sprains. One of the studies examined in this review found a 60% post-intervention decrease in sprains at one-year follow-up (Eils & Rosenbaum, 2001). No other studies investigated this variable.

A recent Cochrane review examined the effects of interventions to prevent ankle ligament injuries in physically active people from adolescence to middle age using evidence from 14 randomised trials (Handoll, Rowe, Quinn, & de Brie, 2000). This review found limited evidence for the reduction in sprained ankles following wobbleboard training for participants with previous ankle sprains due mainly to various problems with data reporting.

The discrepancies between this review and the previous three reviews, may be attributable to differences in inclusion/exclusion criteria, as the Cochrane review has more stringent exclusion criteria, and the other reviews looked at other treatment modalities in addition to wobbleboard training. Table 8 shows a summary of the results from the RCT's investigating the effects of proprioceptive training on participants with a history of ankle sprains.

Strengthening

Adequate muscular strength surrounding the ankle joint is suggested in the literature to be a key component of a functionally stable ankle (Blackburn, Guskiewicz, Petschauer, & Prentice, 2000). In particular eccentric strength enhances the stability of the ankle

joint and contributes to balance by providing antagonistic resistance to joint translation (Blackburn et al., 2000).

Three clinical trials were found examining a combination of strengthening and proprioceptive treatment, however, they have been included in the strengthening section as the studies separated these interventions, and strengthening was deemed to be a larger aspect of the intervention than proprioceptive training. Due to the absence of recent RCT's examining the effects of strengthening on ankle sprain participants, one prospective randomised study and two pre-test post-test randomised group studies have been included and the results are presented in Table 8.

Hoiness, Glott, and Ingjer (2003) conducted a prospective randomised study examining the use of a bi-directional pedal cycle programme in comparison to a unidirectional pedal cycle training programme in 19 recurrent ankle sprain participants. Outcome measures included ankle evtor strength, postural sway, and subjective functional improvement. Researchers found significantly greater improvements in evtor torque in the intervention group. Individually assessed work rates were calculated for all participants following four sessions of sub-maximal work-rate and VO^2 max testing. Work rate (W) and heart rate (HR) were used to determine VO^2 max and participants were instructed to maintain HR and W corresponding to VO^2 max levels varying from 50% to 80% throughout the three training sessions. The intervention group, comprising of ten participants (four male) were randomly assigned to a high intensity 45 minute bi-directional pedal bicycle exercise programme, three times a week for six weeks. The control group, (nine participants, four males) were randomly assigned to the same high intensity 45 minute bicycle exercise programme as the intervention group, three times a week for six weeks, however, they were biking in only one direction. Eversion torque of all ankles in the intervention group increased 11.4% at 60° ($p = 0.037$), and 14.2% at 180 ° ($p = 0.020$). Eversion torque did not increase significantly in the control group, an increase of 1.6% and 1.7% at 60° and 180° respectively. Figure-of-eight running scores increased substantially in the intervention group compared with the control group however, these results were not significant. The intervention groups postural sway increased to the maximal 80% after training from a mean 72.5% pre-training ($p = 0.005$), and the control group participants also improved from a mean 56.1% pre-training to 67.8% post-training ($p = 0.018$). Unfortunately standard deviations were not presented in this article.

A more recent pre-test post-test study by Powers et al. (2004) investigated the combined effect of a six-week strength and proprioception training programme on measurements of muscular fatigue and static balance in 38 participants with self-reported unilateral functional ankle instability. The participants were randomised into a control group which completed no ankle training for a six-week period and three intervention groups performing exercises three times a week for six weeks. The training programmes comprised of Theraband strengthening of dorsiflexors, plantarflexors, invertors and evertors, a proprioceptive treatment programme utilising Theraband kick training whilst standing on the injured leg, and a combination of the two. All training programmes were progressed as and when the participants were able to complete the tasks. There were no significant effects found correlating strength, proprioceptive, or combined training to the measures of muscle fatigue (EMG traces on peroneus longus and tibialis anterior) and static balance (force plate deviation from the centre of pressure readings). Results indicated muscle fatigue as shown through EMG muscle traces on peroneus longus and tibialis anterior, and static balance in terms of deviation from centre of pressure readings on a force plate showed no significant effects correlating strength, proprioception, or combined treatment with outcome measures (Powers et al., 2004). The study scored four points on the PEDro scale, had an IVS score of two and so was considered limited.

The third study by Kaminski et al. (2003) examined the same interventions investigated by Powers et al. (2004), however, the only outcome measure was peak torque eversion/inversion ratios. Their study validated the findings of Powers et al. (2004) as they also found there were no significant differences between the peak torque ratios generated in any of the three intervention groups, or the control group. Frequency of training was relatively similar with all involved studies training the intervention groups three times a week for six weeks. Their study scored only 3 on the PEDro scale, had an IVS score of only 1 and was also considered limited.

It is difficult to draw other methodological comparisons between Hoiness, Glott, & Ingjer (Hoiness et al., 2003) and the other two studies (Kaminski et al., 2003; Powers et al., 2004). The studies investigated in this review were not RCT's and two exhibited low PEDro scores whereas Hoiness et al. (2003) scored a moderate PEDRO's score, but only a limited QS score.

Bracing

Literature on the use of braces in the acute stage of ankle sprains was often found to be in the literature on functional treatment. Braces are used in physiotherapy management to support and protect the ligament while they are healing. There are many different types of braces available on the market, including elasticised braces, braces that restrict movement, aircasts, and taping. There was a number of RCT's looking at the effect of bracing for acute ankle sprains (See Table 8). The quality of the studies was limited overall as is evident from the QS scores. More evidence was available under the heading of functional treatment protocols.

Functional treatment protocols

Functional treatment has been defined as early mobilisation with the use of an external support if necessary.(BMJ, 2006) or by Pijnenburg (2000) as including taping, strapping or commercially available ankle brace, to allow for early controlled mobilisation. Struijs and Kerkoffs conducted a literature review on the effects of treatment strategies for acute ankle ligament ruptures for *The British Medical Journal Clinical Evidence Concise edition* (BMJ, 2006). The effects of treatment strategies for acute ankle ligament ruptures were summarised into five categories: beneficial; likely to be beneficial; trade-off between benefits and harms; unknown effectiveness; and unlikely to be beneficial. The only heading under the beneficial section was functional treatment, defined as early mobilisation with the use of an external support. A systematic review and a subsequent RCT showed that, compared with minimal treatment, functional treatment reduced the risk of the ankle giving way and that compared with immobilisation, functional treatment improved functional outcomes and symptoms at less than six weeks, six weeks to a year, and at greater than a year follow up, however, the authors also found that one SR and a subsequent RCT found insufficient evidence to compare functional treatment to surgery. Struijs and Kerkoffs noted that a SR and two additional RCT's provided insufficient evidence to compare different types of functional treatments (BMJ, 2006).

Functional treatment protocols often included multimodal physiotherapy treatments and it should be made clear that these two types of treatments are on a continuum. We identified six trials that compared immobilisation with functional treatment protocols (Ardèvol et al., 2002; Avci & Sayli, 1998; Dettori & Basmania, 1994; Eiff & Smith,

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1994; Konradsen et al., 1991; Regis et al., 1995). Five of these trials investigated the effect on pain; four finding that functional treatment led to greater reductions in pain (Ardèvol et al., 2002; Eiff & Smith, 1994; Konradsen et al., 1991; Regis et al., 1995); and one finding that the reduction in pain was similar with both treatment protocols (Avci & Sayli, 1998). Only two of the trials investigated the effect on functional recovery (Dettori & Basmania, 1994; Regis et al., 1995), both found that functional treatment resulted in a greater return to function. Four of the trials investigated the effects on ROM (Ardèvol et al., 2002; Avci & Sayli, 1998; Dettori & Basmania, 1994; Eiff & Smith, 1994), all finding that functional treatment resulted in a greater ROM. Only two of trials investigated the effects on ankle volume (Ardèvol et al., 2002; Dettori & Basmania, 1994), both finding less swelling with functional treatment.

Clinical reviews by Kerkhoffs and colleagues (Kerkhoffs, Blankevoort, van Poll, Marti, van Dijk, 2001; Kerkhoffs, Rowe, Assendelft, Kelly, Struijs, van Dijk., 2002), also compared immobilisation and functional treatment protocols. The earliest review found that functional treatment is significantly favourable with regard to the outcome measures of functional recovery, ankle ROM and persistent ankle swelling (Kerkhoffs et al., 2001). These results were confirmed in their more recent review, however, the results should be interpreted with caution, as the differences between the interventions were not significant after the low quality trials have been excluded (Kerkhoffs et al., 2002).

The third meta-analysis conducted by Pijnenburg, van Dijk, Bossuyt, & Marti (Pijnenburg et al., 2000) investigated trials for Grade III injuries only. They also found evidence in favour of functional treatment. With regard to pain, functional treatment resulted in significantly less residual pain than cast immobilisation. It must be noted that operative treatment was found to result in even less residual pain than functional treatment, however. It is likely that the results indicate the usefulness of operative treatment, due to the inclusion of trials for Grade III injuries only. Had the review included trials with Grade I and II injuries (where surgery is rarely performed) results may have differed.

Based on the results of the identified trials, it is apparent that functional treatment results in a faster functional recovery, greater ROM and less persistent ankle swelling, than treatment of ankle sprain with cast immobilisation. Trials that investigated each of

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these outcome measures all found significantly better results with functional treatment. Four of the five trials that investigated the outcome measure of pain found that functional treatment resulted in a faster reduction in pain. However, one trial found no significant difference in pain scores between groups treated with cast immobilisation or functional semi-rigid cast immobilisation (Avci & Sayli, 1998). The results of this trial should be interpreted with caution however, as it received the lowest methodological quality score of all the literature pertaining to the principle of functional treatment.

The three SR's identified, confirm that functional treatment results in faster functional recovery, greater ROM, less persistent ankle swelling (Kerkhoffs et al., 2001; Kerkhoffs et al., 2002) and less residual pain than treatment with cast immobilisation (Pijnenburg et al., 2000).

From the trials that compare functional treatment protocols, it is impossible to state whether any of the protocols are of greater value. Two of the three trials, found that their functional treatments resulted in improvements, however, there were no significant differences between treatment groups (Boyce et al., 2005; Johannes et al., 1993). Only one trial found a significant difference between treatment protocols (Scotece & Guthrie, 1992). Scotece and Guthrie found that strapping which is changed daily resulted in a faster functional recovery than prolonged strapping (changed every three days) or treatment with a gel cast. Whereas Johannes, Sukul, Spruit, and Putters (1993) found that strapping was of similar benefit to treatment with a semi-rigid cast.

A recent Cochrane review of 21 trials involving 2184 participants examined immobilisation versus functional treatment in acute ankle sprain adult participants (Kerkhoffs et al., 2005). Seven outcome measures significantly favoured functional treatment compared with immobilisation. Favourable functional treatment outcomes included long term return to sport, decreased time to return to sport, increased numbers of patients returned to work at short term follow-up, decreased time to return to work, decreased swelling at short term follow-up, decreased objective instability (as tested by stress X-ray), and increased functional satisfaction with treatment. There were no significant differences between varying methods of immobilisation, and no treatment intervention. These findings advocate for early mobilisation and functional treatment following acute ankle sprain in adults. There was a large variety of functional

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treatments examined and many trials were poorly reported. In all of the analyses no significant results were found in favour of immobilisation (Kerkhoffs et al., 2005)

A recent review article on the prevention of ankle sprains in athletes found that multi-faceted prevention programmes which collectively included education, technical training, taping, flexibility exercises, and wobbleboard training in participants with and without sprain history led to significant reductions in re-injury compared to controls (Osborne & Rizzo, 2003). These findings are similar to those by Holme et al. (1999), who reported that following intervention only 7% of the participants suffered a re-injury while 29% of those in the control group suffered re-injury (see Table 8).

Multi-modal physiotherapy

There was a lack of RCT's in the literature looking at the effect of multimodality for acute ankle sprains. Only one RCT by Holme et al. (1999) was identified in abstract form, examining the results of overall physiotherapy management of ankle sprains. As the complete reference of this study is not known to be available in English, methodology was not analysed in-depth, and the poor quality score was obtained through the PEDro database.

Table 12: RCT examining the effect of multi-modality physiotherapy on ankle sprain participants

Author	Purpose	Intervention & Control	Results	PEDro Score	IVS	QS
Holme et al.(1999)	To determine the effect of a supervised physiotherapy rehabilitation programme on postural sway, position sense, and isometric ankle strength which were measured at 6 weeks, 4 months and 12 months post injury, in 92 participants with acute ankle sprains	<u>Intervention group:</u> Received supervised physiotherapy for one hour 2x per week with an emphasis on balance training. In addition the intervention group received standard information regarding early ankle mobilisation. <u>Control group:</u> Received the same standard information regarding early ankle joint mobilisation as the intervention group.	Both groups exhibited a significant difference in postural sway but not positional sense was found to be different between the injured and uninjured sides ($P<0.01$) at 6 weeks. The injured to uninjured side percent differences were similar in both groups for all variables at 6 weeks ($P<0.05$) and there were no side-to-side differences shown between groups after 4 months. In the control group 29% suffered a re-injury, while in the intervention group only 7% suffered a re-injury ($P<0.05$).	3	1	Limited

Results of Holme et al.'s (1999) study indicated that twice weekly physiotherapy treatment and advice resulted in significant reductions in re-injury rate compared with controls receiving advice alone. However, there were no significant between-group differences noted in joint positional sense or postural sway (see Table 13).

Summary of the evidence for physiotherapy modalities

Early physiotherapy management for acute ankle sprains is recognized as being multimodal. There are a variety of treatment options which the physiotherapist can use depending on their clinical judgment, based on healing timeframes the patient and the nature of the injury. Treatment options include but are not limited to; RICE options, electrotherapy, bracing, proprioception, mobilisations, strengthening functional retraining, range of movement exercises and acupuncture. With respect to each individual modality there is a brief paragraph to summarising the recent literature. Although there is research looking at various treatment options there was only one paper that met our inclusion criteria that looked at multimodal physiotherapy.

Ultrasound and electrotherapy

The conclusion from this review was that ultrasound was unlikely to be beneficial for acute ankle sprains based on the current literature (BMJ, 2006). TENS may be useful for pain relief in the acute stage.

Mobilisations

The available evidence is in favour of mobilisations and MWM's for the treatment of talocrural and inferior tibiofibular dysfunction. However, this evidence is very limited and there is a paucity of RCT's, and review articles to prove or disprove treatment efficacy. More research is necessary to examine the optimal treatment stage, mode, intensity, and frequency necessary when applying mobilisations and MWM's in an ankle sprain population.

Proprioception

Wobbleboard training is a widely used clinical intervention to reduce the incidence of ankle sprains and the results of the studies examined in this review provide some evidence supporting its use while other forms of proprioceptive treatment have not been examined adequately by RCT's. Improvements seen in the examined studies may be

due to peripherally and/or centrally modifiable mechanisms. However, regardless of the mechanism of change, both may contribute to decreased incidences of lateral ankle sprains and improved functional outcome. The varied methodology and low quality of the recent studies makes it difficult to draw conclusions. Further high quality RCT's examining the effects of proprioceptive training on an ankle sprain population are necessary to further support or refute its efficacy and to determine the most beneficial frequencies, intensities, and duration of treatments.

Strengthening

There is a lack of strong evidence to support or refute the use of different methods of strengthening as treatment interventions following lateral ankle sprains. In the evaluated studies kick exercises and progressive resistance training using Theraband™ failed to yield significant improvements in outcome measures. However, a high-intensity bi-directional pedal exercise programme did yield significant improvements, and further study may be warranted to further validate this treatment intervention. High quality RCT's are needed to retest Theraband™ and other strengthening treatment modalities, as 'A' grade evidence was currently absent.

Bracing

There appears to be some evidence that bracing is effective in the acute stage of grade II –III injuries. Taping is effective in reducing the rate of recurrence for ankle sprains.

Functional treatment protocols

Functional treatment is more effective than immobilisation for grade I and II ankle injuries (BMJ, 2006). It would appear that multi-faceted prevention programmes which collectively included education, technical training, taping, flexibility exercises, and wobbleboard training in participants with and without a history of ankle sprains are effective; however, there is a need for further research to quantify the most appropriate treatments at the most effective time in the healing process.

Multimodality physiotherapy

As there was only one trial that investigated multimodal physiotherapy and the IVS of that study was 1 with a QS of 'limited' which meant the quality of the research was poor and further research is needed in this area.

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To conclude, results generally indicated that physiotherapy can be effective in the treatment of ankle sprains to decrease the likelihood of re-injury, and to improve functional outcomes. However, these results should be viewed with some caution as there was insufficient evidence in the form of high quality RCT's to support or refute this claim. More research is necessary to determine optimal combinations, modes, frequencies, and duration of physiotherapy treatment for ankle sprains for the various stages of healing.

There was a lack of evidence for multimodality physiotherapy treatment for ankle sprains. As it would be normal for a physiotherapist to use a range of treatments over the duration of a patient's treatment for an acute ankle sprain (and often multiple modalities are used in the same session) the interaction effects if the multimodality physiotherapy treatment also needs to be investigated.

As the evidence (for and against) some physiotherapy modalities mounts, and the need to practice evidenced based practice becomes paramount, it is necessary to continuously reflect and review ones own practice. Where strong evidence is lacking, decisions on the quality of the intervention are required to be made on moderate or limited evidence, this being the quality of the available evidence for many physiotherapy modalities. Physiotherapy appears to be beneficial for Grade I and II acute ankle sprains however surgery appears to be the most efficacious long term management for Grade III injuries.

CHAPTER 3: METHOD**Introduction**

The study employed a randomised controlled study to determine whether or not physiotherapy combined with RICE treatment was more effective than RICE treatment alone in improving outcomes of pain, function and swelling in the clinical situation for early ankle sprains (up to 11 days post injury). Although there is literature on the effect of physiotherapy management of ankle sprains, there is little information on the effect of RICE advice compared to physiotherapy.

The current study***Possible benefits of the study to the physiotherapy profession and to the participants***

The outcome of the study may benefit physiotherapists, health care providers, ACC and the general population, as it helps increase the evidence based medicine knowledge pool to help health care practitioners provide cost effective and appropriate management of acute ankle sprains.

The benefits for the participants included receiving a new re-usable ice pack and compression bandage, education about the RICE method, subsidised physiotherapy visits, and travel expenses paid for by ACC.

Risks of the study

Qualified physiotherapists delivered the treatment and assessed the outcomes of the research. There were some risks associated with physiotherapy treatment modalities. These included, but were not limited to, risks with the electrotherapy modalities such as TENS, Interferential and Ultrasound. Risks included electrical burns due to high intensity application over anaesthetised skin, application with improper technique or an allergic reaction to the electrode pads. The risks of ice included cold burns and skin hypersensitivity to cold. Strapping can result in skin irritations or reactions if the tape is left in situ for prolonged periods, or friction blisters due to improper application of the

tape. There was a risk of transmitting infections or micro-organisms from patient to patient during the volumetric analysis, which was negated by thorough cleaning and drying of the tank in between patients and by using fresh water for each patient. Appropriate implementation of techniques with a thorough understanding of contraindications associated with electrotherapeutic modalities, taping, ice, manual therapy and exercise prescription minimised any risks associated with the treatment. All efforts were made to ensure personal information remained confidential.

Study design

A doubly multivariate repeated measures model design was used as there were three measurements (swelling, pain, and function) taken for all participants on five occasions (Days 1, 3, 7, 11 and 24) for two groups of participants (RICE versus physiotherapy). Data on compliance and medication was collected in a home diary. Figure 2 depicts a flow diagram for the study.

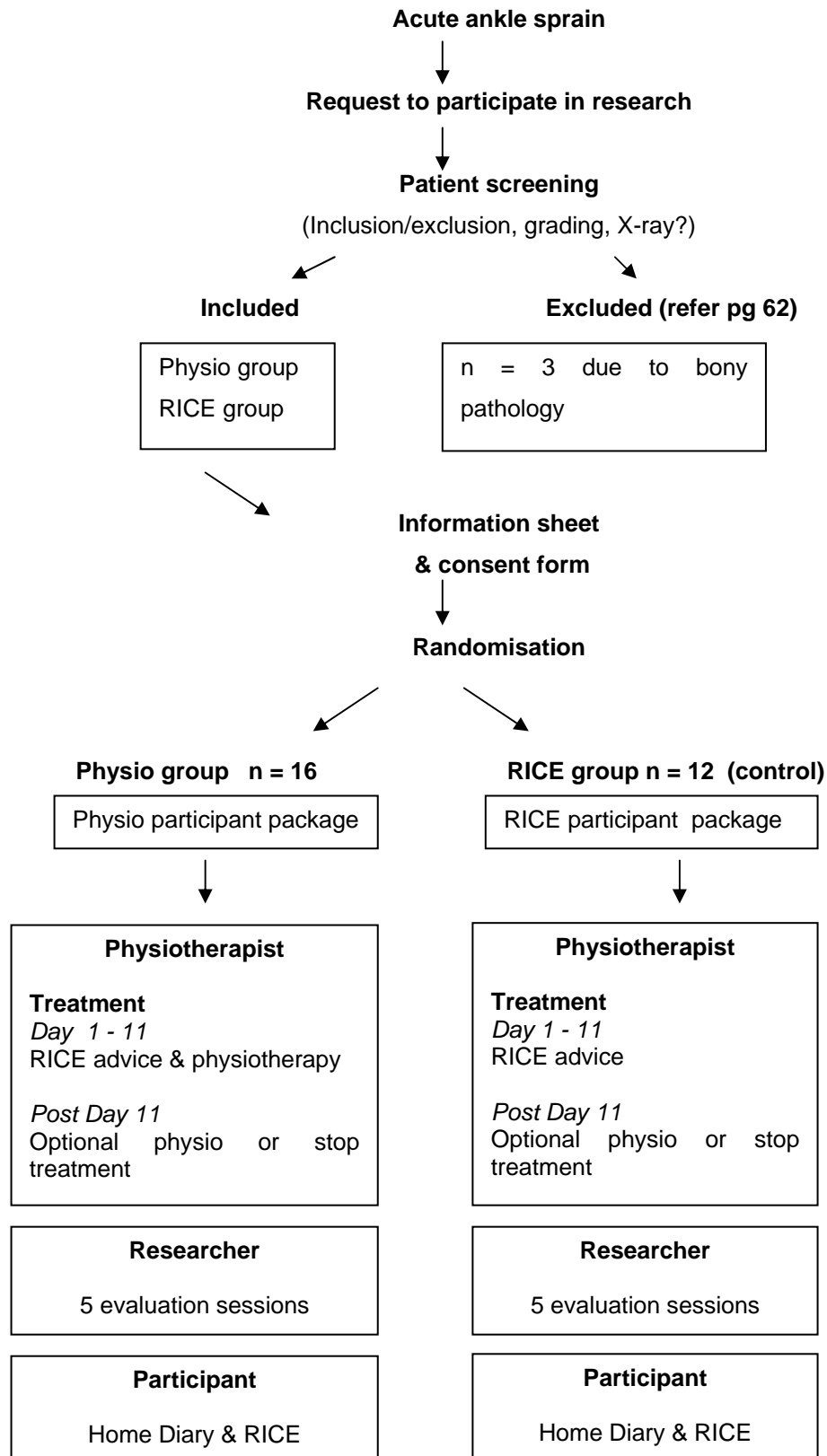


Figure 2: Flow chart for study

Participants

Funding

Funding was supplied by ACC. This allowed for physiotherapy practice surcharges and expenses and for each participant to receive an elastic compression bandage, an ice pack and money for petrol to attend the measurement days.

Ethical approval and participant consent

The Auckland University of Technology Ethics Committee (AUTEC) granted ethical approval for the study (see Appendix 5). The study methods were clearly explained prior to participation in the study; a handout was issued and every participant was given six hours to consent to the study. Thirty one participants signed written consent forms to participate in the study and were randomly allocated to one of the two treatment groups.

Inclusion and exclusion criteria

A participant was deemed eligible to be included in the study if they matched the inclusion criteria:

1. Males and females between the ages of 16 and 49 who sustained an ankle sprain in the last 48 hours; and
2. Consenting to taking part in the study.

A participant was excluded from the study if they:

1. Had a previous sprain of the same ankle;
2. Sustained a fracture or other injury other than a soft tissue ankle injury;
3. Could not understand or speak English;
4. Withheld consent; and
5. Had a systemic disorder that interfered with normal healing timeframes.

Randomisation of participants into RICE and physiotherapy groups

The participants were randomly allocated to one of the two treatment groups using a list of 40 numbers which corresponded with either the physiotherapy group or the RICE group generated by the random number generator in Excel. These numbers and the group were printed onto a piece of paper and put into 40 sealed envelopes which were then shuffled.

Participant recruitment

Participants were recruited by notices and advertisements at local doctor's clinics and football clubs (see Appendix 14), and from the patient population at the physiotherapy clinic where the principal investigator worked. If someone was deemed to be appropriate to be included in the study (because they fitted the inclusion and exclusion criteria) they were approached by the physiotherapists working on the project. Participants chose an unmarked envelope which allocated them to either the physiotherapy or RICE group depending on what was inside the envelope.

The reason that both groups were not equal in number is because the 40 randomisation envelopes had already been made, sealed, and were in use from the start of the study. The randomised assignment of the participants into the treatment and control groups was also compromised, by the insistence of some participants that they receive physiotherapy (some of the participants were professional athletes). At the start of the study the goal was to recruit 60 participants, with 30 in each group. Due to recruitment difficulties the final number of participants recruited was 31.

Equipment

Materials used in conducting this research included: a pamphlet called "Managing your Sports Injury" (see Appendix 1) produced by ACC SportSmart in April 2003 (A.C.C., 2003); a Nexcare Instant and Re-usable Cold Pack (3M Health Care, St Paul, USA CAT# 2642); a crepe 75mm elastic compression bandage; a participant handout (see Appendix 5); a participant home diary (see Appendix 6); a volumetric tank custom made from 6mm thick Plexiglass (Modern signs (NZ) Ltd, Auckland, New Zealand); a recipient container that weighed 17.9g; electronic scales (accuracy 0.01g, VIBRA-CG, Wedderburn scales Ltd, Auckland, New Zealand); a mercury thermometer; (see Figure 3).

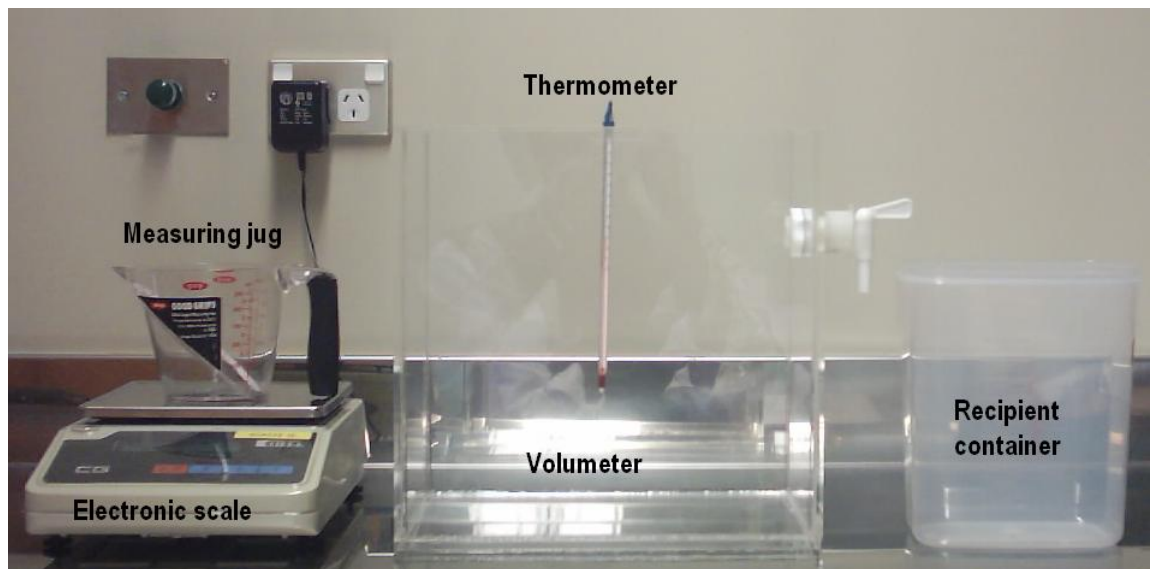


Figure 3: Volumetric measurement tools

Procedure

Participants received a total of five ankle assessments; an initial ankle assessment on Day 1 and four further ankle assessments on Day 3, 7, 11 and 24. All efforts were made to ensure that the time the volumetric measurements are taken were similar for all five measurements. At each of these assessments the participant was encouraged to complete their home diary, a VAS score was recorded, a group of functional questions were completed, and three foot and ankle volumetric measurements were taken. The physiotherapy group received treatment up to six times until Day 11, and as they needed it at the physiotherapists discretion after that. During this time the RICE group received only the standard RICE advice. After Day 11 the RICE group could choose to begin receiving physiotherapy, and either group could choose to stop treatment. Patients were permitted to take any medication they were prescribed (or had elected to take). The name and dose of the medication was documented in the *medications* section of the home diary.

The initial assessment

The study procedure was explained to each participant and consent gained. A subjective history was taken and the ankle was assessed to exclude all other ankle pathologies, such as fractures, Achilles tendon pathology, ankle dislocation, and vascular or neurological damage. Consenting participants received the same general advice about the RICE treatment protocol (see Appendix 1), a hand-out and consent

form (see Appendix 5), a participant home diary (see Appendix 6), a re-usable ice pack, and a compression bandage. An initial grading was given using an adapted version of the West Point Ankle Grading System (see Table 3). Grading in the acute setting is difficult and not reliable (van Dijk, 1999), therefore final grading took place on Day 7. The initial volumetric analysis, and VAS scores were taken, and functional questions were completed. The physiotherapy group received 30 minutes of physiotherapy treatment and both groups received advice on how to RICE the ankle.

Follow up assessments

At the next four assessments (on Day 3, Day 7, Day 11 and Day 24) the three volumetric measures and VAS recordings were repeated and compliance for the home diary was encouraged. On Day 7 the participants' sprained ankle was reassessed and on Day 24 the home diary was handed back. Participants could change from the RICE group to the Physiotherapy group after Day 11 and participants in the Physiotherapy group could stop treatment after Day 11 (five treatments) or join the RICE group.

Outcome measures

Five different outcome measures were used to investigate the impact of the ankle sprain on the patient. The first three were measured on Days 1, 3, 7, 11 and 24. **Pain** was measured using a visual analogue scale (VAS), **Function** was quantified using a functional question adapted from de Bie et al. (1997), and **Swelling** was measured using a volumetric analysis of the foot, ankle and lower leg. The last two were investigated through a home diary. **Compliance** was investigated by looking at the percentage of the home diaries that were completed and by looking at the first day of documented non-compliance. **Medication** was compared by looking at the documented percentage use.

Pain

The Visual Analogue Score (VAS) is a measurement instrument that has been used since the 1920's to measure a characteristic or attitude that ranges over a continuum of values that can not be easily quantified. It is most valuable when looking at change within individuals. The VAS is easy to use, reliable and is a well established, validated, self report measure (Wewers & Lowe, 1990) that consists of a line on paper with descriptive anchors at either end; 'no pain' at the left end and 'unbearable pain' on the right side (see Figure 4). The participant marks a spot on the line that they believe

represents their perception of their current state. The VAS is scored by measuring the distance (in millimetres) from one end of the scale to the participants mark on the line (Wewers & Lowe, 1990).

VAS is commonly used to measure pain and it has advantages over verbal rating scales and numerical scales in sensitivity to changes in pain intensity (Jamison et al., 2002). A study by Kelly (2001) in a teaching hospitals Emergency Department investigated the minimum clinical significant difference (MCSD) to see how many millimetres (mm) difference participants have to mark on the 100 mm VAS scale to illustrate a significant difference in their pain. The MCSD for severe pain was 10 mm, for moderate pain was 14 mm and for mild pain was 11 mm and overall was shown to be 12 mm (95% CI 9 mm-15 mm) in an ED department. They concluded that the MCSD does not differ depending on the severity of the pain being experienced (Kelly, 2001). The VAS is more sensitive to fine changes in pain compared to numerical and four point rating scales (Wewers & Lowe, 1990). However, it needs to be clearly explained and the patient has to understand the concept and purpose of the scale or the results may not be valid. Differences in VAS scores across groups needs to be interpreted with caution because the differences between groups in VAS scores can have no clinical significance, even if they achieve statistical significance (Farrar, Portenoy, Berlin, Kinman, & Strom, 2000). This is due to the VAS being more sensitive for measuring the change in one person's pain, than in comparing pain between people. The VAS is useful for identifying the pattern of pain in individuals however.

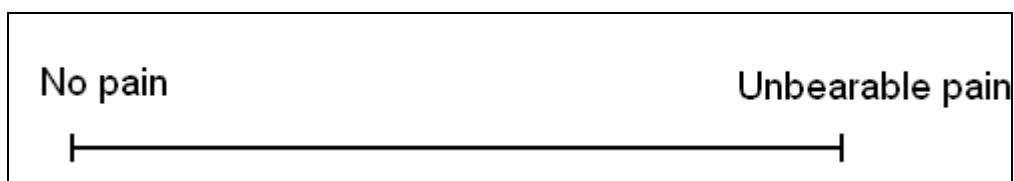


Figure 4: Visual analogue scale

Function

Following an acute ankle sprain function can be measured either objectively (using physical tests) or subjectively, using functional questions or questionnaires. However, as there is always a danger of re-injuring the ankle by carrying out the physical tests the subjective method was considered more appropriate in the acute setting.

Haywood et al. (2004) identified and reviewed the evidence for measurement properties of published multi-item outcome measures used in conservative management of lateral ligament injuries of the ankle. The following seven disease-specific measures of ankle status were included in their study:

- Ankle Joint Functional Assessment Tool;
- Clinical Trauma Severity Score;
- Composite Inversion Injury Scale;
- Kaikkonen Functional Scale (KFS);
- Karlsson Ankle Function Score (KAFS);
- Olerud and Molander Ankle Score (OMAS); and
- The Point System,

and two generic measures of health:

- McGill Pain Questionnaire;
- Sickness Impact Profile.

Haywood et al. (2004) found on the basis of limited evidence, firstly, that the KFS offered the most promising approach to a combined clinician, and patient, assessment of ankle function, and secondly that the KAFS or OMAS would be more appropriate if a patient-assessed evaluation is required (Haywood et al., 2004). In conclusion, these researchers found a disappointing lack of evidence for measurement reliability, validity and responsiveness for all the functional measures included in their review.

The question used in our study was adapted from the Lysholme score which was created for knee injuries, and adapted for ankle sprains by de Bie et al. (1997). There are five categories in the de Bie functional score; pain, instability, weight bearing, swelling and gait pattern. Each category has functional symptoms which the participant can choose to best illustrate their function at the time the questions are completed. Each functional symptom is allocated points, in such a way to illustrate the disability rate. The points are totalled, and a score of thirty-five points correlates with the person being able to walk, seventy-five points illustrates that the person can maintain a normal gait pattern in most circumstances. In the questionnaire format it had sensitivity of 97% and specificity of 100% for discriminating between light (<2 weeks) and severe (>2 weeks) ankle sprains.

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For the current study, the questionnaire was modified by removing specific questions as we were specifically investigating the functional ability of the participant, not the severity of the ankle sprain (see Appendix 15). There was also crossover between some of the questions, with questions investigating pain (which we look at separately using VAS scores), swelling (which we look at independently using volumetric scores), functional tasks such as running and stair climbing and questions that combined parts of other questions such as weight bearing ability (question nine) and question seven that looked at work activities, sport, and leisure activities. Therefore only question seven, which incorporated comments on the participants work, leisure and activities of daily living (see Figure 5), was used to give a description from the participant of their functional ability.

Question seven asks participants to rate their “work activities, sport, leisure activities” into one of four possibilities: a) same as pre-injury; b) same work, less sports normal leisure activities; c) lighter work, no sports, normal leisure activities; d) severely impaired work capacity, decreased leisure activities. Participants were asked to tick the box that most applied to the level they felt their ankle was at. This was then coded and entered into a SPSS programme.

7. Severely impaired work capacity, decreased leisure activities

- ☐ Same as pre-injury
- ☐ Work activities, sport, leisure activities
- ☐ Same work, less sports, normal leisure activities
- ☐ Lighter work, no sports, normal leisure activities

Figure 5: Functional question from home diary

Swelling

Water displacement was used to measure swelling. It is an accurate, cheap and easily reproducible method for measuring foot and ankle volume. It has been used for evaluating swelling of the upper extremities and has recently been validated for measuring the volume of the lower limbs (Brijker, Heijdra, van den Elshout, Bosch, & Folgering, 2000; Petersen et al., 1999; Tierney, Aslam, Rennie, & Grace, 1996).

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The validity of an apparatus can be defined as; “the degree to which it measures what it is supposed to measure” (van Thiel, Ram, & van Dalen, 2000). The accuracy of the materials used for the volumetric analysis of the apparatus were quantified in a previous study (Balasundaram, 2006). Two researchers investigated the intra-rater reliability, inter-rater reliability and the within day variation of the volume of a metal object and the foot, ankle and lower limb in normal healthy individuals without foot or ankle injuries, or cardiovascular pathology.

When measuring the volume of water displaced by the metal ball the greatest difference between measurements was 2.10 ml, the mean difference for all the trials was 0.44 ml and the mean percentage of error was 0.04%. The within day intra-rater reliability *p* value was greater than 0.05 in all occasions suggesting no systematic bias between trials. The correlation co-efficient was identical (ICC = 0.999) for both raters between each trial on all three different days, indicating high inter-rater reliability. The magnitude of difference for both researchers on different days was from -10 to +9 ml difference, or ± 10 ml. The standard error of measurement (SEM) for both researchers was ± 3.5 ml.

The between day measurements showed no evidence of systematic bias and the range of difference for both researchers was ± 20 ml. The Bland and Altmans 95% limits of agreement (LOA) and SEM were in the range of ± 20 ml and ± 7 ml respectively for both researchers, indicating the error had increased two-fold during repeated measurements on different days. The inter-rater reliability also showed no evidence of systematic bias between all the trials, with a range of ± 13 ml for both researchers.

Overall, the within day intra-rater reliability had the lowest range of error, followed by inter-rater reliability and then between day reliability which had the greatest range of error. The day to day biological variation in foot and ankle volume between the three days for both raters showed no significant difference when calculated using an independent ANOVA ($p < 0.05$) (Balasundaram, 2006). There was no statistically significant ($p < 0.05$) day-to-day biological variations in normal foot and ankle volume over the three measurements from Day 1 to Day 5 as estimated from both researchers. These results were used to help identify outliers in the current study.

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A diurnal variation of foot and ankle volume has been observed by Brijker, (2000). In healthy participants this is minimal with a 1.2% increase during the day reported by Goldie et al. (cited in (Brijker et al., 2000)). In patients with ankle oedema there may be a greater increase such as the 5.7% increase shown by Brijker, (2000). Therefore, in order to standardise the measurements, the participants were asked to present for the five separate volumetric measurements at a similar period of the day. However, this was not always possible due to participant's timetables.

To investigate the effect of volumetric scores over time and the interaction effect across groups for swelling a one-way repeated measures ANOVA with the factor being Days post injury and the dependant variable being the average of the second and third volumetric scores was conducted.

Preparation of the volumetric tank: The tank was placed on a level surface in proximity to a water tap. Using the measuring jug, the tank was filled with water to just above the level of the closed tap. The recipient container was placed beneath the tap in the tank. Once the waves had settled the tap was opened and the displaced water was collected in the recipient container. The thermometer was used to ensure the water temperature inside the volumeter was constantly within 25-35°C. The temperature was maintained by adding fresh hot or cold water from the tap. When the dribbling of the water was dripping at only one drip per second the tap was closed (cut off point).

The electronic scale was prepared by placing it on a level surface, plugging it into the wall and switching it on. Once the display registered '0.00' the recipient container (17.8g) was placed on the scale. After two seconds a button could be pushed on the scale which reset the display to show '0.00' with the container on the scale. This meant that the reading would only show the weight of the displaced water once it was in the container. The volume of the foot and ankle is equal to that of the displaced water.

Procedure for volumetric measurement: The tank and scale were prepared. The testers demonstrated the foot positioning as suggested by Petersen et al. (1999) to the participants without putting their foot in the water. Each participant was instructed to sit behind the volumetric tank on a computer chair. The seated participant lowered the plantar aspect of their foot into the tank until the foot rested flat at the bottom of the tank, with the toes lightly touching the anterior wall of the tank and the calf muscle of

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the leg in contact with the posterior wall of the tank (see Figure 6). This ensured a reproducible position that allows even severely swollen ankles and feet to be accurately measured on subsequent testing days (Petersen et al., 1999). Once lowered, the leg the foot was shaken gently to eliminate any air bubbles. The participants were advised to sit still and to maintain this position throughout the measurement period, and for the next two consecutive measurements. Once the waves on the surface of the tank had settled, the tap was opened and the displaced water was collected in the recipient container. Water drained out of the tap was captured in the recipient measuring cylinder until the drip speed was less than one drip per second.

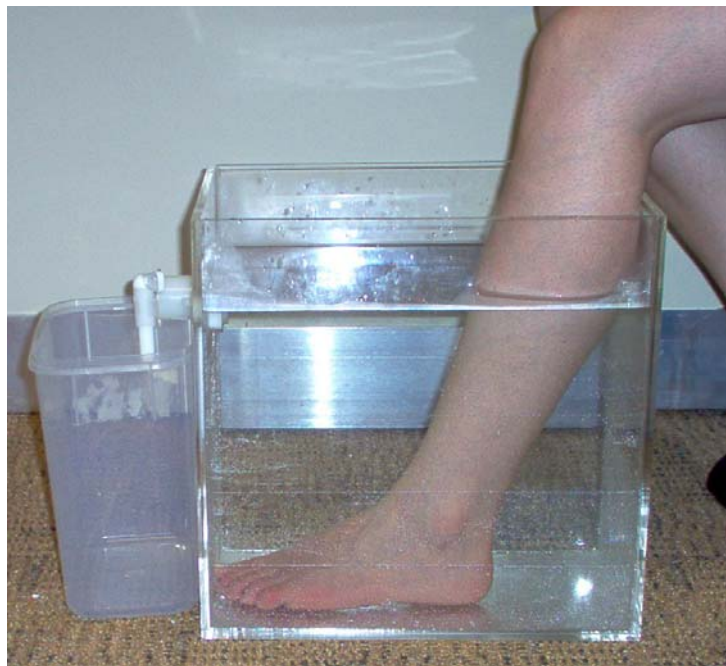


Figure 6: Foot position for volumetric measurement

The cylinder was removed and immediately weighed using the digital scale and the displaced water was recorded in grams. Then the recipient container was removed from the scale and the displaced water was emptied back into the volumetric tank and topped up if necessary. The recipient container was dried thoroughly with a towel to remove any water in it. The dry recipient container was placed again beneath the tap and the volumeter was ready for measurement.

The volumetric tests were conducted and recorded three times with the average score used for the final analysis. After the third measurement the participants' leg was taken out of the volumeter and dried. The water was emptied out of the volumeter and the

tank was cleaned and dried to ensure that no infections or micro-organisms were transmitted between participants.

Compliance

Compliance can be defined as ‘The degrees to which patients adhere to the treatment plan’ (MOHP, 2006) or are acquiescent to instructions. Even the most thorough and well-designed therapeutic programme can fail without patient compliance. Various studies showed that 15% to 95% of patients have been found to be non-compliant (MOHP, 2006). Non-compliance is encountered more when certain factors associated with the therapeutic situations, and patient characteristics exist. Forgetfulness is the most frequent reason given for non-compliance but non-compliance may also result from fear of the state that treatment implies or fear of loss of independence. Education augmented by hard evidence promotes and improves compliance. Trust in the prescribed therapy is essential, and crucial to patient compliance and therefore, for good compliance, communication between the therapist and the patient is essential (MOHP, 2006).

A RCT investigating compliance to exercise prescription for Osteoarthritis was conducted by Campbell (2001). They investigated compliance through an interview process. The authors found that initial compliance was high due to feelings of loyalty to the physiotherapist, however reasoning underpinning continued compliance was more complex. As well as being motivated by the hope that they might benefit from the exercises, participants were also inspired by a collectivist ethic; they were contributing to research which might help others. Continued compliance was dependant on the willingness and ability to accommodate exercises within everyday life, the perceived severity of symptoms, attitudes towards the injury and co-morbidity, and previous experiences. A necessary precondition for continued compliance was the perception that the physiotherapy was effective in ameliorating unpleasant symptoms. From the patient's perspective, decisions about whether or not to comply are rational but often cannot be predicted by therapists or researchers. Ultimately, this study suggested that health professionals need to understand reasons for non-compliance if they are to provide supportive care (Campbell et al., 2001). The authors support moving away from a view of patients as compliers and non compliers to one which sees patients as legitimate participants in rational decisions about therapy.

Medication

A full literature review on medication use for ankle sprains was outside the scope of this review. Medication use was investigated in the current study to elucidate any differences in pain between groups that was not related to the use of RICE and physiotherapy.

Procedure for analysis of results

Statistical analyses

After three participants were excluded due to bony injury, the remaining 28 participants were analysed using the Statistical Package for Social Sciences (SPSS) software package (SPSS Institute, Cary, NC, USA).

The outcome measures were analysed using a variety of methods. Groups were compared using an independent samples t-test to ascertain if there was any difference between groups on Day 1. The demographics of the participants were described and the groups discussed. Because participants had an option of changing the treatment they receive after Day 11, only the data for Days 1, 3 and 11 were analysed and described according to the participants group.

Missing data from ankle assessments

Missing data was a concern for the study due to poor compliance in terms of completing the home diary and not showing up for assessments. The decision on how to handle missing data was difficult as there is no specific protocol on the best method of dealing with missing data. The default setting for SPSS is to delete the variables with missing data; however, this would have led to a dramatic reduction in the number of participants and therefore Type II error. Estimating missing data, by deleting outliers and then taking the mean of the remaining two volumetric measures could have been used but it was considered more appropriate to use the Expectation Maximisation (EM) method using the SPSS MVA (missing values analysis) which is specifically designed to highlight patterns of missing data as well as replace them in a data set (Tabachnick & Fidell, 2007).

EM forms a missing data correlation (or covariance) matrix by assuming the shape of the distribution for the partially missing data and bases inferences about missing values on the likelihood under that distribution. It is an iterative procedure with two steps -

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expectation and maximisation. The initial 'E' step finds the conditional expectation of the 'missing' data, given observed values and correlations, and then the 'M' step performs maximum likelihood estimation as though the missing data had been filled in. Finally, after convergence is achieved the approximated data is saved in the data set. An independent samples t-test was then done to ensure that there was no significant difference between the original data and the EM data. Finally the EM data was used for the final analysis. Advantages of this system are that it avoids impossible matrices, avoids over-fitting, and produces realistic estimates of variance (Tabachnick & Fidell, 2007).

Pain: To investigate the effect of pain scores over time, and the interaction effect across groups for pain, a one-way repeated measures ANOVA with the grouping variable being days post injury and the dependent variable being VAS scores was conducted. The pain scores were also analysed for missing data. The VAS pain scores for the treatment and RICE groups from Days 1, 3 and 11 were compared using an independent samples t-test and univariate analysis of variance (ANOVA) using the GLM (General Linear Model) procedure with SPSS. Type I error was set at $\alpha = 0.05$. The VAS data was treated using the EM method where there was missing data from no shows in the data collection. The significance of difference amongst means was examined post hoc at the 95% Confidence Interval (CI) using an appropriate set of contrast co-efficients.

Function: To investigate the effect of function over time and the interaction effect across groups for function, a one-way repeated measures ANOVA with the grouping variable being days post injury and the dependent variable being the function score was conducted. The functional scores from question seven in the home diary were compared using an independent samples t-test and univariate analysis of variance (ANOVA) using the GLM procedure with SPSS for both groups. Type I error was set at $\alpha = 0.05$. The functional data was also treated using the EM method where there was missing data from 'no shows' in the data collection. The significance of difference amongst means was examined post hoc at the 95% CI using an appropriate set of contrast co-efficients.

Swelling: To investigate the effect of swelling over time and the interaction effect across groups for swelling, a one-way repeated measures ANOVA with the grouping

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variable being days post injury and the dependent variable being the average score of the second and third volumetric measurement was conducted. The volumetric data was treated using the EM method. First the volumetric data was run with only the 'no show' data missing, i.e. those participants who had not shown up for a volumetric analysis, or had stopped due to poor compliance. Secondly the data was analysed for outliers by identifying the data with variations within the three measurements on a single day that were greater than 30 ml apart, as this was the range of error that Balasundaram (2006) had identified in his reliability and validity study. Scatter Graphs were constructed from the data (see Appendix 8) to help identify outliers. The data point that had the greatest difference from the other two was removed. This data was called 'no outliers' and was run using the EM missing value analysis. SPSS creates a new file when it does the analysis that fills in the missing data using maximum likelihood estimation.

The original data was run against the 'no show' data and the 'no outliers' data to see if there was a significant difference between the three sets of data. Finally the data set that is created by running the MVA in SPSS was compared to the other two analyses to see if there was a significant difference. Because there was only a small amount (<5%) of missing data on Days 1, 3 and 11 there was a significant reduction in the need to use the MVA analysis.

Medication: The *medications* section of the home diary were analysed to see if there was any difference between groups for medication use on Day 1 and Day 11. Differences were illustrated by Bar graphs. The results were also given as a percentage of participants who used medication. An independent samples t-test was used to describe the use of medication on Days 1, 3, and 11.

Compliance: Compliance was analysed in three ways. Firstly, by investigating the amount the home diaries were completed up to Day 24 which was expressed as a percentage. Secondly, the subjective data from the *non-compliance* section of the home diaries was analysed. The data was coded into categories that reflected the reason given for the non compliance. (Participants were told to complete their *non-compliance* section of the home diary by identifying the day and the reason for non-compliance for each RICE variable). Thirdly, the first day the participant recorded that they did not complete one or all of the components of RICE was documented and coded as the first

day of non-compliance for each RICE variable. Finally, an independent samples t-test was performed comparing the two groups in terms of their non-compliance.

CHAPTER 4: RESULTS

Summary of participant information

Of the 31 participants 23 were male and 8 were female, they ranged in age from 16 to 47 years (mean = 28.19). There were 12 individuals in the RICE group and 16 in the physiotherapy group, and three participants (who were all in the physiotherapy group) that were excluded during the study. The final analysis was run on 28 participants (22 male and 6 female) ranging in age from 16 to 39, with a mean age of 27.46 years. There were sixteen participants in the physiotherapy group and 12 in the control group. Table 13 shows the 28 participants demographics.

Table 13: Participant characteristics

	RICE group	Physiotherapy group	TOTAL
Females	3	3	6
Males	9	13	22
Mean Age (years)	30.1	25.5	27.5

There were two participants who requested to be allocated to the physiotherapy group when they were enrolled in the study. One of these participants was a professional athlete and the other participant would not consent to be part of the study unless they were in the physiotherapy group. Due to poor recruitment this participant was included in the final analysis. When comparing the physiotherapy and RICE participant characteristics on day 1 though, there were no significant difference between the groups in terms of functional ability ($p = 0.603$), perceived pain ($p = 0.238$) or swelling ($p = 0.687$). There were no reported incidences of skin burns, nerve palsies, or any other potentially deleterious effects in either group throughout the duration of the trial in either group.

Activity at time of injury

Twenty-six participants' (92.85%) injured their ankle playing sport (volleyball, rugby, netball, football, seven-side football, indoor football, and running); one participant injured their ankle at work (3.6%), and one at home (see Table 14).

Table 14: Activity at time of injury

Activity	Frequency	Percent
Football	18	64.3
Football (7 aside)	2	7.1
Football (indoor)	1	3.6
Home	1	3.6
Netball	1	3.6
Rugby	1	3.6
Running	2	7.1
Volleyball	1	3.6
Work	1	3.6
Total	28	100

The initial ankle assessment took place three to 48 hours post ankle injury (mean 27.3, SD 12.6). At Day 7 the ankle was re-assessed to ensure the provisional diagnosis at Day 1 was correct. There were three participants excluded because they were diagnosed with bony pathologies after Day 7 (all of whom were in the physiotherapy group). No participants were diagnosed with a Grade III sprain.

Participant recruitment

The strict inclusion/exclusion criteria restricted the number of recruited participants from the large number of eligible ankle sprain patients that presented to the clinic. At least fourteen patients presenting to the clinic within 48 hours of an ankle injury, but were not accepted into the study, as they did not meet the inclusion or exclusion criteria (e.g., fractures, previous sprain, under 16 years of age, conditions that affected the rate of tissue healing (such as diabetes etc).

Treatment prior to being assessed by physiotherapist

Prior to presenting for assessment and treatment, participants managed their injuries in different ways, from doing nothing (10.7%), to using one or more of the components of RICE (85.7%), strapping and medication (see Table 15). Most participants used at least

one part of the RICE principles prior to seeing a physiotherapist, with 28.6% using all components of RICE.

Table 15: Treatment undertaken prior to seeing Physiotherapist

Treatment	Frequency	Percent
Compression	2	7.2
Ice	5	17.9
Ice Compression	3	10.7
Ice Elevation	1	3.6
Ice Strapping	1	3.6
Ice Voltaren	1	3.6
Nil	3	10.7
Rest Elevation	1	3.6
Rest Ice	1	3.6
RICE	8	28.6
RICE Crutches	1	3.6
Strapping	1	3.6
Total	28	100

Time taken to present for physiotherapy

The time taken to present for physiotherapy for both groups was investigated. There was no statistical significant difference between groups. The mean time for the physiotherapy group to present was 28.9 hours and the mean for the RICE group was 28.3 hours. The minimum time was 3 hours and the maximum was 48 hours with an overall mean of 28.6 hours.

X-rays and investigations

X-rays were conducted on nine out of the final 28 participants (32.1%) as they presented with signs that suggested an investigation was appropriate using the Ottawa Ankle Rules (see Table 16). Out of the eleven participants investigated, three (27.27%) had a positive result for a bony pathology, excluding them from the study.

Table 16: Investigations

Investigations	Number of participants	Percentage of participants
X-ray	9	32.1
No X-ray	19	67.9
Total	28	100

Exclusions during the study

Three participants were excluded due to bony pathology that was diagnosed after the participants had been entered in to the study. X-rays on two participants showed loose bodies and an MRI on one participant after Day 24 confirmed a bone bruise.

Similarities of the group at Day 1

A comparison of the two groups was conducted at Day 1. The results are presented in Table 17, and indicate that there is no significant difference between the two groups in terms of pain and swelling, however, there is a significant difference in function on Day 1. This may indicate that the one of the groups had better function at the start of the study.

Table 17: Results of Independent Samples Test Day 1

Outcome measure	t	p
Function Day 1	-.527	0.016
VAS Day 1	.132	0.720
Swelling Day 1	1.380	.251

Pain

A one-way within participants ANOVA was conducted with the factor being the Days post injury and the dependant variable being the pain scores. For each of the three Days the mean, minimum, and maximum values are given in Table 18.

Table 18: Summary of all participants pain scores

	Day 1	Day 3	Day 11
Participant numbers	28	28	26
Mean VAS score	4.6	2.6	1.3
Min VAS score	1.1	0.3	0
Max VAS score	7.7	6.7	6.2
Standard Deviation	1.8	1.7	1.5

The VAS data from 14 participants in the physiotherapy group and 12 from the RICE were analysed using a repeated measures one-way ANOVA. Box's Test of Equality of Covariance Matrices was non-significant ($p = 0.014$) indicating that a Multivariate analysis was inappropriate, and so a Univariate analysis was used. Mauchly's Test of Sphericity was non-significant, and with Sphericity assumed $p < 0.001$ with a Partial Eta Squared value of 0.727. There was a linear effect over time $p < 0.001$ and the Tests of Between-Participants Effects for groups were non-significant (see Appendix 7). These results suggest that the physiotherapy and RICE groups significantly improved in their pain scores over time and there was no difference between groups (see Figure 7).

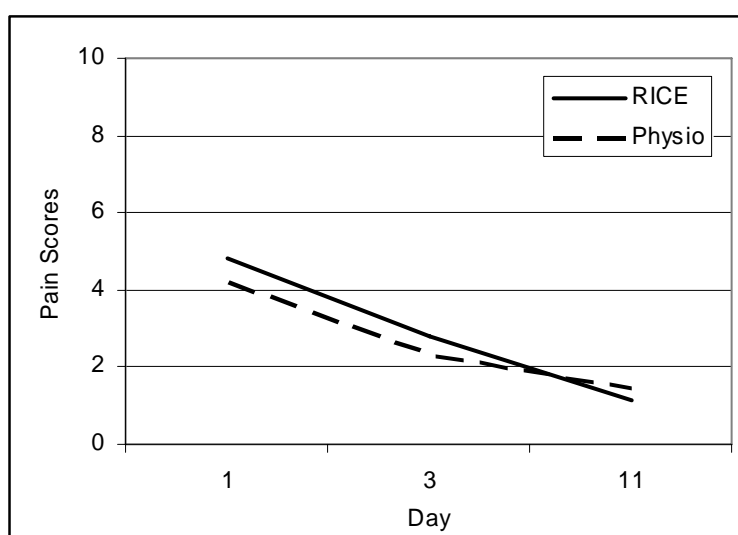


Figure 7: VAS scores for both groups at Days 1, 3 and 11

Function

A one-way within participants ANOVA was conducted with the factor being the Days post injury and the dependant variable being the function scores. The function question was completed on all occasions by 22 participants (14 in the physiotherapy group and 8 in the RICE group). Box's Test of Equality of Covariance Matrices was significant ($p = 0.539$) indicating that Multivariate analysis was appropriate.

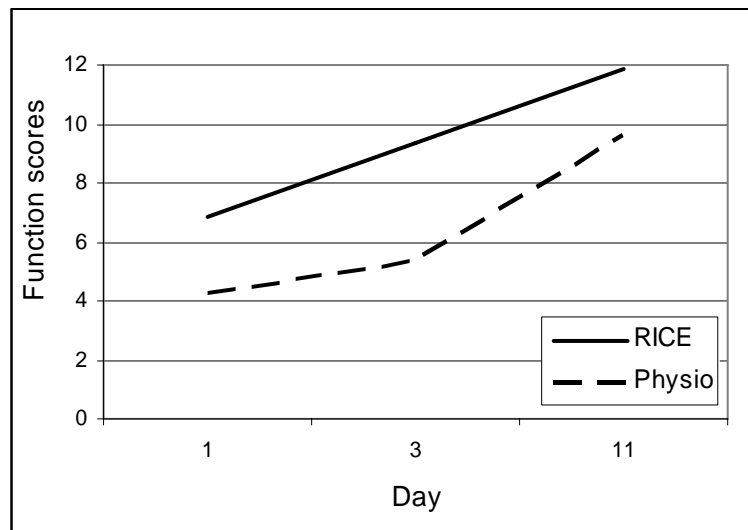


Figure 8: Function scores for both groups at Days 1, 3 and 11

The results for the ANOVA indicated a significant time effect, Pillai's Trace = 0.000, $F(2, 19) = 27.927$, $p = 0.000$, with a large Partial Eta Squared value of 0.746. These results show a significant effect over time for the function scores ($p = 0.000$) indicating that function improved as time passed for both groups. There was an interaction effect observed between the two groups ($p = 0.042$) with a small to medium Partial Eta Squared value of 0.191 (for results see Appendix 8). These results suggest that from Day 1 to 11 both groups self assessed function scores improved, and that there was a significant difference between groups (see Figure 8).

Correlation between pain and function

A scatter plot was produced to show the correlation between the pain and function scores on Day 1 (see Figure 9), Day 3 (see Figure 10) and Day 11 (see Figure 11).

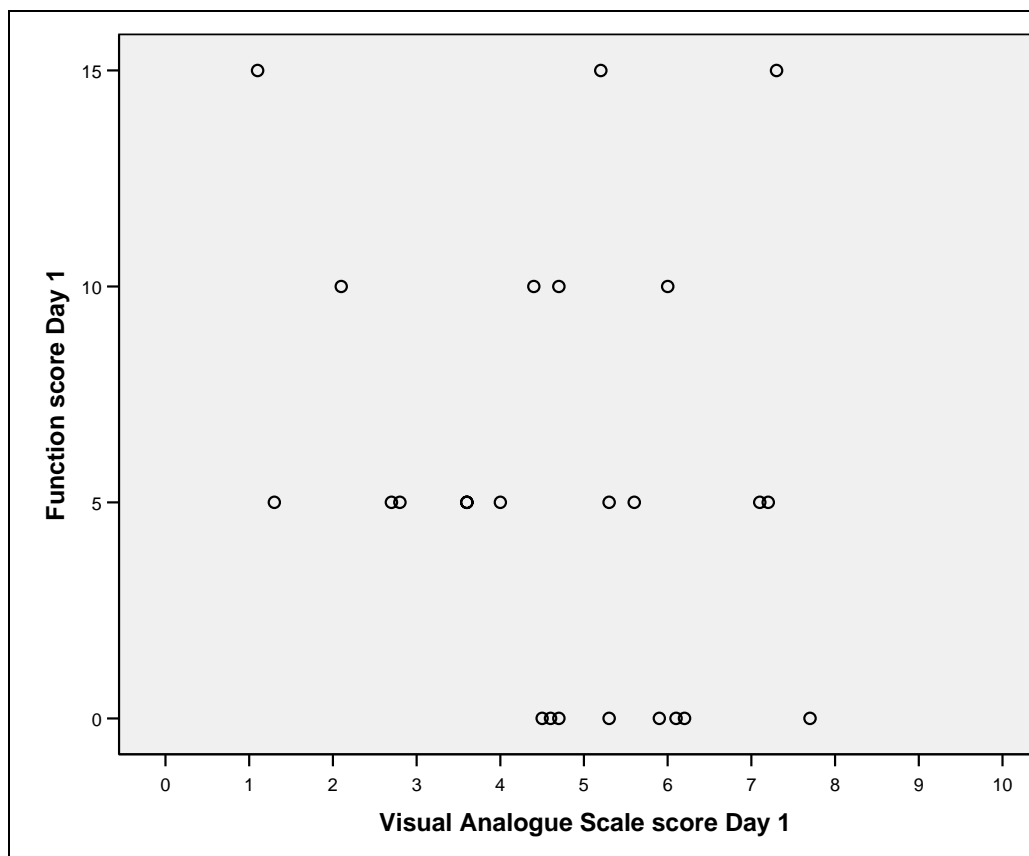


Figure 9: Scatter plot of the correlation between pain and function scores Day 1

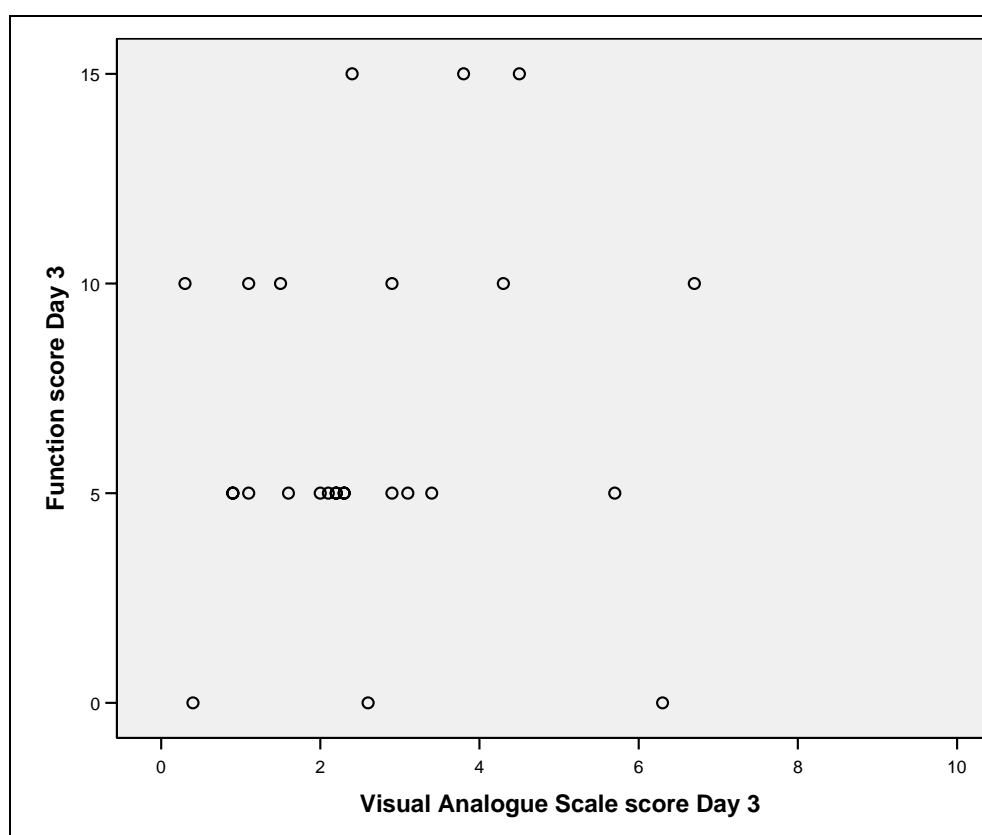


Figure 10: Scatter plot of the correlation between pain and function scores Day 3

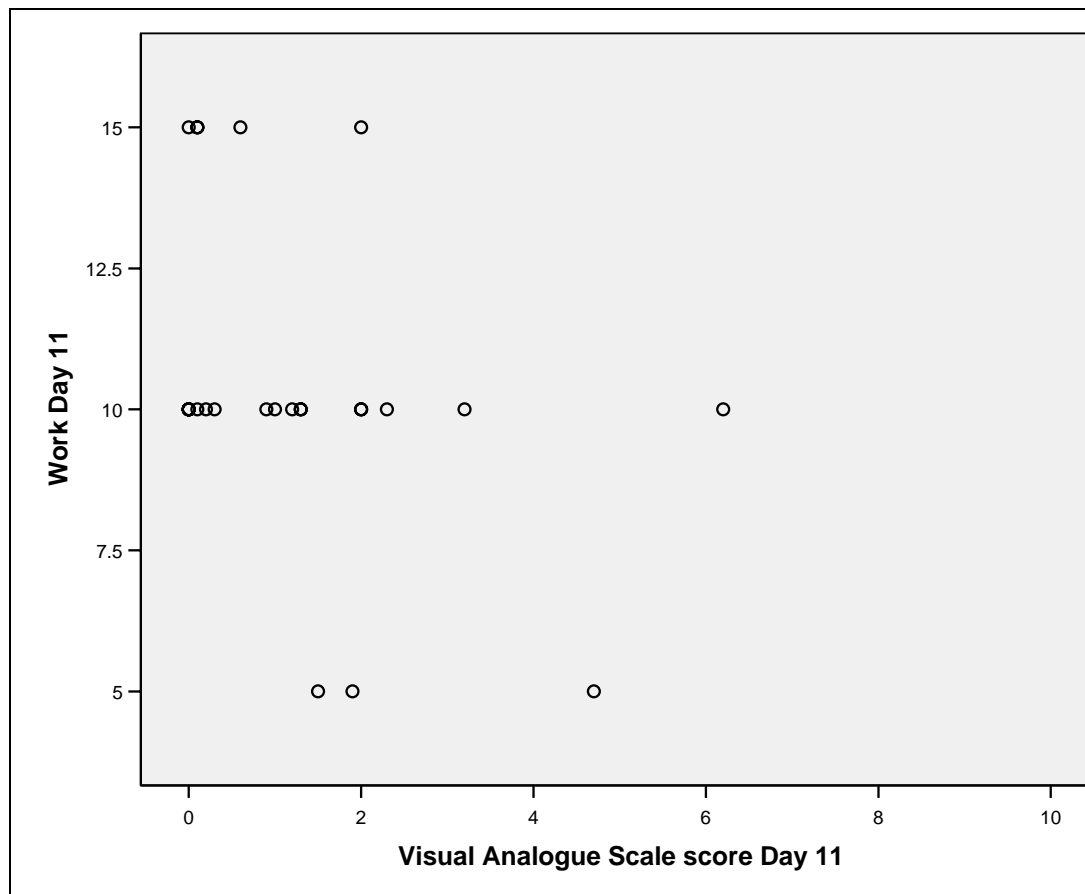


Figure 11: Scatter plot of the correlation between pain and function scores Day 11

The Figures show a trend for increased function scores and decreased pain scores over time, however, there appears to be no true correlation.

Swelling

Only 25 of the 28 participants completed all of the volumetric measurements (16 in the physiotherapy group and 12 in the RICE group), resulting in missing data. The ankle was at its lowest volume on Day 24 for 13 of the participants; for six on Day 11, three on Day 7, and three on Day 3 illustrated in Figure 12. The range of error in the volumetric measurements was within 189.89 ml and 1.21 ml.

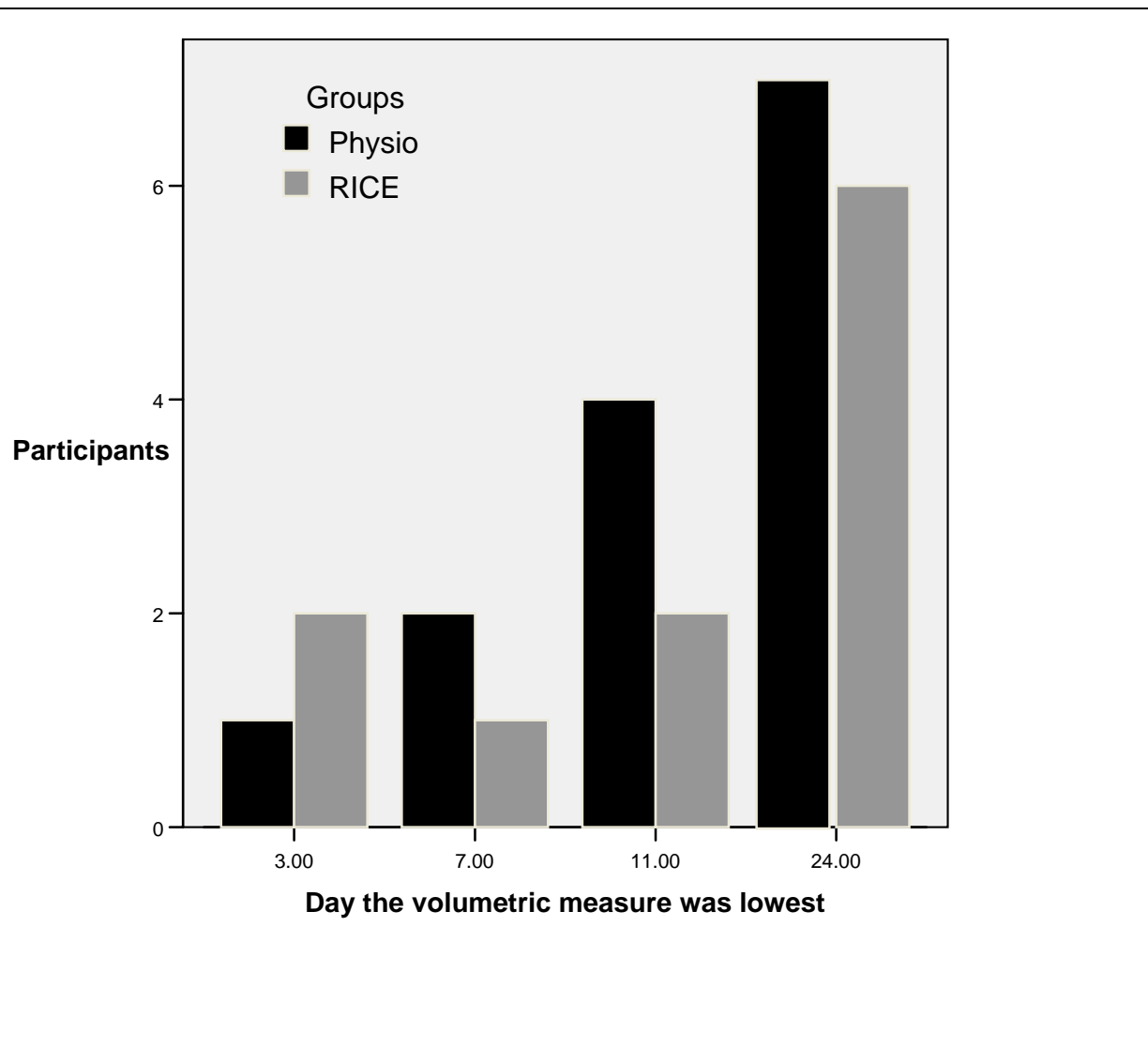


Figure 12: Day of lowest ankle volume

Data from 16 participants in the physiotherapy group and 12 from the RICE were analysed. Box's Test of Equality of Covariance Matrices was significant ($p = 0.123$) indicating that Multivariate analysis was appropriate. The results for the ANOVA indicated a significant time effect, Pillai's Trace = 0.377, $F(2,25) = 7.548$, $p < 0.01$, with a medium to large Partial Eta Squared value of 0.377 (for results see Appendix 9). These results show a significant effect over time for the average volume scores ($p < 0.01$) indicating that the average volume of the foot and ankle reduced from Day 1 to Day 11 for both groups. There was no interaction effect observed for the two groups (see Figure 12).

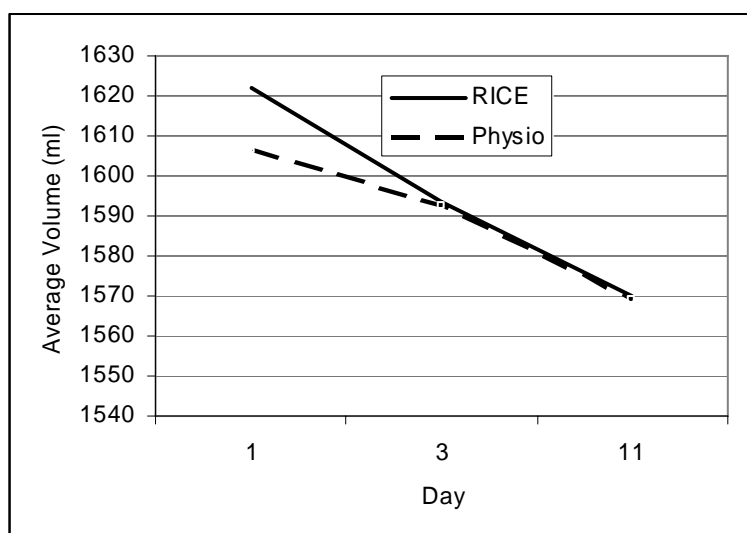


Figure 13: Volumetric scores for both groups at Days 1, 3 and 11

Anomalous first volumetric reading

A repeated measures analysis was done on the missing value analysis for volumetric data which showed there was a significant difference for the first of the three measurements. Overall the first measurement was significantly different and had a higher likelihood of becoming an outlier (i.e., this number was usually >30 ml different from the other two data points for that day). It was usually less than the subsequent two measurements ($p = 0.048$). This happened for Days 1, 7, 11 and 24. The first measurement was therefore dropped from the analysis due to the significant variation from a physiological effect, and the average of the other two measurements was used for the volumetric data.

Medication

Between group comparison of medication use Days 1-11

The results from the *medications* section of the home diary were analysed to see if there was any difference between groups on Day 1 and Day 11, given as a percentage of participants who used medication, and illustrated in a series of bar graphs, which showed the number of participants using medication and the type of medication (see Figure 13 and Figure 14). Please note that the graph in Figure 14 shows only one participant in the physiotherapy group. This is because although the second participant in the physiotherapy group recorded that they did use medication, they did not record the type that they used. This happens again on Day 3 which is why the Figure 14 does not illustrate that participant's type of medication. No bar graph was produced for Day 11 as there was only one participant taking medication in the physiotherapy group.

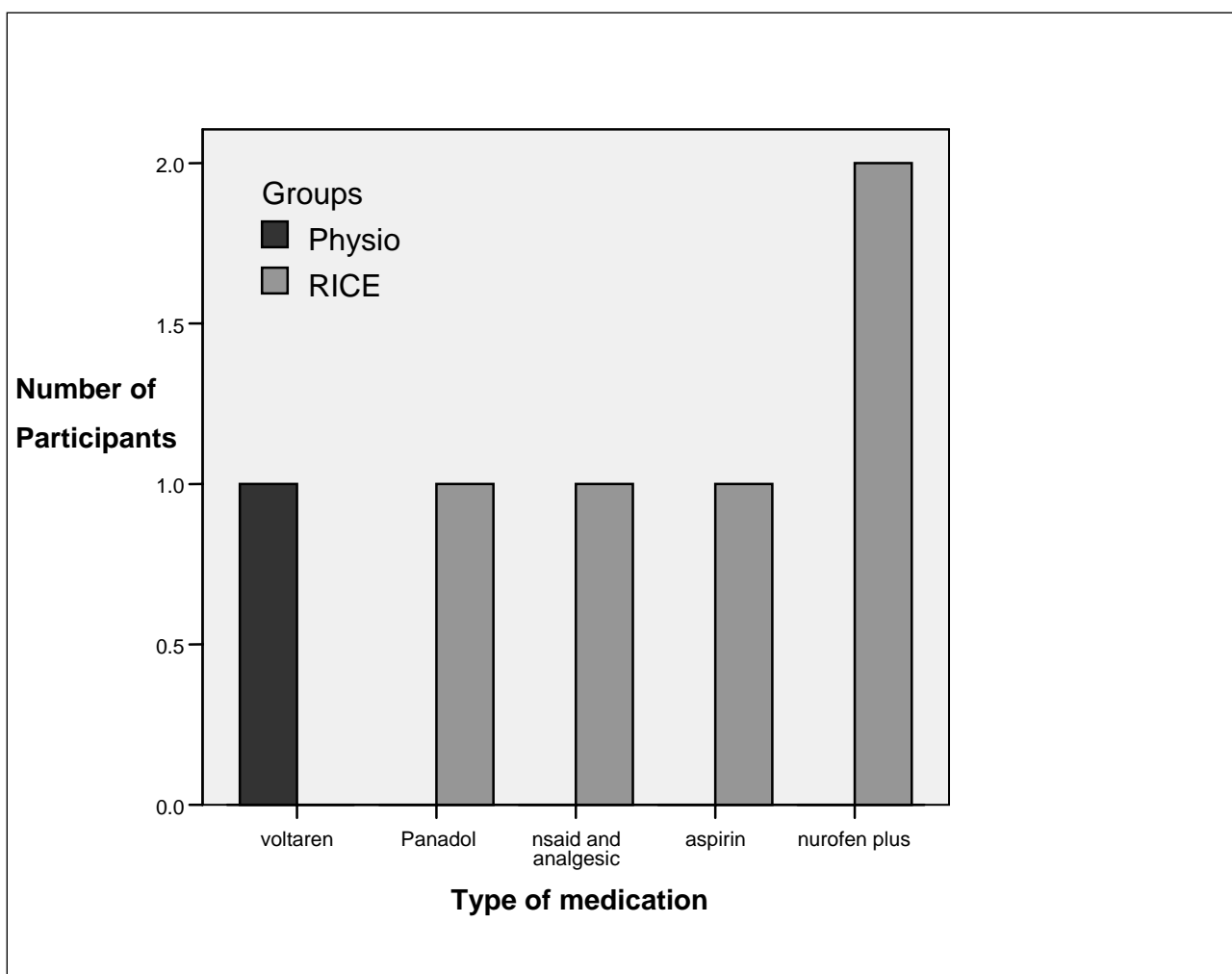


Figure 14: Use of medication on Day 1

All the medication used by the participants was self prescribed. On Day 1 a total of 32% participants recorded using medication, two in the physiotherapy group (6.45% of participants), and five in the RICE group (16.13% of total participants).

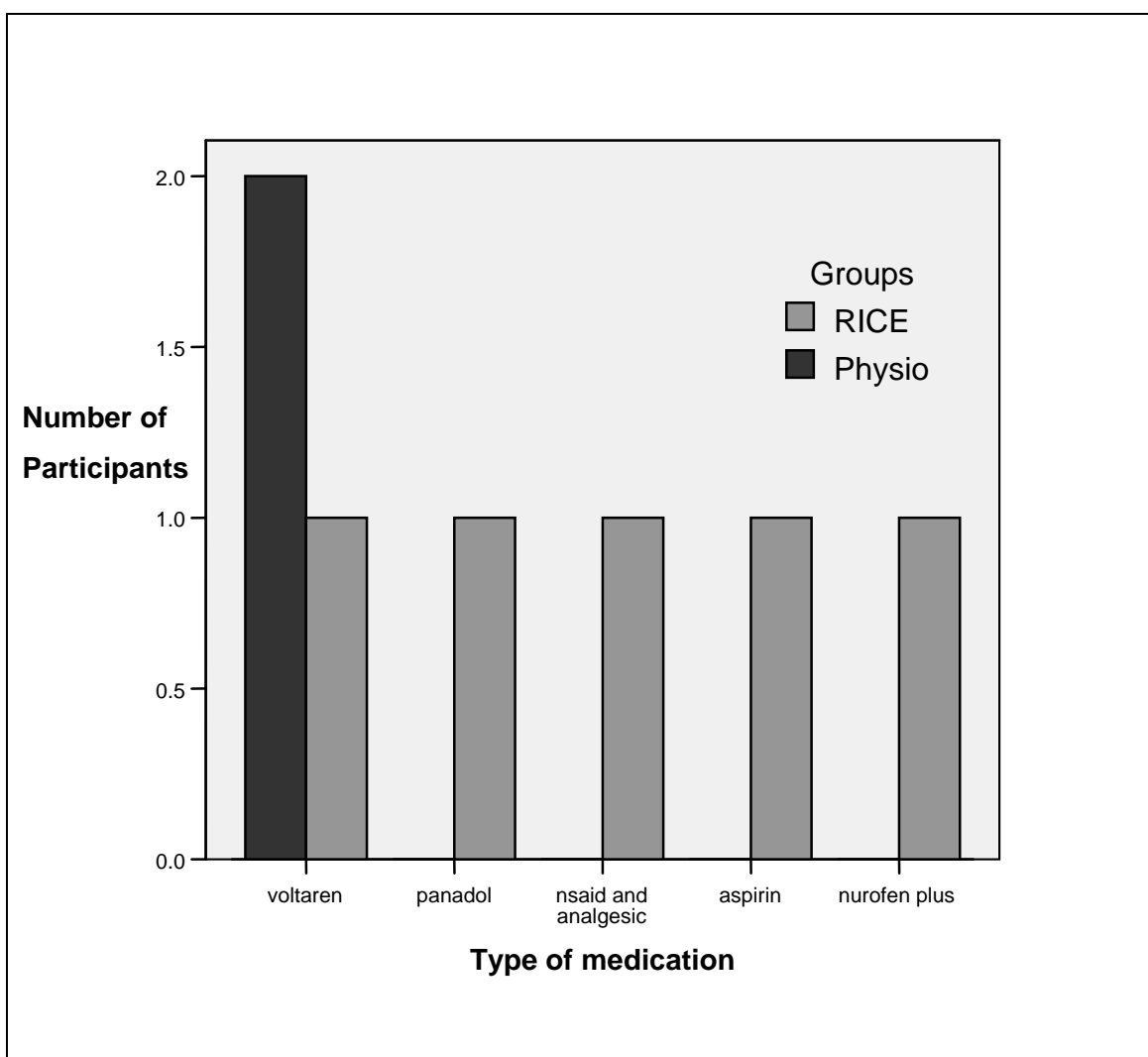


Figure 15: Use of Medication Day 3

By Day 3 the medication use had increased to 39% of the total participants, three in the physiotherapy group (9.68% of participants), five in the RICE group (16.13% of total participants). By Day 11 only one participant (in the RICE group) was still taking Voltaren (see Table 19).

Table 19: Percentage of Participants using medication

Group	Day 1	Day 3	Day 11	Day 24
Physiotherapy	6.7%	6.7%	0%	0%
RICE	13.3%	10%	6.7%	0%
Excluded	10%	10%	6.7%	6.7%

The t-test illustrated that there was a significant difference between the two groups in relation to their use of medication on Day 1 ($p = 0.035$) and Day 11 ($p = 0.048$), but no significant difference on Day 3 (see Table 20).

Table 20: Independent samples t-test results for the use of medication on Days 1, 3 & 11

Medication use	F	p
Day 1	5.14	0.035
Day 3	1.60	0.222
Day 11	4.47	0.048

Compliance

The percentage of the home diaries that were completed to Day 24

Overall compliance for completing the home diary was acceptable for both groups. However, of the 16 participants in the physiotherapy group six did not complete their home diaries to Day 24 (37.5%), compared to only one participant in the RICE group (8.3%).

Data from the non-compliance section of the home diaries

A variety of reasons were given for non-compliance to continuing the RICE treatment (see Table 21) along with the day that the non-compliance occurred. The reasons given for non-compliance were broken into four general groups; a) use of heat, alcohol, running or massage (HARM-ful factors); b) lazy, forgot or did not get time; c) did not feel it was necessary; or d) no access to materials (see Table 21). Two participants drank alcohol in the first 48 hours post injury, and one continued playing sport on their injury once the ankle had been strapped on the day of the injury and the next day. No participants documented using heat on the ankle or massaging the ankle post injury.

Table 21: Reasons for non-compliance in completing RICE, and the day non-compliance started

General rationale for non compliance <i>HARM-ful factors (including exercise)</i>	Stated reason for non compliance	Group	Day
	1 beer after game	RICE	1
	Drank Alcohol	Physio	8
	Played 20 mins after strapped during game	RICE	1
	Played 85 mins Gaelic football (strapped)	RICE	2
	Played rugby		6
	Played netball	Physio	11
	Trying to exercise area to strengthen recovery	Physio	8,10,11
	Had to do physio for rugby team- ran onto field three times (right foot toe running)	Physio	3
	No rest (training)	RICE	5
	Forgot	Physio	7,8,9,10
<i>Lazy, forgot, or did not get time</i>			
	Did not get time	RICE	5,8,9
		Physio	8,10,11
<i>Did not feel it was necessary</i>	Lazy	Physio	7
	Didn't feel like it	Physio	7,8,10
	Didn't feel I needed to	RICE	5,6,7,8,9,10,
		Physio	7,8,10
<i>No access to materials</i>	Physio said no need to ice it anymore just rest	Physio	5,6,7,8,9,10,11
	Wasn't on feet much	Physio	9
	Felt OK	Physio	11
	No access to cooling material	Physio	10,11

The first day of non-compliance for each RICE variable

The first day that the participants documented non compliance to the 'RICE' advice were recorded for each participant. The physiotherapy group had 51 entries in this section of the diary compared to 22 from the RICE group up to Day 11. Eight of the 16 participants (50%) from the physiotherapy group and four out of the 12 participants (33.33%) from the RICE group recorded non-compliance.

An independent samples t-test was performed comparing the two groups in terms of their non-compliance to the RICE protocol (see Table 22). Fully compliant individuals were recorded as being compliant until Day 11. The t-test indicated there was no

significant difference between the two groups in terms of their first documented day of non-compliance overall ($p = 0.529$).

Table 22: Comparison of the two groups in terms of their first documented day of non-compliance in completing the RICE protocol

Activity of compliance	Probability value (independent samples t-test)	Significance of the difference between group
Overall	$P = 0.529$	Non-significant
Rest	$P = 0.460$	Non-significant
Ice	$P = 0.589$	Non-significant
Compression	$P = 0.387$	Non-significant
Elevation	$P = 0.723$	Non-significant

Most participants appear to have adhered to the RICE advice until at least Day 4. Out of the four components of RICE advice that were investigated, compression had the highest compliance.

In addition when the total number of entries in the *non-compliance* section were compared between groups there was no significant difference between groups

CHAPTER 5: DISCUSSION

There are very few RCT's investigating multimodal physiotherapy, even though this is the way that most physiotherapists manage ankle sprains (Holme et al, 1999; Zoch, 2003). Due to the high number of variables, there is difficulty elucidating which of the variables have a positive response, which have no response, and which have a detrimental effect on the healing process. The purpose of this thesis was to conduct and describe a RCT which compared multimodal physiotherapy and RICE management of acute ankle sprains, to RICE management in isolation, in shortening the time to full recovery in a clinical situation for acute (up to Day 11 post injury) ankle sprains, by looking at pain, swelling and functional outcomes.

The hypothesis is that physiotherapy administered in the acute stage of an acute ankle sprain injury will decrease swelling, and pain, and encourage range of movement, promote early function and prevent complications and chronicity better than using RICE without physiotherapy.

Demographics of the participants

The demographics of the participants of this study appeared to be influenced by the population that is serviced by the physiotherapy clinic where the research was carried out. As the majority of the participants were recruited when they presented to the clinic that was conducting the research, the demographics reflected this clinics population. The clinics' business is predominantly to service local football clubs and the local community and this was reflected in the demographics of the participants (i.e., high male bias, large number of participants who injured their ankle playing football). Notices were also put up at five local football clubs which led to five participants presenting at the clinic for the study, and finally, participants were recruited at a seven-aside football tournament.

This population may not represent the general population, and therefore caution needs to be taken when extrapolating the outcomes of the data; however, it does represent

Chapter 5: Discussion

similar clinics that service local sports clubs in New Zealand where the majority of their business is drawn from the members of the club, their families and friends, and their local community. The recruitment from the football population may have biased the results of the study as the highest percentage of ankle injuries in the study occurred during sport (92.86%), mainly football (75%).

There were a couple of problems encountered during the study due to the football playing population that was presenting at the clinic. As there was a high incidence of ankle sprains in this population, there were many instances where potential participants were excluded as they had previously sprained their ankle. This population may have pressures from their club to return to playing football and therefore wanted to return to their sport as soon as possible. This may mean the participants did not rest as long as they should have, or prematurely returned to sport. After Day 11 a common request amongst the RICE group after Day 11 was for taping so they could return to sport.

Activity at time of injury

A high proportion of the participants injured their ankle playing sport (93.6%). One participant injured their ankle at work and one at home.

Lack of Grade III injuries in the study

No participants presented with a diagnose Grade III injury. This is potentially due to a number of factors. Firstly, people who have suffered a severe ankle sprain may present to an Accident & Emergency clinic or Hospital instead of presenting to a physiotherapy clinic. As we received no referrals from Hospitals or Accident and Emergency clinics we may have missed out on these patients. Secondly, Grade III injuries occur less frequently than Grade I or II injuries. Thirdly, although MRI is the gold standard for diagnosis, it is not done routinely. As none of the participants underwent MRI scanning, the clinicians may have missed a Grade III injury and diagnosed it as a Grade II. Fourthly the study only followed participants to Day 24, therefore would not pick up problems associated with the injury that last longer than Day 24. A severe Grade II sprain would be expected to take six weeks, or up to day 42 to resolve, and a Grade III injury potentially may be unstable and present with ongoing problems. In the clinical situation manual ligament testing should be specific and sensitive to pick up the severity of the sprain after Day 7, but it is not 100% specific, and there are some instances where

severe injuries are not diagnosed until the problem persists or healing does not occur in the normal timeframes.

Three participants were excluded, due to diagnose of bone bruise ($n = 1$) and loose bodies ($n = 2$) however, none were diagnosed with Grade III injuries. Although the literature suggests that it is difficult to predict the severity of an ankle sprain in the acute stage, in this study the researchers did not change their assessment of the grade of injury from Day 1 to Day 7. The use of MRI would have confirmed the diagnosis as a Grade I, II or III injury with certainty.

X-rays and investigations

X-rays were conducted on nine out of the final 28 participants (32.14%) as they presented with signs that suggested an investigation was appropriate using the Ottawa Ankle Rules. Out of the eleven participants investigated, three (27.27%) had a positive result for a bony pathology, excluding them from the study.

Time taken to present for initial ankle assessment

We analysed the time taken post injury for the participant to present to physiotherapy using an independent samples t-test. There was no statistical significant difference between groups. The mean time for the physiotherapy group to present was 28.94 hours and the mean for the RICE group was 28.25 hours. The minimum time was 3 hours and the maximum was 48 hours with an overall mean of 28.64 hours. One participant presented to the main researcher at a seven a-side football tournament resulting in the assessment within 3 hours. It should be noted that patients with ankle sprains did not meet the inclusion criteria because they presented to the physiotherapy clinic when the injury was past the acute phase, citing the reason that they were afraid the physiotherapist was going to hurt them as reason for not attending earlier.

There is a perception amongst a portion of the population that they should not present to physiotherapists in the very acute stage post injury as their injury is too painful. Despite the fact that pain relief and education on injury management are specialties of physiotherapists and in many cases early assessment can lead to better long term outcomes (Dettori, 1994, Sloan et al, 1989). This role of physiotherapists may need to

be marketed better in the future as it could potentially reduce costs for insurers, patients and result in better long term outcomes.

Treatment prior to initial ankle assessment

All participants, except three, used some part of the RICE advice prior to the initial assessment. This demonstrates that education of RICE, as an early management for ankle sprains, by companies such as ACC, who have educated the public about early management of soft tissue injuries, appears to be effective. In fact, prior to seeing the physiotherapist 28.57% of all participants used all four components of RICE and 85.72% of participants use at least one component of RICE. This is also an indication of the ease that the general population can access and implement the RICE principals which may be why they have been so popular, as a first aid regime, despite the limited evidence of their effectiveness.

The various methods of implementing the RICE advice goes to show that although the population is aware that it may be beneficial to RICE their injury, they may not be sure of the best way to do this. There may be a confounding factor in the data as the majority of participants are from a sporting population, many of whom presented to a physiotherapy clinic, and who may actively seek medical treatment more than the general population in the acute stage of an injury.

Cross over treatment options after Day 11

All participants were given the option of physiotherapy treatment after Day 11 if they requested it. Prior to Day 11 the RICE group received no physiotherapy treatment whereas the physiotherapy group received at least five treatments. After Day 11 eight participants in the RICE group opted to receive physiotherapy treatment, which impacted on the ability to reliably comment on the difference between groups after Day 11. It is worth noting that the majority of participants opted to receive physiotherapy treatment after Day 11.

As the majority of participants, who consented to take part in this study, had presented for treatment at a physiotherapy clinic it is not surprising that they decided to continue with physiotherapy treatment after Day 11, even if they were in the RICE group. This, in some instances, may have only been in the form of taping for return to sport. This

could be due to the participants being open to the choice of physiotherapy, or because they were for the most part a sporting population who felt that physiotherapy would help them return to sport quicker.

Pain

Results indicated that both groups VAS scores reduced significantly over time ($p < 0.01$), which was expected. As the injury heals the pain response that is mediated by chemicals caused by tissue damage would decrease. By Day 11 a Grade I injury may have almost resolved whereas a Grade II injury may still be resolving (Hunter, 1998).

There was, however, no significant difference between the two groups over time ($p = 0.620$), although the physiotherapy group started with a higher mean pain scores and finished with lower pain scores than the RICE group (see Figure 7). This is interesting as it was hypothesised that the group in the physiotherapy group would have less pain as treatment in the early stage as treatment is often directed at reducing pain.

Overall pain scores were low, scoring on average less than five out of ten. Mean scores for Days 1, 3 and 11 respectively were 4.64, 2.61 and 1.28 out of ten. Indeed, these values agree with other studies on pain post ankle sprain, which indicate that scores of below six out of ten are representative of moderate pain and below three out of ten represents low pain (Bleakley et al., 2006). Medication may have been a confounding factor in this analysis though. The physiotherapy group had higher mean pain scores initially; however the RICE group was taking 100% more medication on Day 1 than the physiotherapy group.

Graphs of the individual participants VAS scores are shown in Appendix 10. These show the general pattern of lower scores as the time progresses. However, there are anomalies. The graph for physiotherapy group participant number 4 and 5 only has a couple of scores as they did not complete VAS data on Days 7, 11 and 24. These graphs show that there is a participant whose pain is at its highest on Day 3, (physiotherapy number 7) which may be explained as this time corresponds with the peak of inflammation. There are also participants whose highest pain score was at Day 11, possibly due to returning to sport (RICE number 1, 6, 7, physio number 10).

Function

The results from this study indicated that there was a significant time effect for both groups ($p = 0.001$) which indicates an improvement in function from Day 1 to Day 11. There was also a significant difference between groups for function scores ($p = 0.042$) from Day 1 to Day 11.

The significant improvement over time for both groups was expected as participants functional ability improved drastically over the 11 days post injury. Often, participants would be limping significantly on Day 1, and would not be able to walk comfortably due to pain and/or stiffness. Some had taken a day off work and most were unable to participate in their sport. By Day 11 many of the participants were able to jog and some had returned to their sport. Individual graphs of the function data for both the physiotherapy and RICE group are shown in Appendix 11.

The significant difference between groups in regards to function is very important. The ability to return to work in a timely manner influences time off work and other costs associated with ankle sprains. There is a possibility that the means, used to elucidate functional information, was not specific enough. For instance, it would be more appropriate to use one of the validated functional questionnaires in the future. Further analyses into the use of more appropriate and comprehensive means of analysing function are required.

Correlation between function and swelling

The correlation between function and swelling was not analysed as there was no normal data to allow for an accurate calculation of the exact amount of swelling for each individual. It would appear that the effusion that results from ankle sprain injury is not an indicator of the self assessed functional ability (Man & Morrissey, 2005; Pugia et al., 2001). Previous research investigating the relationship between volumetric analysis and subjective functional questionnaires resulted in no significant difference between foot and ankle volume change and functional ability (Man & Morrissey, 2005). Objectively however, it has also been shown that there can be neuromuscular inhibition in the muscles around the ankle joint in the presence of an effusion (Hall, Nyland, Nitz, Pinerola, & Johnson, 1999), in particular decreased plantarflexion torque (Hopkins & Palmietti, 2004). The hypothesised altered feedback from joint damage and or oedema may negatively affect dynamic stabilisation of the ankle joint (Hopkins & Palmietti,

2004). There may also be a difference between the relationship between swelling and subjective functional tests, and swelling and objective functional tests, which were not used in the current study.

Another confounding factor may be that the water volumetric technique used in this study for assessing ankle swelling measures foot, ankle and lower limb volume. Changes in volume of any of these anatomical structures would affect the results. Therefore a method that assesses only the change in volume at the ankle joint, such as MRI, may be a more appropriate means of studying the change in volume at the ankle joint post ankle sprain.

Correlation between function and pain

There is research to suggest that there is a correlation between higher pain scores and lower functional ability. A study by Brown et al. (2001) investigating the incidence of late pain and hardware removal after open reduction and internal fixation (ORIF) of ankle fractures using Analogue pain score measure, a Short Form-36 Health Survey (SF-36), and a Short Form Musculoskeletal Functional Assessment (SMFA), showed a correlation between higher pain scores and lower functional ability (Brown et al., 2001). There were statistically significant differences between patients with pain and those without pain after ORIF of unstable ankle ($p < 0.004$). Although the pain was post ankle fracture, it would seem reasonable that the results could be extrapolated to research on ankle sprains.

Swelling or volume change

Three participants did not complete their volumetric data collection, on Days 1, 3 and 11. MVA was used to fill in the missing data as the missing data was less than the 5% threshold for recreating missing data as suggested by Tabachnick (2007). The day that the ankle was at its lowest mean volume was also identified and analysed. The ankle was at its lowest volume on Day 24 in 14 of the participants, five on Day 11, four on Day 7, and two on Day 3. As patients could present anywhere in the first 48 hours, post ankle sprain, the description of 'Day 1' refers to the day the participant presented, not necessarily Day 1 post injury. 'Day 1' in the trial may indeed be day two in tissue healing timeframes. This may have influenced the results of the swelling section. Inflammation (and swelling) peaks between forty-eight and seventy-two hours post injury. Therefore, swelling may have still been increasing when the initial assessment

was carried out. This may explain why in some participants the amount of swelling was worse on Day 3 when compared to Day 1.

Although it was expected that the lowest ankle volume would be on Day 24 for all the participants, this was clearly not the case. In fact the ankle was at its smallest volume on Day 3 for two participants, one in the physiotherapy group and one in the RICE group. There could be a variety of reasons for these results. There has been shown to be a diurnal change in ankle volume, where the ankle is larger as the day progresses, perhaps due to gravity (Brijker et al., 2000). Although all efforts were made to ensure that the measurements were done at the same time of the day for all five measurements, this was not always practical. Secondly the vast majority of participants were sports people who were keen to return to sport and often had done so by Day 24. In a couple of cases participants had re-aggravated their sprain slightly by returning to sport, or had come in for a measurement after jogging (even though they were asked to come in with no prior exercise apart from walking for 4 hours prior to measurement. Thirdly, the volume of an injured ankle depends on the position that the participant has been sitting in prior to the measurement being taken. It has been shown that both elevation and elevation with compression treatment for thirty minutes reduces the ankle volume by $17.3 \text{ ml} \pm 4.05 \text{ ml}$ between the pre treatment measurement and post treatment measurement in participants with acute ankle sprains. The effects of both these treatments however, had returned to the pre-treatment measurement less than five minutes after the limb was returned to the gravity dependant position (Tsang et al., 2003).

There were no normal values taken prior to assessing the volume of the injured ankle. A comparison of the opposite limb in the same position could have given an indication of a normal value, however if that ankle or foot had sustained a previous injury then that reading would not give a true indication of the size of the ankle that would be examined by this study. An attempt to look at the size that the foot and ankle had returned to (and take this as the normal) was undertaken by requesting some participants to return and re measure the affected limb over six months post assessment. The results of all these volumetric measurements are illustrated in Appendix 13 (including the 'normal' values). These results were all higher than the lowest mean result of the five assessments taken during the study. Hypothesised reasons for this could be that some of the 'normal' values were taken from adolescents aged 16-20 and they could still be

growing. Weight gain could be a factor but given the participants height and weight were not taken during the study given physiotherapy clinic practical reasons, this could not be corrected for.

Balasundaram (2006) conducted a study where the same materials and method were used to repeatedly measure the volume of a fixed metal object and normal foot and ankle volumes over three days (Days 1, 3 and 5). The within day intra-rater reliability had the lowest range of error, followed by inter-rater reliability, and that between day reliability had the greatest range of error. The day-to-day biological variation in foot and ankle volume between the three days for both raters showed no significant difference when calculated using an independent ANOVA ($p < 0.05$) (Balasundaram, 2006). There was no statistically significant ($p < 0.05$) day-to-day biological variation in normal foot and ankle volume over the three measurements from Day 1 to 5, as estimated from both researchers, with the range of error being within 20 ml. The measurements were carried out, on the same normal feet and ankles, by the same researchers on different days. This compares to the current study where we investigated sprained ankles which had a component of swelling due to injury. The volumetric measurements range of error for this study was within 189.9 ml and 1.2 ml

Table 23: Results of volumetric studies

Normal	Reference	Results
	Cloughley (1995)	Increase in ankle and foot volume after 15 minutes moderate exercise
	Balasundaram (2006)	Day to day biological variation in normal ankle volume at same time of day <20 ml
Injured	Reference	Results
	Tsang (2003)	Ankle returned to normal volume after 5 minutes in dependant position
	Moholkar (2001b)	Possible to use normal ankle as control for injured ankle at any time of day, in ambulatory or non-ambulatory situation
	Man (2005)	No correlation between function and swelling scores
	Puglia (2001)	No correlation between function and swelling scores

This could partly be explained by the fact that not all measurements were done at the same time of day (due to researchers and participants timetable clashes), and there has been shown to be diurnal changes in ankle volume in normal feet and ankle which would probably be magnified by the presence of swelling. Similarly, it has been shown that there is a change in the volume of the ankle with changes of positioning. When an

ankle has been elevated and is then moved to a dependant position it takes less than five minutes to lose the reduction in volume it gained from being elevated (Tsang et al., 2003). There is however, research that suggests that it is possible to consider an uninjured foot and ankle of a normal participant as a control limb, at any given time of the day, in an ambulatory or non-ambulatory situation and compare its volume with that of the injured side (Moholkar & Fenelon, 2001a). This was shown using a commercially available volumeter. There has also been research that has shown there is a statistically significant increase in volume after short duration (15 minutes) running exercise (Cloughley & Mawdsley, 1995). As the measurement position for measuring ankle sprains was in a dependant position, and participants were not controlled as to what exercise they did prior to assessment, this may explain some of the differences in volume in the within day measurements that the current study.

Anomalous first volumetric reading

There was a significant difference ($p = 0.040$) between the first and the subsequent two of the three measurements. The first measurement was significantly more likely to be an outlier and less than the other two measurements. This differs from the data that Balasundaram (2006) found in the validation study for the same materials on normal ankles. Reasons for the reduced volume of the first measurement could be due to participants removing their compression stocking, socks, shoes etc. just prior to conducting the volumetric analysis. Secondly, the time it takes to do a single measurement using the apparatus is approximately five minutes. It has been shown in a previous study by Tsang et al. (2003) that the effect of elevation on volume change lasted less than five minutes when the limb was returned to the dependant position. It appears that the effect of the compression stocking may have a similar timeframe before the swelling returns.

Significant difference in ankle and foot volume over time for both groups

These results show a significant effect over time for the average volume scores ($p < 0.01$) indicating that the average volume of the foot and ankle reduced as time passed for both groups. The decrease in foot and ankle volume over time is expected and reflects the reduction in swelling as the normal healing processes progress. There was no interaction effect observed for the two groups (see Figure 12).

Swelling is not always detrimental. The sudden influx of protein rich fluids helps to dilute harmful substances that may be present, transports large amounts of oxygen and nutrients necessary for repair to the damaged tissue, and allows the entry of clotting proteins which prevents the spread of bacteria and other harmful agents to surrounding tissues (Marieb, 1995). It should be remembered that swelling is a normal physiological response that serves a purpose in the healing response post injury.

Medication

Participants were allowed to take whatever medication they were prescribed or decided to take during the study, which may have impacted on their pain and function scores. They did describe the medication they had taken in the home diary. Most medication was either analgesics such as Panadol or NSAIDS such as Voltaren. No medication was prescribed so all medication that was taken during the study was self prescribed. This is relevant as Voltaren is a prescription drug which increases the risk of stroke and heart attack.

The results from the *medications* section of the home diary were analysed to see if there was any difference between groups on Day 1 and Day 11, given as a percentage of participants who used medication. On Day 1 a total of 32% participants recorded using medication, two in the physiotherapy group (6.45% of participants), and five in the RICE group (16.13% of total participants). By Day 3 the medication use had increased to 39% of the total participants, three in the physiotherapy group (9.68% of participants), five in the RICE group (16.13% of total participants). By Day 11 only one participant (in the RICE group) was still taking Voltaren (see Table 19). A t-test illustrated that there was a significant difference between the two groups in relation to their use of medication on Days 1 and Day 11 ($p = 0.05$).

The results indicated that the highest number of participants using medication was on Day 3 which may correspond to the peak of inflammation.

Both participants who were taking medication in the physiotherapy group stopped on day four. In the RICE group one participant stopped on day two, one stopped on Day six, one stopped on Day 11 and one had stopped between Day 11 and Day 24. In the 'Excluded' group one participant was still taking medication at Day 24; however, the other two stopped on Day 8 and Day 4 respectively.

From Day 1 to Day 3 only the RICE group had decreased in the numbers of participants who were taking medication from 13.3% to 10%. However, by Day 11, the entire physiotherapy group had stopped taking medication, whereas only half the RICE participants who had started taking medication were still taking medication, and one third of the excluded participants were still taking medication.

There was only one participant who was still taking medication on Day 24. She was in the Excluded group because she was diagnosed with a bone bruise by MRI, which may explain her need for ongoing medication.

Compliance

The percentage of the home diaries that were completed to Day 24

The physiotherapy group had higher non-compliance than the RICE group when it came to completing their home diaries. In the physiotherapy group six out of the 16 participants did not complete their home diaries to Day 24 (37.5%), compared to only one participant in the RICE group (8.3%).

Data from the non-compliance section of the home diaries

The reasons given in the *non-compliance* section of the home diary for non-compliance were broken into 4 general groups; a) use of heat, alcohol, running or massage (HARMful factors); b) lazy, forgot or did not get time; c) did not feel it was necessary; or d) no access to materials.

In the RICE advice pamphlet that was issued to the participants there was also advice not to do anything that might cause further damage or aggravate the injury. The advice was to avoid heat, alcohol, running or massage for 72 hours (HARMful factors). Two participants drank alcohol in the first 48 hours post injury, and one continued playing sport on their injury once the ankle had been strapped on the day of the injury and the next day. No participants documented using heat on the ankle or massaging the ankle post injury.

There is research investigating common reasons for non-compliance. Reasons for non-compliance are complex. Forgetfulness is the most frequent reason given for non-compliance and non-compliance may also result from fear of the state that treatment

implies or fear of loss of independence. Compliance was dependant on the willingness and ability to accommodate exercises within everyday life, the perceived severity of symptoms, attitudes towards the injury and comorbidity, and previous experiences

The first day of non-compliance for each RICE variable

The t-test indicated there was no significant difference between the two groups in terms of their first documented day of non-compliance overall ($p = 0.529$). Most participants appear to have adhered to the RICE advice until at least Day 4. Out of the four (Rest, Ice, Compression and Elevation) pieces of RICE advice that were investigated, compression had the highest compliance.

Out of the four (Rest, Ice, Compression and Elevation) pieces of advice that were investigated, compression had the highest compliance. This is interesting as it would be easiest to elevate and rest the ankle as these activities do not require any materials. Some participants commented that they could not get ice easily and at times ice may be unpleasant which may explain why icing the ankle did not have the highest compliance.

Unfortunately there is a bias in this manner of investigating compliance. The diaries were collected after Day 11, and potentially could be filled out just prior to handing in. The rationale for using ice in the acute stage is for pain relief and vasoconstriction. Applying ice in the sub-acute stage however, may impair healing and participants were considered non-compliant if they had stopped ice before Day 11. Attendance to physiotherapy sessions was not investigated or described, all of which makes it difficult to comment on the validity of the claims of compliance.

Between group comparison of compliance

Compliance is to be acquiescent, to obey the rules. In this study participants were required to be compliant on many levels. They were required to turn up for assessments and treatments, to actively follow the RICE advice in the participant hand out, truthfully complete their home diary on a daily basis, and to follow the therapist's instructions. Not all of these compliance requests were measured during the study. For instance, if a participant did follow the RICE advice as requested by the researcher, however, did not complete the home diary they were considered non-compliant. Similarly if a patient did not follow the RICE advice but filled out the *non-compliance* section of the home diary they were considered compliant.

Participants were instructed to complete their home diaries for the first eleven days post injury. The advice in the RICE pamphlet the participants were issued on Day 1 described RICE advice for muscle sprains, strains and bruises (see Appendix 1). The instructions for ice are “to keep the ice on the injury for twenty minutes every two hours for the first 48 hours”. The pamphlet gives no further instructions for the next nine days, other than to avoid “H.A.R.M-ful (heat, alcohol, running and massage) for 72 hours post injury”. Therefore, even if participants did not follow any of the RICE advice after 48 hours they could hardly be considered non-compliant as they were not given any specific instructions to continue with the RICE advice to Day 11.

There were only four instances of non-compliance registered in the home diary for the first three days, three in the RICE group and one in the physiotherapy group. All three instances in the RICE group were from a single RICE participant. One participant in the RICE group kept playing post injury with the ankle strapped for 20 minutes and drank a beer after a sports game on Day 1, then played a game of Gaelic football with the ankle strapped on Day 2. The participant in the physiotherapy group had to run onto a field to give medical attention to a player on Day 3. It could be said that overall the participants were compliant with the RICE protocol with 93.3% following the RICE advice in the acute stage. The timeframes for the effectiveness of RICE management are considered to be most appropriate in the acute phase of injuries, which is usually completed by 72 hours post injury or by the end of Day 3.

The physiotherapy group documented thirty-eight episodes of non-compliance in the *non-compliance* section of the home diary compared to only nineteen by the RICE group. However, as seen in Table 21, the reason the participant was not complying with the RICE advice was because the therapist had instructed them it was no longer necessary. Therefore although the participant was following the therapists’ instructions they were documented as being non-compliant. Similarly, a participant documented that they did not rest because they were trying to “exercise area to strengthen recovery” after day eight. Strengthening the muscles around the joint at day eight is appropriate, however, in the outcomes of the research is considered non-compliant.

Furthermore, by only looking at the first day the participant did not comply with the RICE advice, this does not take describe whether this was the only day that the

participant did not comply with the advice. There were many instances where a participant did not comply on one day, (and therefore this day was noted as the first day of non-compliance) but was compliant for the next five or six days.

Compliance in both groups may have been higher than the general population due to the need to maintain a diary for the study, however, further research would need to be carried out to support or refute this hypothesis.

Social Desirability effect

There is a chance that the participants in the study had a response bias in the form of a social desirability effect where they scored their subjective home diaries and pain scores in a manner that they thought would please the researcher. This was unavoidable as although the participants were randomised they were aware which treatment group they were in.

LIMITATIONS OF THE STUDY

There are theoretical and practical issues that should be considered as limitations in the current study. Theoretically, attribution of causality to independent variables is in no way assured by statistical tests. As the independent variables are typically manipulated by the experimenter, and the desire for causal inference provides the rationale behind the elaborate controls. The inference, therefore, that the significant differences in the dependant variables are caused by changes in the independent variables is a logical exercise, not a statistical one as the statistical analysis can be run regardless of the ability to control the variables (Tabachnick & Fidell, 2007). The small sample size will affect the power of this study as two groups, each of around 14 participants may not give statistically significant differences when real differences between groups (populations) are small.

Practical issues affected the robustness of the study too. There were unequal sample sizes, presence of outliers and missing data due to poor compliance. Steps were taken to reduce the impact of these limitations by the means of missing value analysis, and by removing the first volumetric measurement of each day and using the average of the second and third measurement. Although there was unequal sample sizes, the two groups were similar at the start of the study (Day 1). Outliers in the volumetric data could have produced a Type I or II error and so were removed prior to the analysis. The low number of participants in each group may also lead to Type I error.

There is also a timeframe limitation in this study. Participants were recruited up to 40 hours post ankle injury. This means that they could be at either day one or two in tissue healing timeframes, but are recorded as being at Day 1 in the study. This has a follow on effect throughout the study as it means that on Day 3 of the study the participants can be anywhere from day three to day four in the tissue healing timeframe. This has implications on the interpretations of results as they relate to time throughout the study.

Limitations due to the effect of cross over between groups post Day 11

Because participants were allowed to cross over to the other treatment group after Day 11 this meant that the results for Day 24 were contaminated, and real differences between groups were no longer identifiable and leading to the data from Day 24 being dropped from the analysis completely. There were participants in the RICE group that specifically wanted strapping so they could return to their sport and so requested to cross over groups, and there were two participants who felt they did not need any further physiotherapy as they felt the injury had resolved.

Limitations of VAS

There is a possibility that there were not enough participants to see any significant differences between the groups. Due to recruitment difficulties the target participant numbers were not attained, and therefore the results may lack power. This research does not look at people who receive no treatment and there may be an effect on both groups due to just seeing a qualified person who can diagnose the injury and put the injured persons mind at ease that they do not have a serious injury. All participants were assessed and treated in the first 48 hours post injury and this may also have an effect on the end result. Due to the nature of multi-modality physiotherapy it is difficult to know which treatments, or combinations of treatments would have the best effects. The research did not record the type of physiotherapy treatment or 'dose' of treatment. Further research may elucidate more answers to these problems.

Differences in VAS scores across groups needs to be interpreted with caution because the differences between groups in VAS scores can have no clinical significance, even if they achieve statistical significance (Farrar et al., 2000). This is because one individuals' pain score of eight out of 10 on the VAS scale may have the same amount of tissue damage as somebody who rates their pain as only two out of ten.

Limitation of the functional question

By using only one question out of a battery of questions that was originally in a validated questionnaire (de Bie et al., 1997) the full functional status of the participant was probably not truly elicited. Using a validated functional questionnaire such as the KAFS or OMAS would be more appropriate in the future if a patient-assessed evaluation is required (Haywood et al., 2004).

Limitations of the volumetric analysis

It is difficult to get a true normal value as the ability to sample normal values immediately prior to an ankle sprain injury is unlikely to happen. Therefore normal values are usually taken from the opposite ankle, or once the injury has resolved. Unfortunately body shape can change over a relatively short period and this could affect the true normal value. There were no normal values taken for the ankles which meant that the difference in swelling over the study for each participant was unable to be calculated. Height and weight were not taken either so the body mass index could not be used. Other studies taken 'normal' values from measurements from the unaffected limb, or measurements of the affected ankle after 10 weeks and extrapolate their normal data from these figures.

Limitations of the non compliance section

It is worth noting that the *first* day of non-compliance identified by a participant may have been the only day they did not do the RICE component of the treatment (i.e., this documented non-compliance event did not necessarily mean they stopped RICE from this day on, and participants may have returned to compliance). Overall, there was no significant difference between the two groups in terms of the amount of documented non-compliance.

RECOMMENDATIONS

- The use of time terms used in future research should be representative of the healing timeframes post injury and not just when the participant presents for assessment.
- The use of RICE advice as an acute management for early management of injuries needs to be reconsidered. The evidence for the individual components of RICE and as a whole is limited.
- RICE advice needs to be more specific to clarify the best method and timeframes for each component. It is not enough to just tell somebody to “RICE your ankle”. They need to be told that they should take the compression off if they are elevating the ankle or if they are supine. They need to be warned of the complications and risks associated with ice, and inactivity for long periods. For example, advice to ice should be to ice for ten minutes with crushed ice (which is not in direct contact with the skin), take the ice off for 10 minutes then put the ice back on for 10 minutes. Repeat every two hours. The importance of functional retraining needs to be explained to ensure they don’t ‘rest’ for too long.
- The population needs to be educated on the importance of early assessment, diagnosis of complications or severe injury and treatment of acute injuries. Physiotherapists are in an excellent position as first care health providers to help manage acute ankle sprain injuries.
- Participants need to ensure that they do not do exercise prior to having volumetric analysis done as this can affect the results.
- Participants should sit with the ankle in a dependant position for at least 5 minutes prior to the volumetric analysis being conducted. This should reduce the inconsistency of the first volumetric reading.

Suggestions for future research

The research could be improved by using a validated functional questionnaire such as the Kaikkonen Functional Scale (KFS) if combined therapist participant outcome measures were required, or by using the KAFS or OMAS if a solely patient-assessed evaluation of function was required. This would ensure results could be reliably extrapolated to other studies. Taking measurements after eight weeks would be interesting as this would give an indication of 'baseline' for ankle volume as the effusion associated with a Grade I or II ankle sprain would have settled by then, and it would be unlikely that significant weight gain or growth spurts would happen during that period. Participant height and weight information should be recorded at the start of assessment procedures so that if further values are taken the size change of the participants can be elucidated. Subjective and objective functional tests to investigate whether there is a difference between the effect on swelling and subjective tests and objective functional tests should be included.

Taking measurements on Days 1, 3, 7, 14 and 56 would be more appropriate than on Day 11 or 24 given ligament healing timeframes. It is a recommendation of the researcher that a final assessment should be done after Day 58 to get baseline values for the 'normal size' of the foot and ankle and to ensure accurate diagnosis has been made.

As the cost of investigations such as MRI reduces and the technology becomes more accessible these tools would improve the grading and diagnosis of ankle sprains.

Ensuring that volumetric measurements are conducted at the same time of day and requesting the participants not play sport a few hours prior to being measured would improve the validity of the volumetric measurements. There is an increase in volumetric displacement when participants have their legs in a dependant position (such as the position the leg is in whilst in the water tank) possibly due to the lymphatic system having to work harder against an increased pressure due to gravity (Sims, 1986). To ensure that the volumetric results were constant and accurate, participants could rest their legs in supine or long sitting position for five minutes prior to each test. This however, would increase the length of time each volumetric measure would take.

SUMMARY OF RESULTS

This study aimed to determine whether or not physiotherapy and RICE treatment was more effective than RICE treatment alone in improving function, pain and swelling outcomes (up to Day 11 post injury) ankle sprains.

Both groups were similar on Day 1 in respect to their initial pain, swelling, the number of participants who were referred for X-rays, and the time taken to present to the physiotherapist. However the RICE group had significantly higher function scores ($p = 0.042$). The RICE group also had a significantly higher use of medication on Day 1 ($p = 0.035$) and Day 11 ($p = 0.048$). For both groups there was a statistically significant decrease in swelling ($p = 0.003$), pain scores ($p = 0.000$), and an increase in function scores ($p = 0.000$) in relation to time over the eleven days of assessment. The physiotherapy group had significantly improved function scores ($p = 0.042$) from Day 1 to Day 11 compared to the RICE group. There were no significant differences between groups for swelling, pain scores, and their first day of documented non-compliance. The within day range of error in the volumetric measurements was within 189.9 ml and 1.2 ml. Three trials were conducted per person within a Day session. The first volumetric analysis was significantly less than the subsequent two measurements ($p = 0.040$).

GLOSSARY

ACC	Accident Compensation Corporation
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
Anterior drawer sign	A test for the integrity of the ATFL. Graded as mild, moderate or severe depending on the laxity compared to the other ankle. Performed in sitting with knee flexed. The heel is grasped and pulled anterior whilst the tibia is stabilized. The formation of a sulcus anterior and medially over the ankle joint is considered a positive sign
A-P	Antero-posterior.
ATFL	Anterior talofibular ligament.
Avulsion fracture	Injury where instead of the ligament being disrupted, a fragment of bone is pulled of at the attachment of the ligament. More common in children and adolescents as they have weaker bones and growth plates.
CCT	Controlled clinical trials
CFL	Calcaneofibular ligament.
Compliance	The extent that advice from the physiotherapist was adhered to
CR	Clinical review
Dorsiflexion	Movement at the subtalar joint which reduces the angle between the tibia and the metatarsals.
Ecchymosis	Bruising
Eversion	Abduction and dorsiflexion movement at the subtalar joint which moves the foot away from the midline.
Functional treatment	The use of various amounts of support to allow early mobilisation and to encourage normal movements and activities as early as the healing timeframes allow.
Haematoma	Crush injury to soft tissue resulting in intermuscular or intramuscular bleeding.
ICC	Correlation co-efficient
In situ	In it's original place
Inversion	Adduction and dorsiflexion movement at the subtalar joint which

	moves the foot toward the midline.
IVS	Internal validity score
Lateral Ligament.	Located on the lateral aspect of the ankle. Comprises of the anterior talofibular ligament, calcaneofibular ligament and posterior talofibular ligament. Stops excessive plantarflexion/inversion.
LOA	Limits of agreement
Manual Therapy	Passive accessory mobilisation and manipulation applied to joints to restore joint movement, reduce pain, and restore function.
Medial Ligament	Located at the medial aspect of the ankle. Stronger than the lateral ligament. Reduces excessive eversion at the ankle joint. Triangular shaped ligament attaches tibia to navicular, calcaneus and talus.
Meds	Medication e.g., analgesia, anti-inflammatories etc.
Mobilisation	Passive oscillatory movements within the normal range of the joint. Used to increase accessory movement or modulate pain.
MRI	Magnetic resonance imaging. Current gold standard for imaging ligaments.
Multi-modality physiotherapy	Combination of different treatment methods used by physiotherapists in the clinic to treat ankle sprains. Including but not limited to: mobilisations, acupuncture, manipulations, strengthening, active and passive exercises, electrotherapy, frictions and massage etc.
n	Number of participants
NSAIDS	Non steroidal anti-inflammatory drugs
Oedema	Swelling
PEDro	Physiotherapy Evidence Database
Plantarflexion	Movement which increases the angle between the tibia and the metatarsals.
Power	Statistical term to describe the probability of correctly deciding that an independent variable had no effect.
Proprioception	The knowledge of where the body is in space. Describes the system where nerve impulses from joints, muscles and tendons are sent to the central nervous system providing information on joint position and movement.

PTFL	Posterior talo-fibular ligament.
QS	Overall quality score
RCT's	Randomised Controlled Trials
RICE	Rest, ice, compression and elevation
ROM	Range of movement. Measured in degrees.
SEM	The standard error of measurement
Sensitivity	The proportion of people with the disorder that return a positive test.
Specificity	The proportion of people who do not have the disorder that returns a negative test.
Sprain	Tearing of ligamentous structures, graded as Grade I, II and III in order of severity.
Strapping	Use of rigid strapping tape for proprioception or support
Subtalar joint	Articulation between talus and calcaneus
Subtalar ligaments	Provide stability between calcaneus and talus
SR	Systematic review
Syndesmosis	A fibrous band that joins the tibia to the fibular. Can extend up to 6 cm proximal from the subtalar joint. Allows movement between the tibia and fibular.
Talar tilt test	Performed by grasping the calcaneus and talus and inverting them whilst stabilizing the tibia. A positive test is where there is marked laxity compared to the other ankle. Graded as mild, moderate or severe.
Talocrural joint	Articulation between the tibia and fibular and the talus.
VAS	Visual analogue score used to subjectively measure an individuals pain
Volumetric analysis	Method of analysing change of volume or mass using water in a tank. Water is filled to the level of an open tap, once water stops dripping out the tap is closed. A measuring jug is put under the tap. A mass is put in to the tank and the tap is open. Once the tap has stopped dripping then the displaced water is weighed and recorded.

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APPENDICES

Appendix 1: General advice on RICE treatment

See the ACC Sport Smart brochure- Injury Management (A.C.C., 2004)



Managing your **sports** **injury**



MUSCLE STRAINS

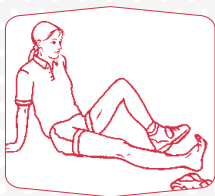
LIGAMENT SPRAINS

AND BRUISES ...

Signs and Symptoms

- Pain
- Swelling
- Tenderness
- Bruising (caused by bleeding into damaged tissues)
- Limited movement
- Difficulty doing daily tasks

What to do straight away – R.I.C.E.D.



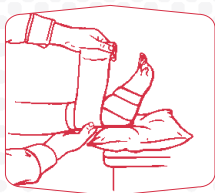
REST

- Rest reduces further damage – stop activity as soon as your injury occurs.
- Avoid as much movement as possible to limit further injury.
- Don't put any weight on the injured part.



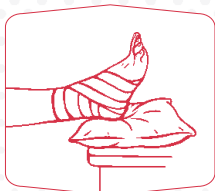
ICE

- Ice cools the tissues and reduces pain, swelling and bleeding.
- Place ice wrapped in a damp towel onto the injured area – don't put ice directly onto bare skin.
- Hold the ice pack firmly in place with a bandage.
- Keep ice on your injury for 20 minutes every two hours for the first 48 hours.



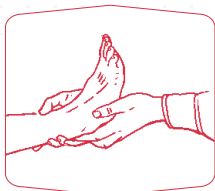
COMPRESSION

- Firm bandaging helps to reduce the bleeding and swelling.
- Bandage your injury between ice treatments.



ELEVATION

- Elevation helps to stop the bleeding and reduce swelling.
- Raise the injured area on a pillow for comfort and support.
- Keep the injured area raised as much as possible.



DIAGNOSIS

- Consult your medical professional especially if you are worried about your injury, or if the pain or swelling gets worse.
- If the pain or swelling has not gone down significantly within 48 hours, also seek treatment.

Avoid H.A.R.M–ful factors for 72 hours after injury

HEAT

- Heat increases bleeding at the injury site.
- Avoid hot baths and showers, saunas, hot water bottles, heat packs and liniments.

ALCOHOL

- Alcohol increases bleeding and swelling at the injury site, and delays healing.
- It can also mask the pain of your injury and its possible severity, which may result in you not seeking treatment as early as you should.

RUNNING

- Running, or any form of exercise, will cause further damage.
- Do not resume exercise within 72 hours of your injury unless your medical professional says it is alright to exercise.

MASSAGE

- Massage causes an increase in bleeding and swelling, and should be avoided within 72 hours of the injury.
- If your injury is massaged within the first 72 hours, it may take longer to heal.

Consult your Medical Professional*

- If you are worried about your injury
- If pain is excessive or gets worse
- For a rehabilitation programme specific to you and your injury

* A medical professional, such as a doctor or physiotherapist

The most common sports injuries are:

- Muscle strains
- Ligament sprains
- Bruises

These injuries are also known as soft tissue injuries.

Taking the time to treat your injury early is important.

Proper treatment will help to relieve immediate symptoms and speed up your recovery.

STEP 1: What can I do to get moving again?

- If the rest, ice, compression and elevation treatment is done correctly, the pain and swelling should decrease, and pain-free movements will return.
- Some gentle movement at the right time is important for healing and recovery. When the pain and swelling have reduced, you should start some gentle exercise.
- When you start exercising again, keep all movements within the limits of pain and never force any movement.

If the pain or swelling return, consult your medical professional.

STEP 2: When can I get back to play?

- Before you return to play, you need to make sure you can do the specific tasks your sport requires, such as jumping, throwing or kicking.
- Once you are able to perform these skills to the same level as before the injury, you are ready to return to play.
- Do not return to play until you are fully recovered from your injury. Returning to play too soon can make your injury worse and delay full recovery.

WANT TO KNOW MORE?

For more information on how to manage some common sports injuries, and for sports injury prevention information, visit the ACC SportSmart website: www.acc.co.nz/sportsmart

For additional free copies of this brochure, phone 0800 THINKSAFE (0800 844 657).

Appendix 2: Standard physiotherapy treatment for acute ankle sprain

The following are based on the ACC Physiotherapy Treatment Profiles (A.C.C., 2000).

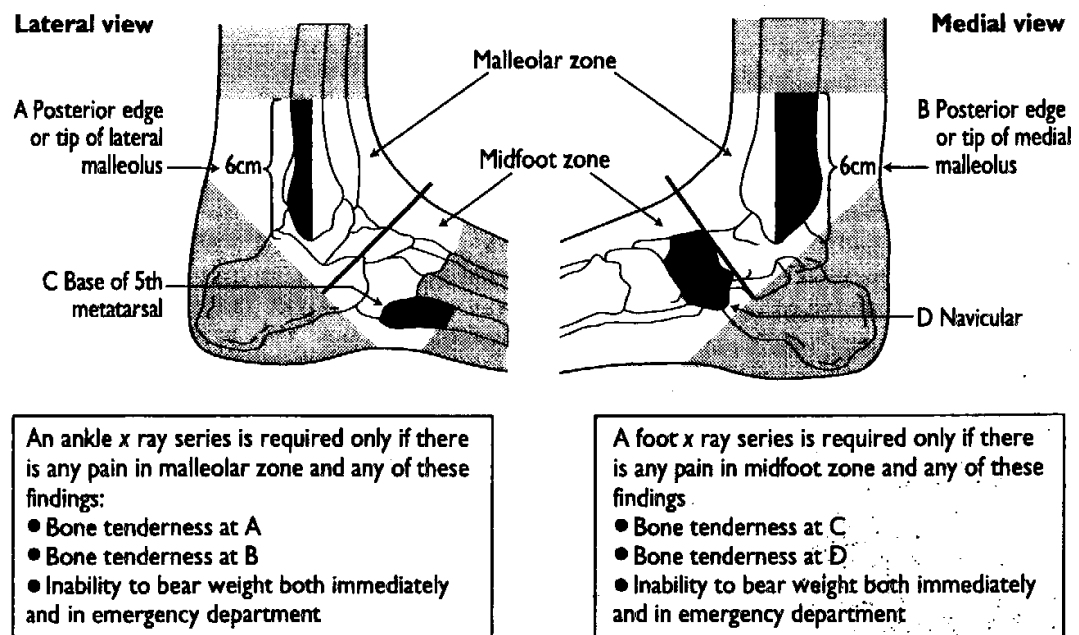
Acute Stage 1-5 days

1. Rest from activity. Ice Compression Elevation, all as indicated in the ACC Acute Soft Tissue injury treatment guidelines (pamphlet).
2. Palliative techniques to reduce pain including modalities such as therapeutic ultrasound, interferential, TENS, and gentle traction.
3. Adhesive strapping in conjunction with felt compression around the lateral malleolus, and a compressive bandage. This would be applied for 24-48hrs and then reviewed. Further support may be needed depending on the severity of the sprain.
4. Gait Re-education. This may or may not include the use of crutches depending on the severity of the sprain.
5. Prescription of lower limb exercises in non-weight bearing (NWB) or weight bearing (WB) depending on the severity of the sprain. This would include active plantar and dorsi-flexion exercises.
6. Proprioceptive exercises (wobble board, balance exercises). These would become more challenging as the subject improved over the week.

Appendix 3: Ottawa ankle rules

The Ottawa ankle rules, first published in 1991 (Stiell, 1992), were created with the aim of reducing the total amount of X-rays used for assessing suspected ankle and foot fractures.

The rules are best summarised by Figure 1 (Stiell, 1995).



Ottawa ankle rules for use of radiography in acute ankle injuries (adapted from Stiell et al¹⁶)

Figure 16: Ottawa ankle rules summary for the use of radiography in acute ankle injuries adapted from Stiell (1995)

X-rays are only required if there is any pain in the malleolar zone or in the mid-foot zone, and if any of the following findings are present.

1. Bony tenderness
 - On the posterior edge or tip of the lateral malleolus
 - On the posterior edge or tip of the medial malleolus.
 - At the base of the fifth metatarsal
 - On the navicular
2. An inability to bear weight both immediately after the accident and subsequently.

Since introduction of these rules in Canada in 1994 there has been a 26.4% reduction in the amount of X-rays used for ankle injury.

The sensitivity of the rules had been established to be 99.5% (Stiell, 1995), with a specificity of 40.1% for diagnosing malleolar fractures (Stiell, 1992).

Appendix 4: ACC physiotherapy treatment guidelines

ACC physio treatment guidelines

Physiotherapy Treatment Profiles

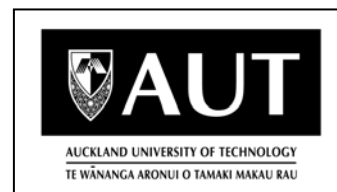
[TABLE OF CONTENTS](#)
[KEYWORD / READCODE SEARCH](#)
[ABBREVIATIONS](#)

9. Ankle

S550	Ankle sprain						Number of Treatments: 10	Triggers: 14
Key Points	Special Considerations	History	Examination	Differential Diagnosis	Complications	Treatment Rehabilitation	Onward Referral	
	NSAID 3 days Age Functional requirements	Trauma / recurrent Mechanism of injury – sport / recreation / work Previous treatment Functional ability this episode General health Pain relief	Observation – swelling WB status Palpation ROM – active / passive and accessory talocrural, subtalar, tibia / fibula, foot Selective tissue tension test – active / passive / accessory movements	Tarsal syndrome Ligament rupture Undetected #s Ligamentous laxity Subtalar joint dysfunction Peroneal nerve neuropathy	Avulsion # Recurrence Instability	Acute: RICE Palliative techniques Strapping / wrap / brace Gait re-education Active exercises / NWB Walking aid Maintenance exercises lower limb Proprioceptive exercises Sub acute: Frictions Stretches Muscle balance Proprioception Biomechanical review Palliative techniques Manual therapy Intrinsic strengthening Progress to full rehabilitation Specific functional rehabilitation work / sport Ongoing bracing / strapping if necessary	Radiographic Specialist Podiatrist GP	

Appendix 5: Consent form for the study

CONSENT FORM



Title of Project: **The effect *physiotherapy* has on the healing and time to recovery of ankle sprains.**

Project Supervisor: **Wayne Hing.**

Researcher: **Justin Lopes.**

- I understand the information that has been given to me and confirm having read the Information for Participants form, for all volunteers taking part in the study on '*The effect physiotherapy has on the healing and time to recovery of ankle sprains*'.
- I have had the opportunity to discuss this study and I am satisfied with the answers that have been given.
- I understand that taking part in this study is voluntary and that I can withdraw at any time without giving reasons and without being disadvantaged in any way. This includes withdrawal of any identifiable information provided at any time prior to the completion of data gathering.
- I (Full name) hereby consent/agree to take part in this study.
- I would like to be sent a summary of the results of the research YES/NO

Participant signature:

Date:

Project Supervisor Contact Details:

Wayne Hing, School of Physiotherapy, Auckland University of Technology, Tel (09) 917 9999 (x7800), wayne.hing@aut.ac.nz

Or

Justin Lopes, Mobile no:021-673732, justin.lopes@xtra.co.nz

This study has been approved by the Auckland Ethics Committees on 14th May 2004. Reference no: AKY/04/04/082

Appendix 6: Participants home diary

Participant ID:

PARTICIPANT DIARY



Dear participant

Thank you for taking part in this research project.

This booklet contains forms that you fill out.

The information you provide has no consequence on your treatment and you will not be disadvantaged in any way. All information is strictly confidential and will only be used for this research project.

The diary contains three forms:

1. Visual Analogue Pain Scale (VAS): Please complete the VAS daily. Mark the average amount of pain you felt that particular day.
2. Medication chart: You are allowed to take medication (NSAID) if you do, we would like you to write down:
 1. How many tablets you take each day 2. Any other medication you are taking and 3. What dose are the tablets.
2. Compliance advice form: Please record which parts of the medical advice you have followed up and how often you have done so. Even if you do not follow all the medical advice it still provides important information to evaluate the effectiveness of the treatment. Please provide us the reason for not following any medical advice.

It is best to fill these forms out at the end of each day and will not take more than a couple of minutes.

The best of luck and we wish you a speedy recovery.



Visual Analogue Pain scale

Participant ID:

Please draw a vertical line through the scale at the point you feel best represents the average amount of pain your ankle has given you all day.

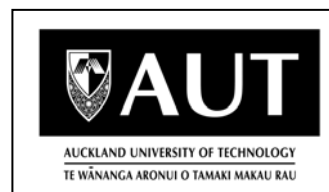
Day

Fill in day

No pain Unbearable pain

Compliance advise form

Please fill this form out as accurately as possible



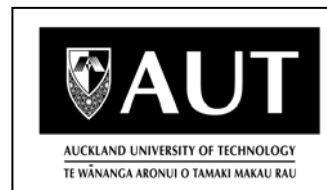
Indicate **how many** times you did each event each day, and the **total amount of time** in minutes you did the event each day.

Participant ID:

[illegible]

Compliance advise form

Please fill this form out as accurately as possible



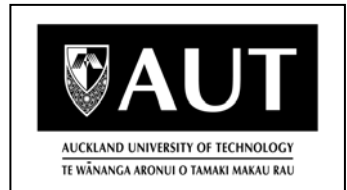
Indicate **how many** times you did each event each day, and the **total amount of time** in minutes you did the event each day.

Participant ID:

Advice	Day 7	Day 8	Day 9	Day 10	Day 11	
Rest: Avoid as much movement of the injured part as possible. Avoid putting weight in the initial stages.	<input type="checkbox"/> Yes <input type="checkbox"/> No -...times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	
Ice: Place ice pack onto the injured area and hold in place with a bandage.	<input type="checkbox"/> Yes <input type="checkbox"/> No -...times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	
Compression: Bandage your injury between ice treatments.	<input type="checkbox"/> All of the time <input type="checkbox"/> Most of the time <input type="checkbox"/> Some of the time <input type="checkbox"/> None of the time	<input type="checkbox"/> All of the time <input type="checkbox"/> Most of the time <input type="checkbox"/> Some of the time <input type="checkbox"/> None of the time	<input type="checkbox"/> All of the time <input type="checkbox"/> Most of the time <input type="checkbox"/> Some of the time <input type="checkbox"/> None of the time	<input type="checkbox"/> All of the time <input type="checkbox"/> Most of the time <input type="checkbox"/> Some of the time <input type="checkbox"/> None of the time	<input type="checkbox"/> All of the time <input type="checkbox"/> Most of the time <input type="checkbox"/> Some of the time <input type="checkbox"/> None of the time	
Elevation: Raise the injured area on a pillow for comfort and support. Keep the injured area raised above the level of the heart.	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	<input type="checkbox"/> Yes <input type="checkbox"/> No -.....times a day -...minutes a day	

Medication chart

Please fill this form out as accurately as possible

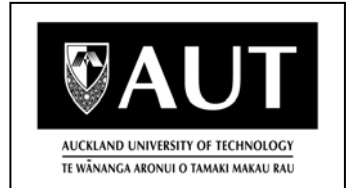


Participant ID:

[illegible]

Medication chart

Please fill this form out as accurately as possible

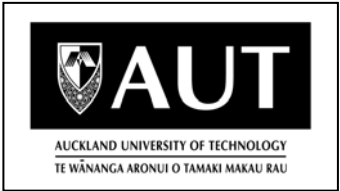


Participant ID:

[illegible]

Compliance advise form

Please fill this form out as accurately as possible



Participant ID:

Please provide the reason for not following an advice on any day.
Also mention if there were any incidents of H.A.R.M-ful factors on any day.
(H.A.R.M-ful factors: Heat, Alcohol, Running and Massage, should be avoided for the first 72 hours after the sprain)

Advice	Day <input type="checkbox"/>	Day <input type="checkbox"/>	Day <input type="checkbox"/>	Day <input type="checkbox"/>	Day <input type="checkbox"/>	Day <input type="checkbox"/>
Rest						
Ice						
Compression						
Elevation						

Appendix 7: SPSS output for VAS scores

General Linear Model

Within-Subjects Factors

Measure: Pain

Trial	Dependent Variable
1	d1vas
2	d3vas
3	d11vas

Between-Subjects Factors

		Value Label	N
Groups	1	Physio	14
	2	RICE	12

Box's Test of Equality of Covariance Matrices(a)

Box's M	18.518
F	2.660
df1	6
df2	3881.065
Sig.	.014

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a Design: Intercept+group

Within Subjects Design: Trial

Mauchly's Test of Sphericity(b)

Measure: Pain

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon(a)		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Trial	.913	2.086	2	.352	.920	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b Design: Intercept+group

Within Subjects Design: Trial

Tests of Within-Subjects Effects

Measure: Pain

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Trial	Sphericity Assumed	135.373	2	67.687	41.856	.000	.636
	Greenhouse-Geisser	135.373	1.840	73.556	41.856	.000	.636
	Huynh-Feldt	135.373	2.000	67.687	41.856	.000	.636
	Lower-bound	135.373	1.000	135.373	41.856	.000	.636
Trial * group	Sphericity Assumed	3.387	2	1.694	1.047	.359	.042
	Greenhouse-Geisser	3.387	1.840	1.840	1.047	.354	.042
	Huynh-Feldt	3.387	2.000	1.694	1.047	.359	.042
	Lower-bound	3.387	1.000	3.387	1.047	.316	.042
Error(Trial)	Sphericity Assumed	77.623	48	1.617			
	Greenhouse-Geisser	77.623	44.170	1.757			
	Huynh-Feldt	77.623	48.000	1.617			
	Lower-bound	77.623	24.000	3.234			

Tests of Within-Subjects Contrasts

Measure: Pain

Source	Trial	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Trial	Linear	133.418	1	133.418	63.775	.000	.727
	Quadratic	1.956	1	1.956	1.712	.203	.067
Trial * group	Linear	2.975	1	2.975	1.422	.245	.056
	Quadratic	.413	1	.413	.361	.553	.015
Error(Trial)	Linear	50.208	24	2.092			
	Quadratic	27.415	24	1.142			

Levene's Test of Equality of Error Variances(a)

	F	df1	df2	Sig.
Visual Analogue Scale score Day 1	.202	1	24	.657
Visual Analogue Scale score Day 3	3.583	1	24	.070
Visual Analogue Scale score Day 11	1.909	1	24	.180

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a Design: Intercept+group

Within Subjects Design: Trial

Tests of Between-Subjects Effects

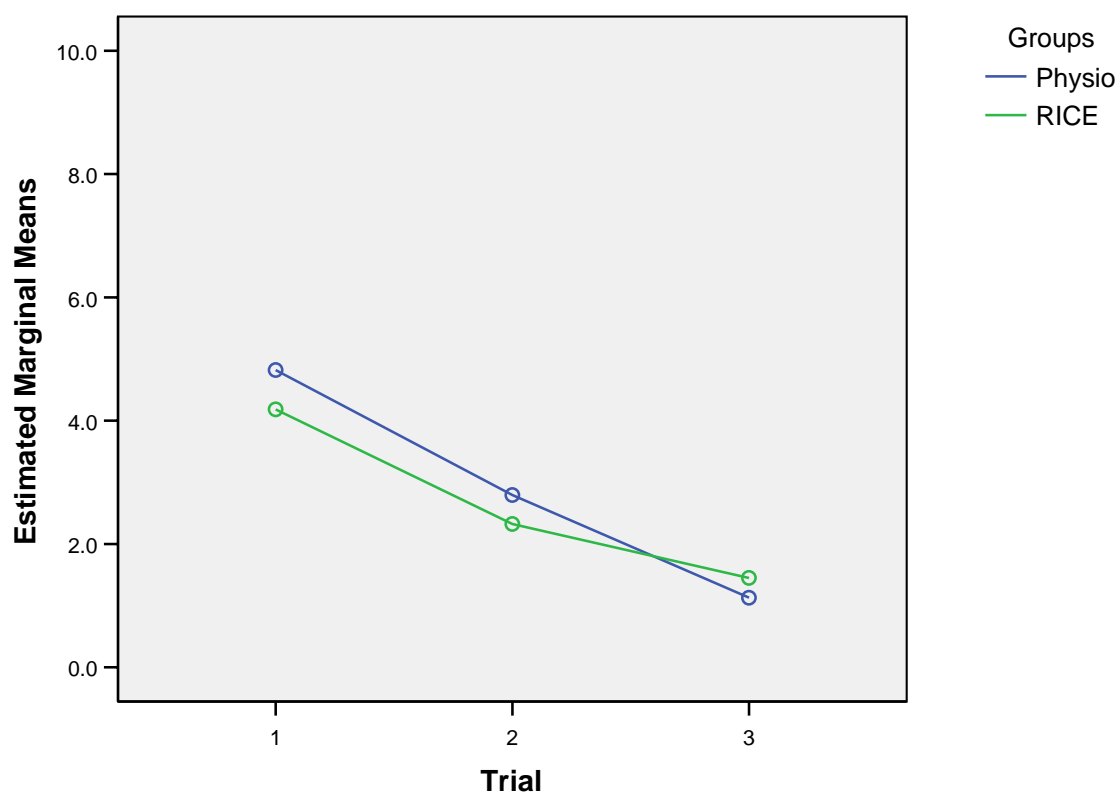
Measure: Pain

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	600.772	1	600.772	114.407	.000	.827
group	1.326	1	1.326	.252	.620	.010
Error	126.028	24	5.251			

Estimated Marginal Means

Estimated Marginal Means of Pain Scores



Appendix 8: SPSS output for function question

General Linear Model

Within-Subjects Factors

Measure: Function

Trial	Dependent Variable
1	d1work
2	d3work
3	d11work

Between-Subjects Factors

		Value Label	N
Groups	1	Physio	14
	2	RICE	8

Box's Test of Equality of Covariance Matrices(a)

Box's M	6.212
F	.840
df1	6
df2	1360.740
Sig.	.539

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a Design: Intercept+group

Within Subjects Design: Trial

Multivariate Tests(b)

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Trial	Pillai's Trace	.746	27.927(a)	2.000	19.000	.000	.746
	Wilks' Lambda	.254	27.927(a)	2.000	19.000	.000	.746
	Hotelling's Trace	2.940	27.927(a)	2.000	19.000	.000	.746
	Roy's Largest Root	2.940	27.927(a)	2.000	19.000	.000	.746
Trial * group	Pillai's Trace	.102	1.080(a)	2.000	19.000	.360	.102
	Wilks' Lambda	.898	1.080(a)	2.000	19.000	.360	.102
	Hotelling's Trace	.114	1.080(a)	2.000	19.000	.360	.102
	Roy's Largest Root	.114	1.080(a)	2.000	19.000	.360	.102

a Exact statistic

b Design: Intercept+group

Within Subjects Design: Trial

Tests of Within-Subjects Contrasts

Measure: Function

Source	Trial	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Trial	Linear	273.052	1	273.052	33.792	.000	.628
	Quadratic	8.766	1	8.766	1.348	.259	.063
Trial * group	Linear	.325	1	.325	.040	.843	.002
	Quadratic	8.766	1	8.766	1.348	.259	.063
Error(Trial)	Linear	161.607	20	8.080			
	Quadratic	130.060	20	6.503			

Levene's Test of Equality of Error Variances(a)

	F	df1	df2	Sig.
Work Day 1	10.006	1	20	.005
Work Day 3	1.640	1	20	.215
Work Day 11	4.891	1	20	.039

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+group

Within Subjects Design: Trial

Tests of Between-Subjects Effects

Measure: Function

Transformed Variable: Average

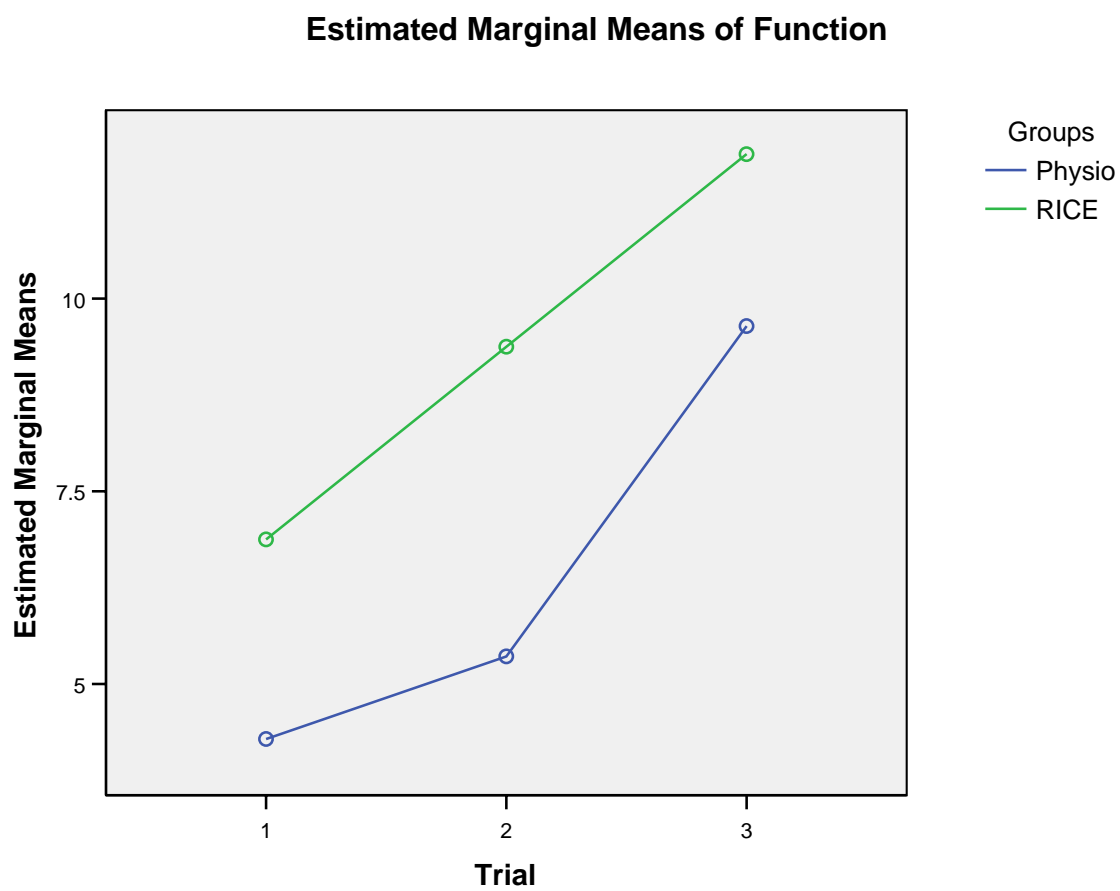
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	3814.407	1	3814.407	135.444	.000	.871
group	132.589	1	132.589	4.708	.042	.191
Error	563.244	20	28.162			

Estimated Marginal Means

Groups * Trial

Measure: Function

Groups	Trial	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Physio	1	4.286	1.253	1.672	6.900
	2	5.357	.936	3.406	7.309
	3	9.643	.779	8.017	11.269
RICE	1	6.875	1.658	3.417	10.333
	2	9.375	1.238	6.793	11.957
	3	11.875	1.031	9.724	14.026



Appendix 9: SPSS output for average volumetric scores

Oneway General Linear Model

Within-Subjects Factors

Measure: Volumetric

Time	Dependent Variable
1	Avgvol1
2	Avgvol3
3	Avgvol11

Between-Subjects Factors

		Value Label	N
Groups	1	Physio	16
	2	RICE	12

Box's Test of Equality of Covariance Matrices(a)

Box's M	11.543
F	1.673
df1	6
df2	3874.837
Sig.	.123

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a Design: Intercept+group

Within Subjects Design: Time

Multivariate Tests(b)

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	.377	7.548(a)	2.000	25.000	.003
	Wilks' Lambda	.623	7.548(a)	2.000	25.000	.003
	Hotelling's Trace	.604	7.548(a)	2.000	25.000	.003
	Roy's Largest Root	.604	7.548(a)	2.000	25.000	.003
Time * group	Pillai's Trace	.013	.169(a)	2.000	25.000	.845
	Wilks' Lambda	.987	.169(a)	2.000	25.000	.845
	Hotelling's Trace	.014	.169(a)	2.000	25.000	.845
	Roy's Largest Root	.014	.169(a)	2.000	25.000	.845

a Exact statistic

b Design: Intercept+group

Within Subjects Design: Time

Tests of Within-Subjects Contrasts

Measure: Volumetric

Source	Time	Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Linear	27328.627	1	27328.627	12.795	.001
	Quadratic	24.429	1	24.429	.016	.902
Time * group	Linear	685.631	1	685.631	.321	.576
	Quadratic	236.817	1	236.817	.151	.701
Error(Time)	Linear	55534.379	26	2135.938		
	Quadratic	40865.759	26	1571.760		

Levene's Test of Equality of Error Variances(a)

	F	df1	df2	Sig.
Avgvol1	1.380	1	26	.251
Avgvol3	.000	1	26	.992
Avgvol11	.024	1	26	.878

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a Design: Intercept+group

Within Subjects Design: Time

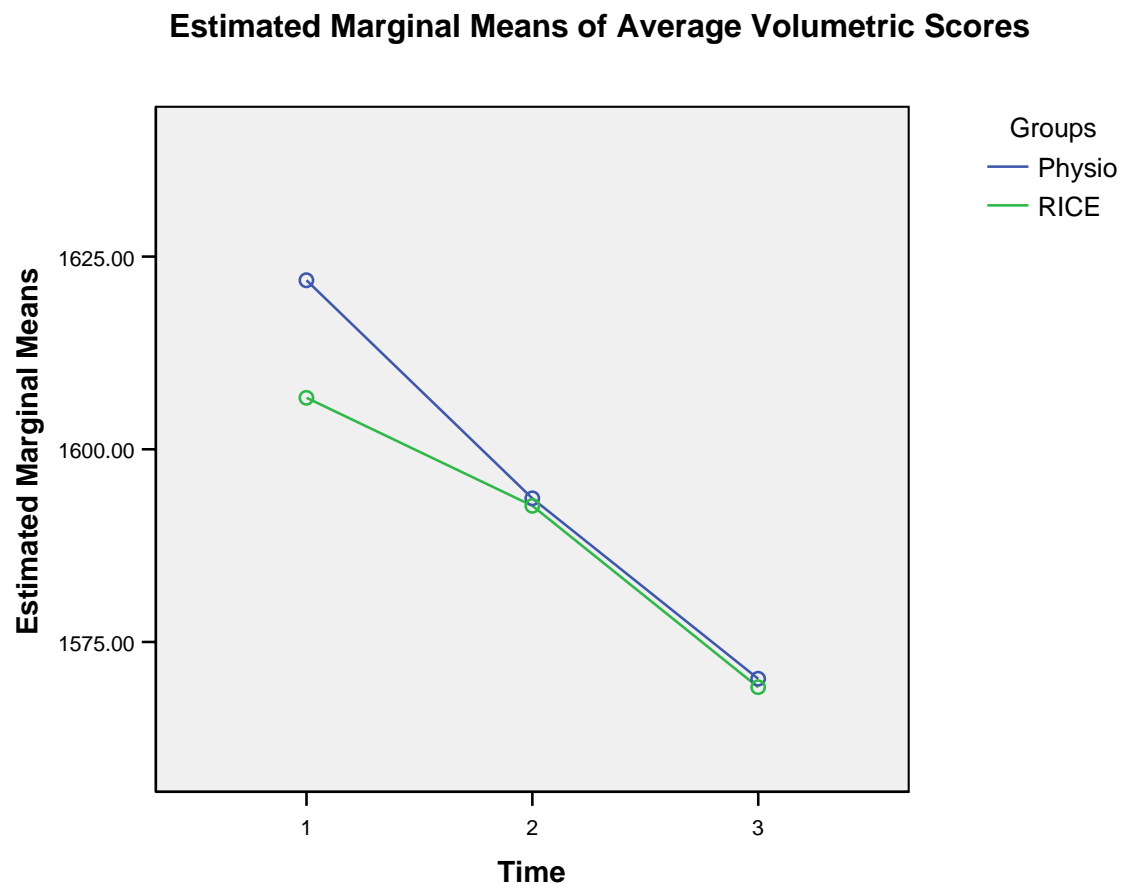
Tests of Between-Subjects Effects

Measure: Volumetric

Transformed Variable: Average

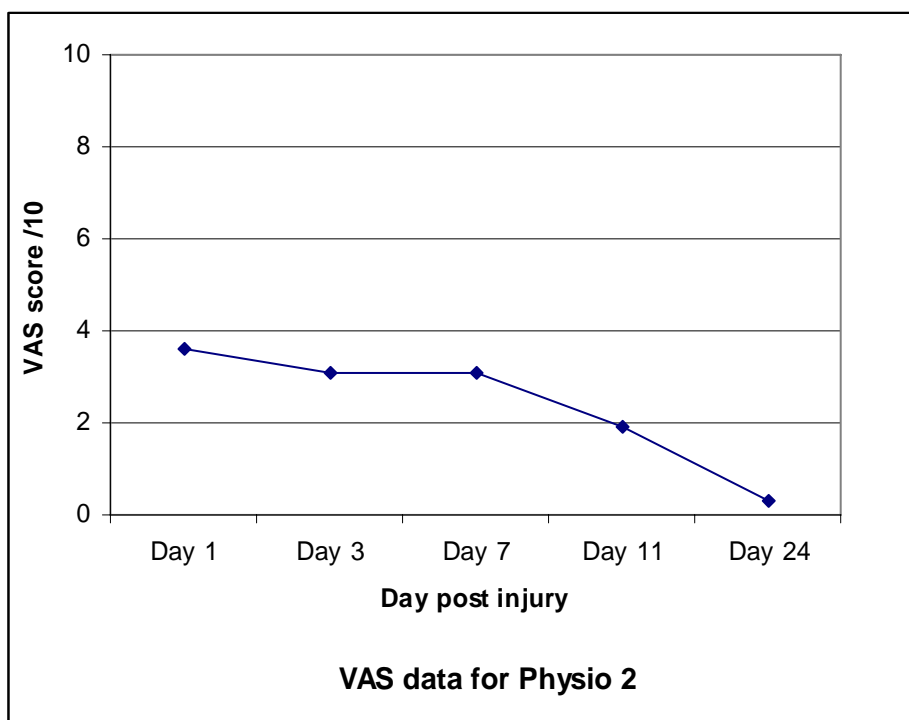
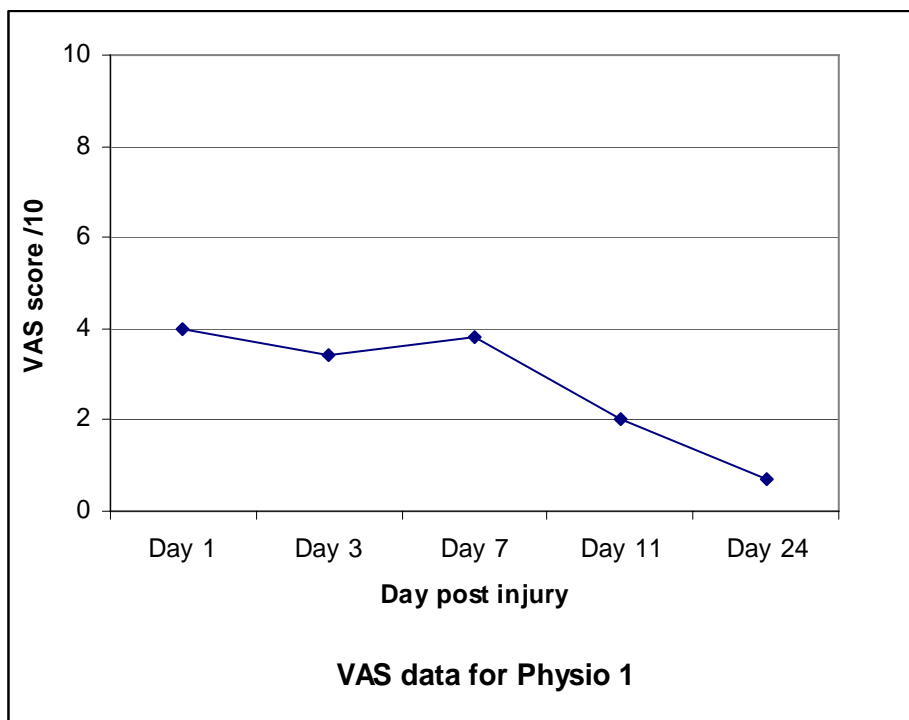
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	208648990.430	1	208648990.430	1898.560	.000
group	686.934	1	686.934	.006	.938
Error	2857362.602	26	109898.562		

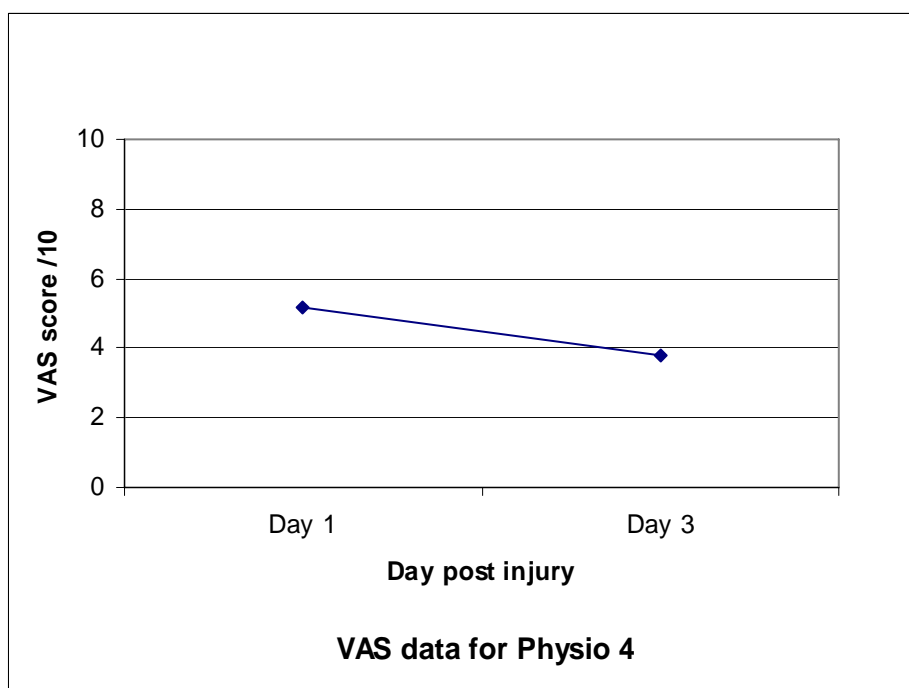
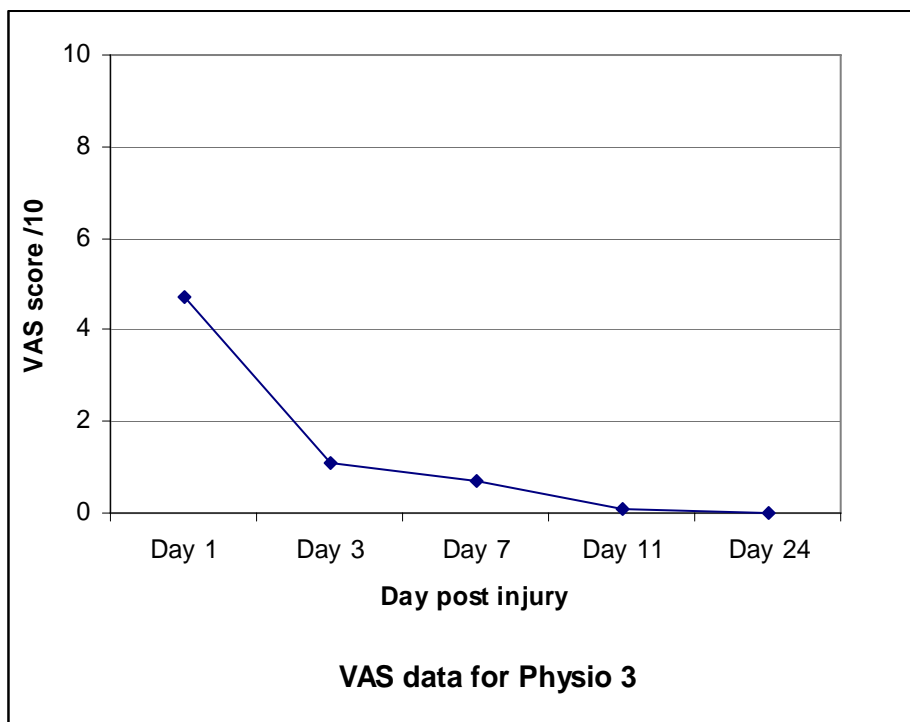
Profile Plot

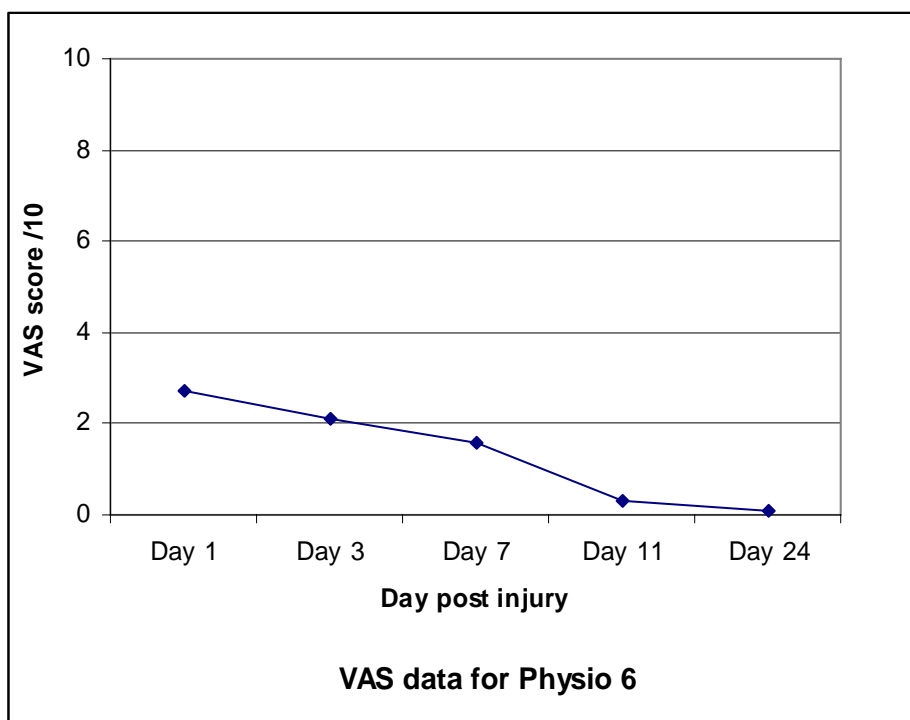
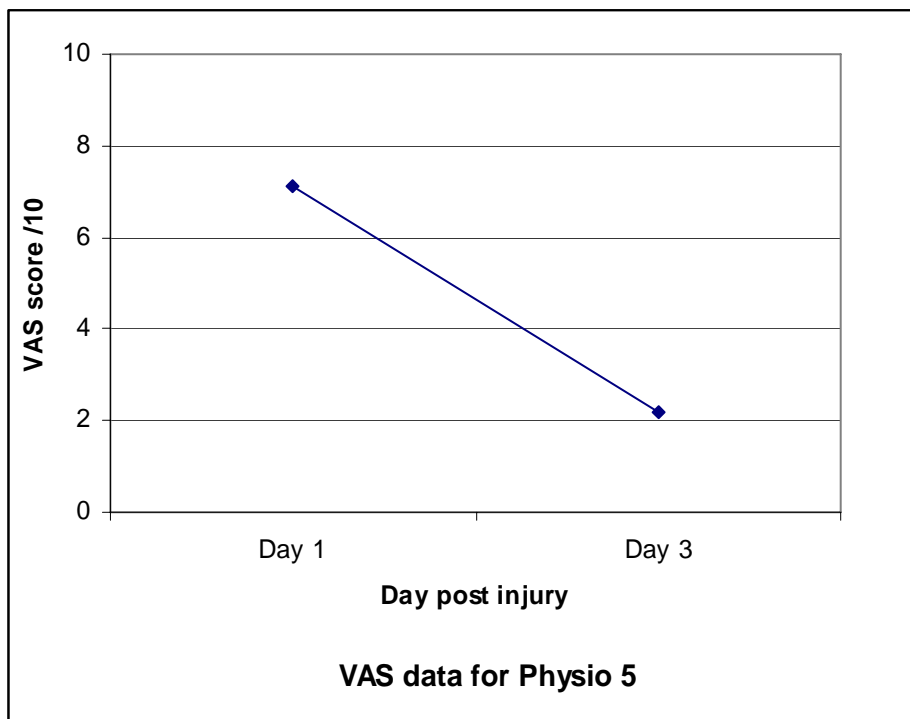


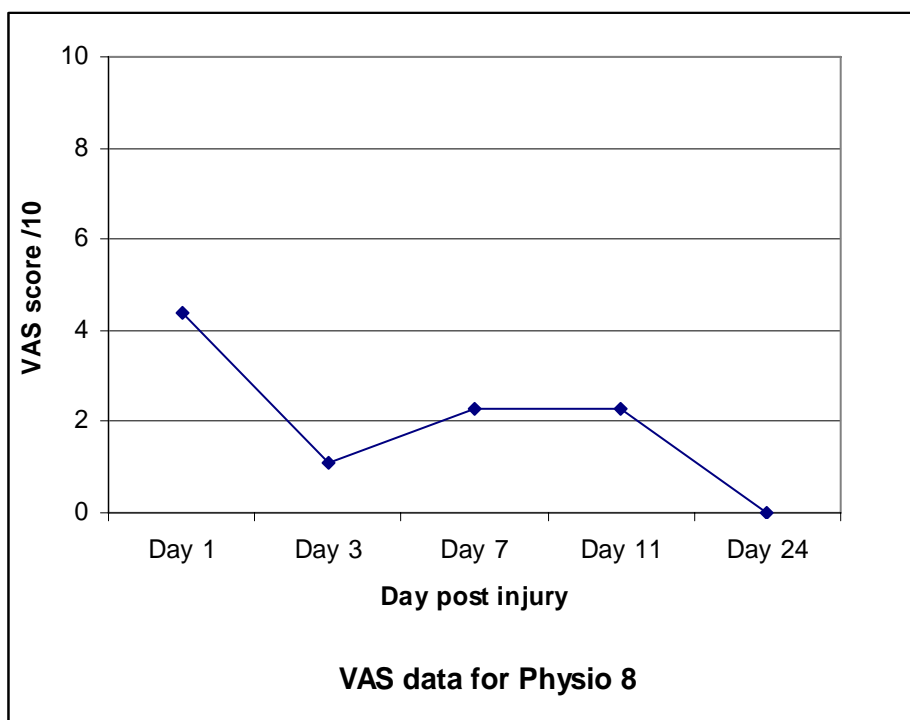
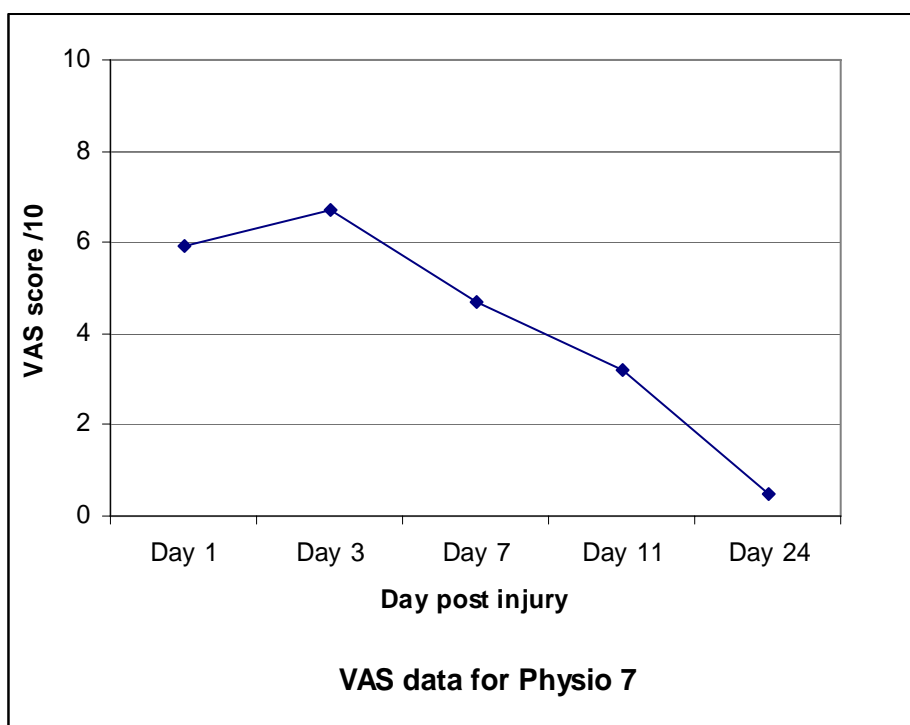
Appendix 10: Graphs of individual Visual Analogue Scale data

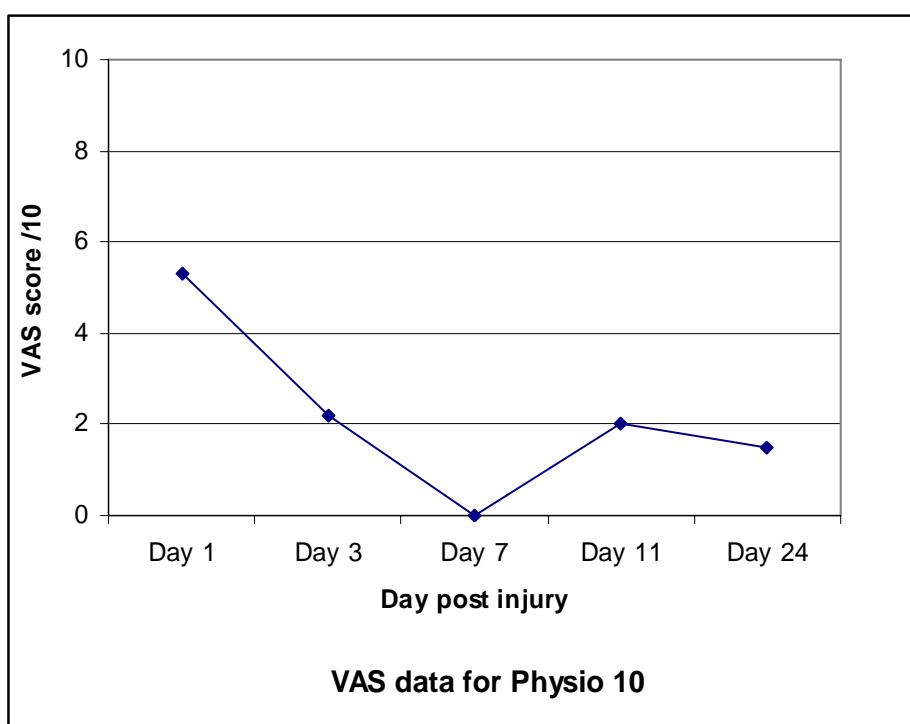
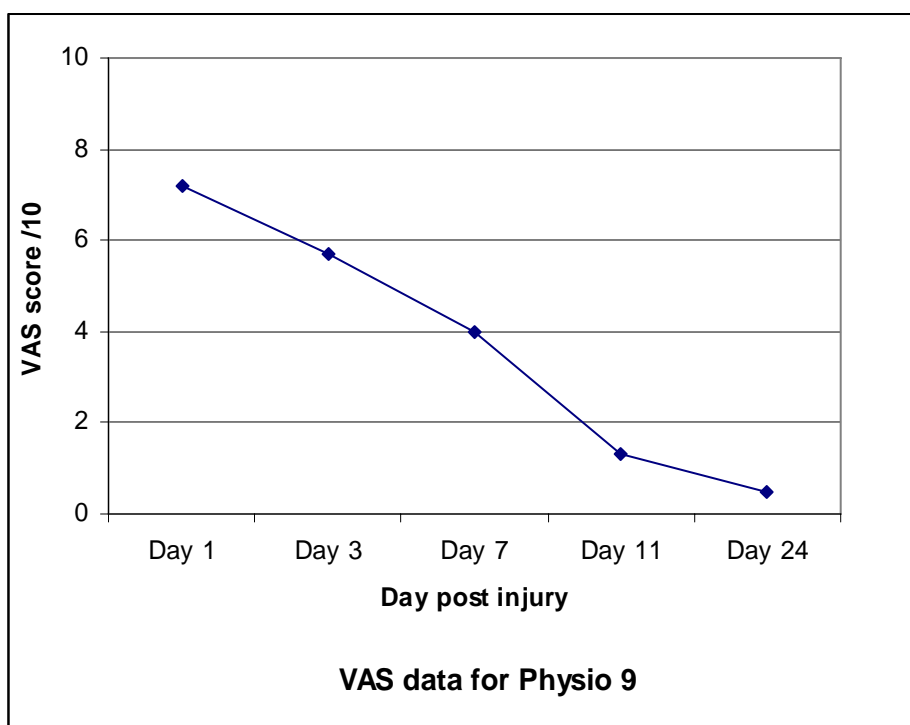
Participants in the physiotherapy intervention are presented as “Physio” and then the corresponding number in that group. The same applies to the RICE group. In the graphs for “Physio 4, 5 and 13” and “RICE 7” there is missing data and so these graphs are not complete. The time periods between the days are not shown to scale.

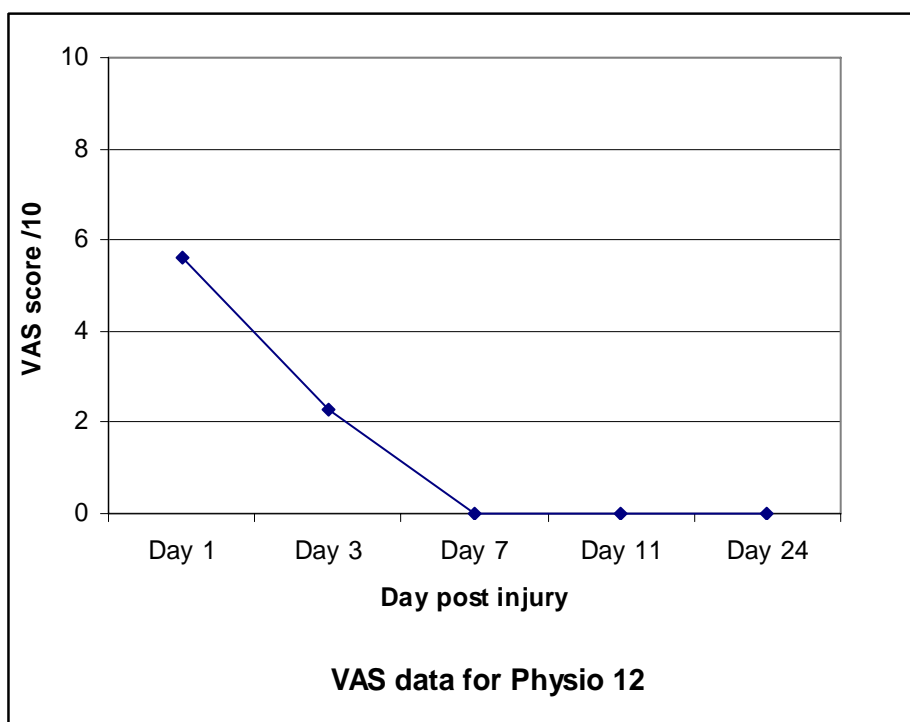
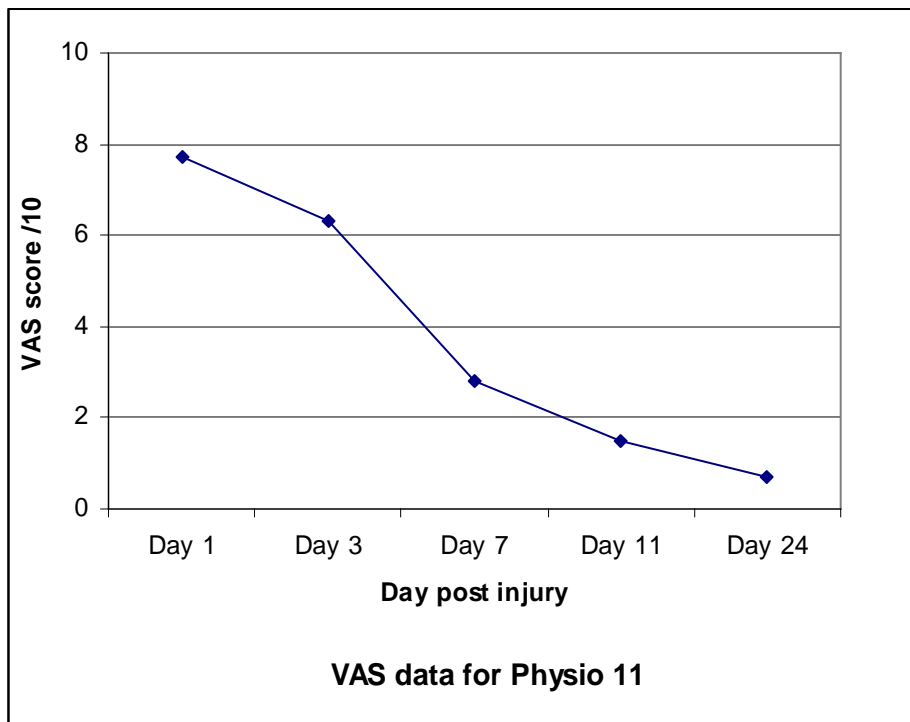


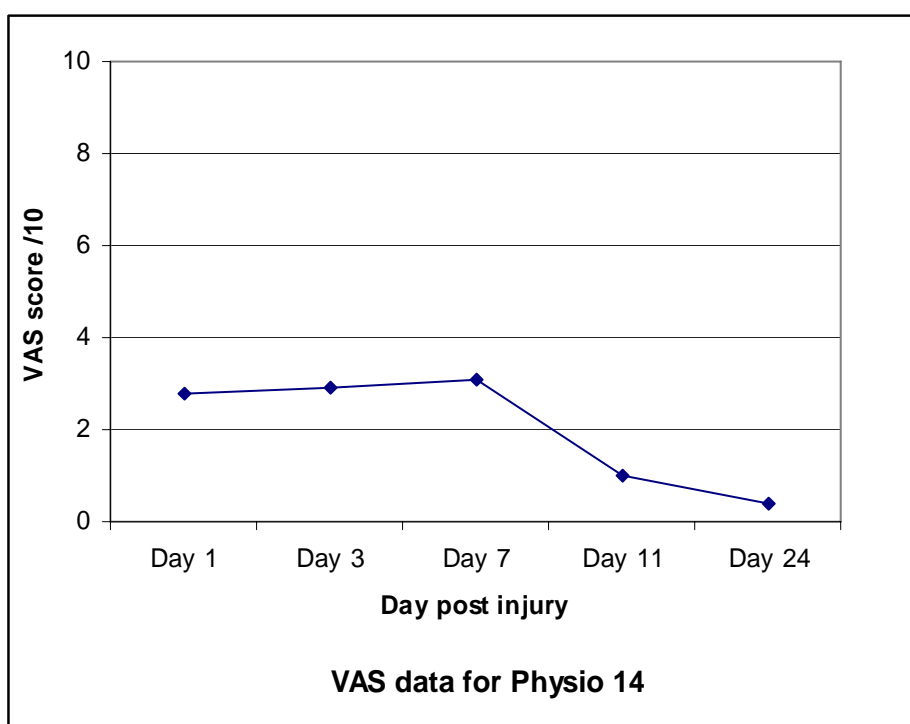
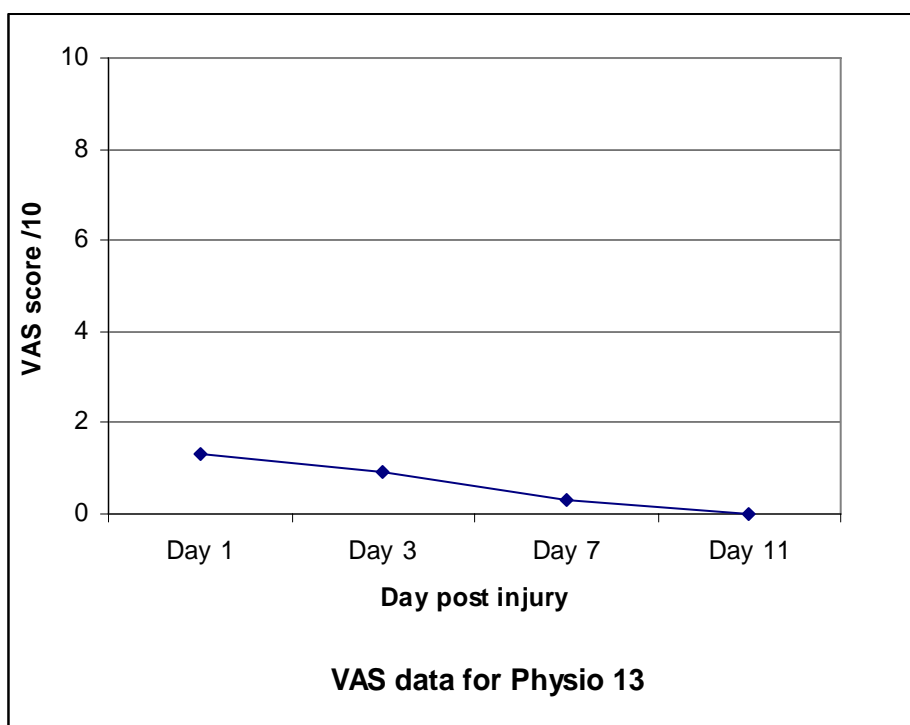


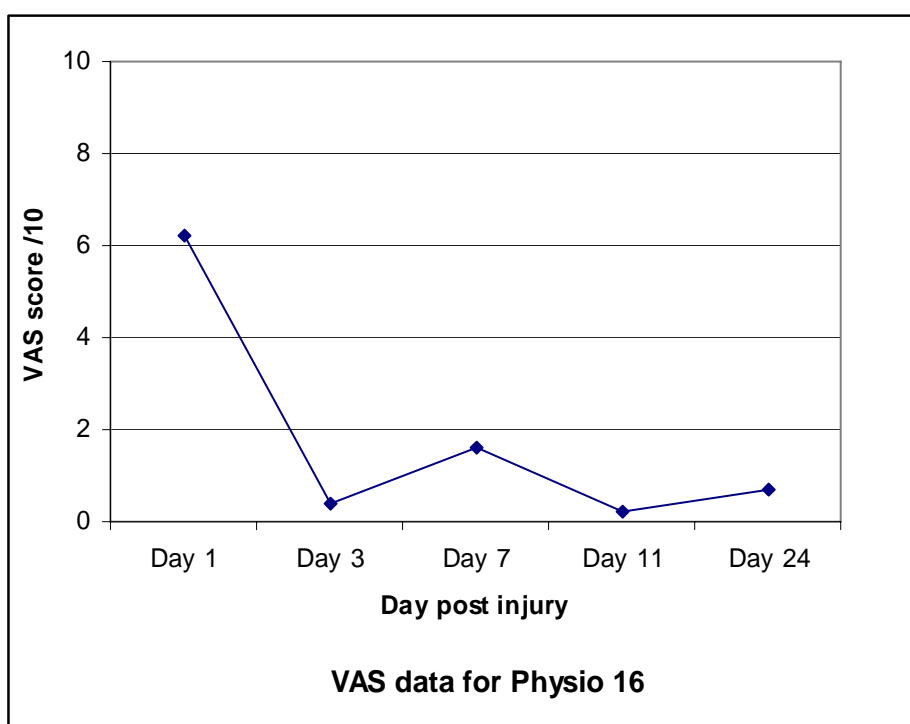
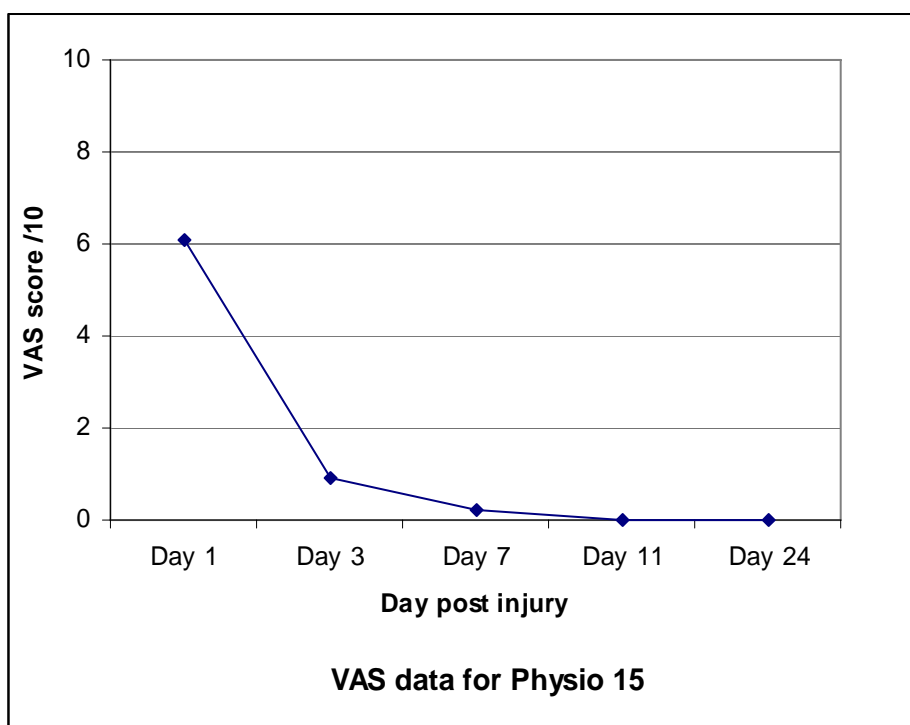


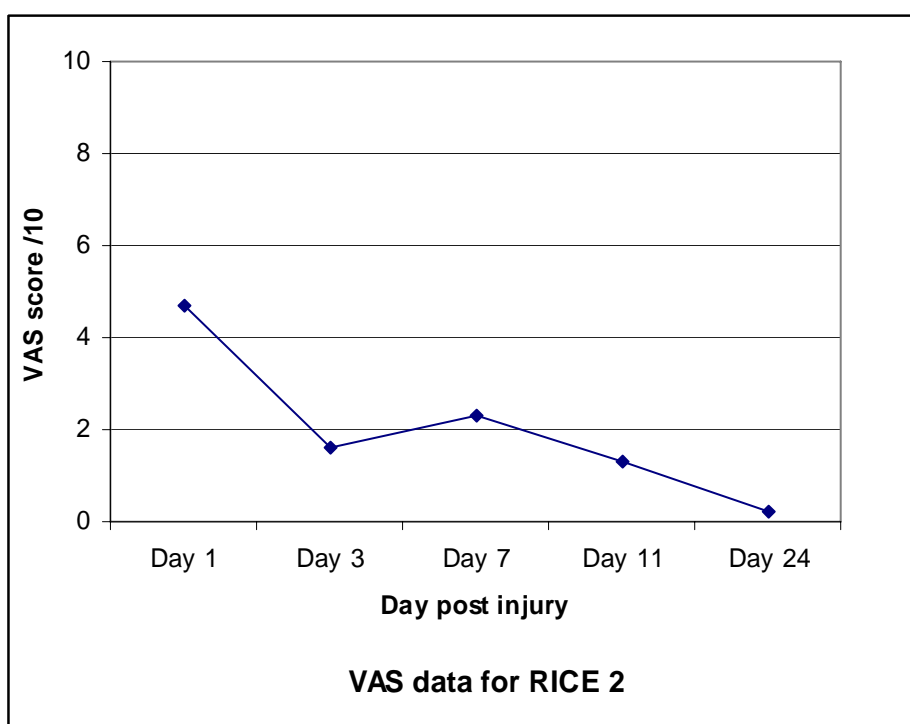
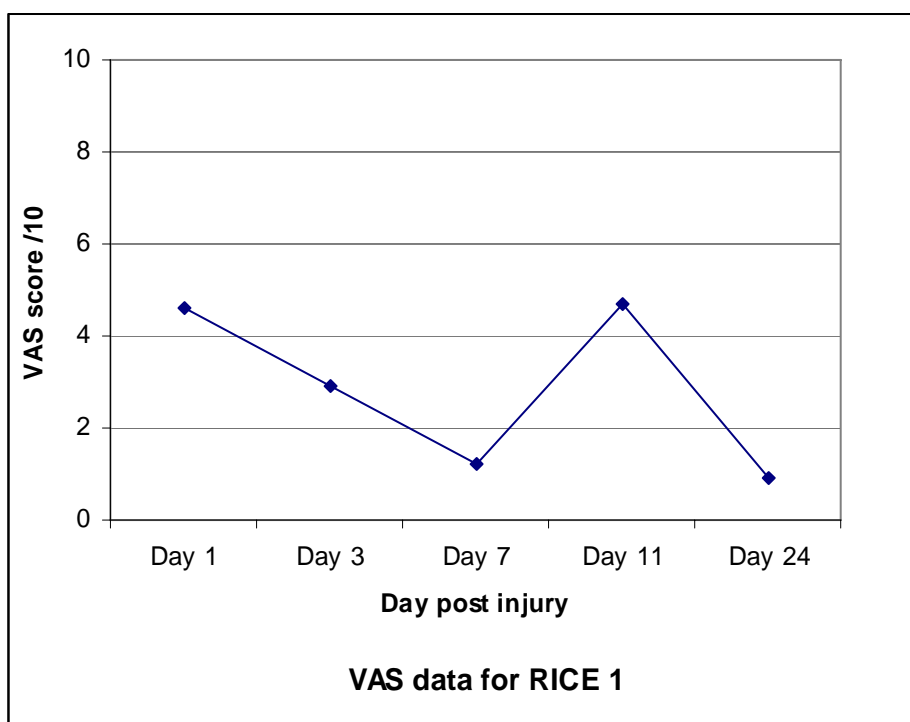


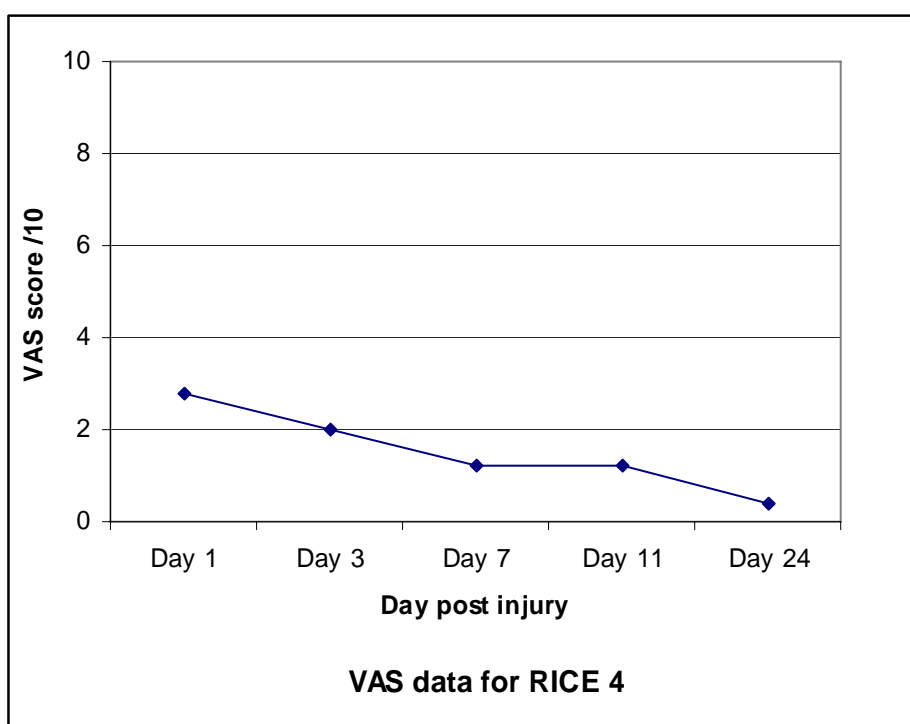
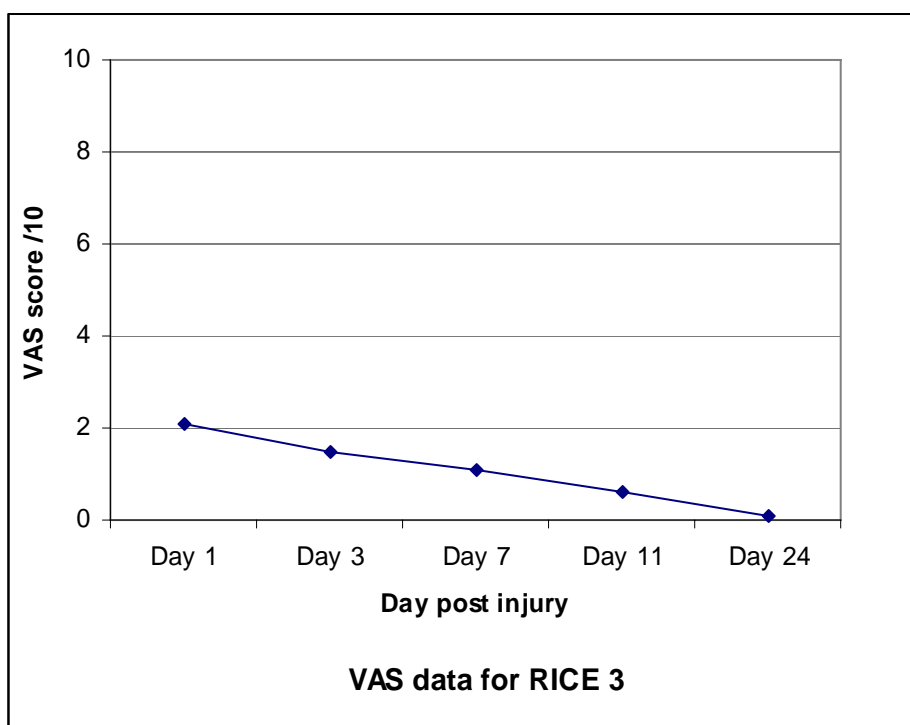


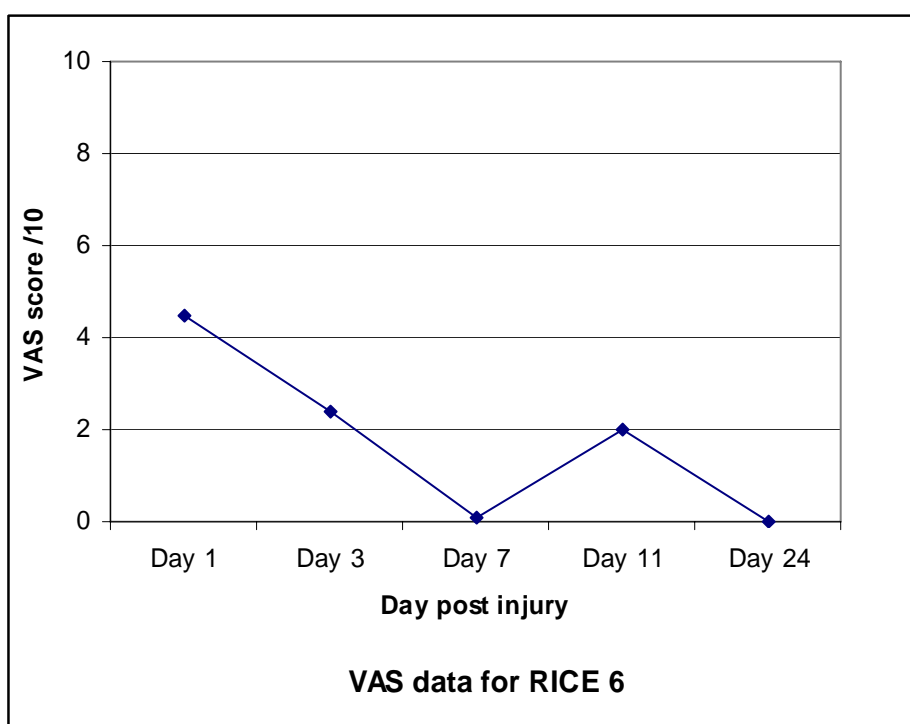
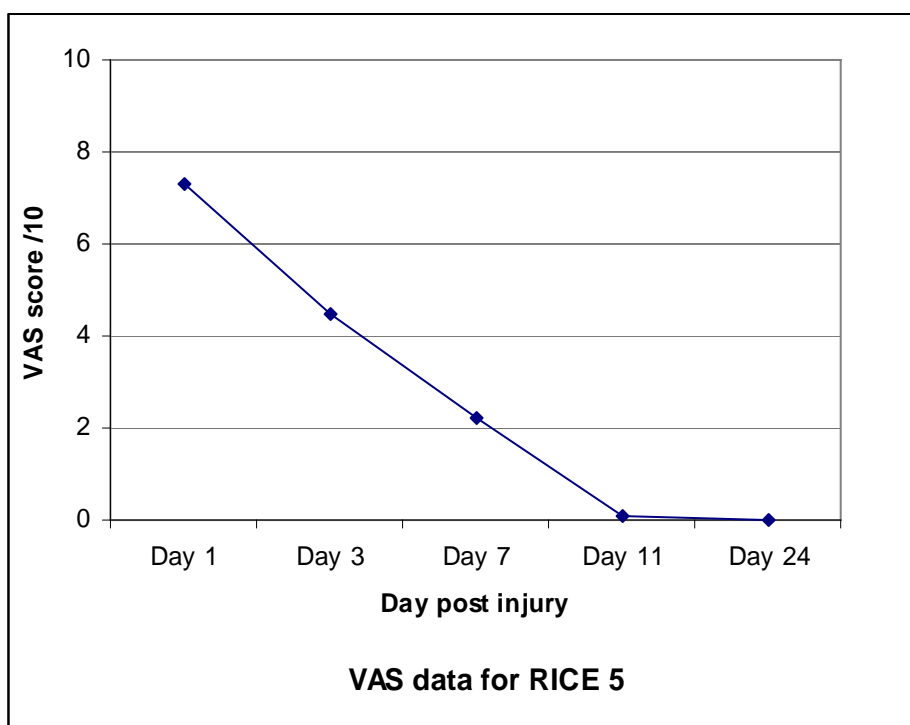


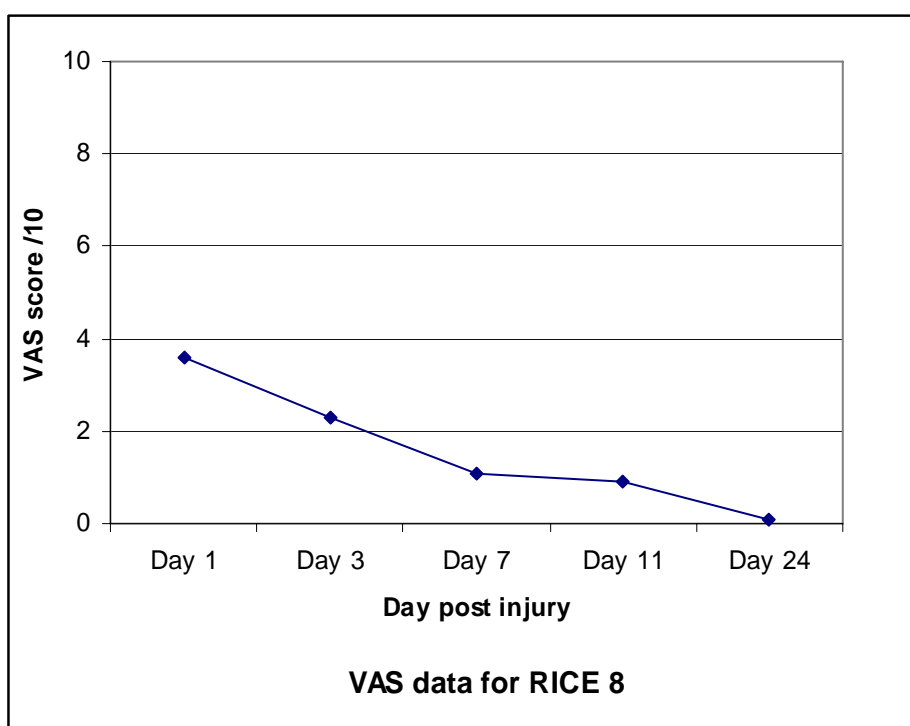
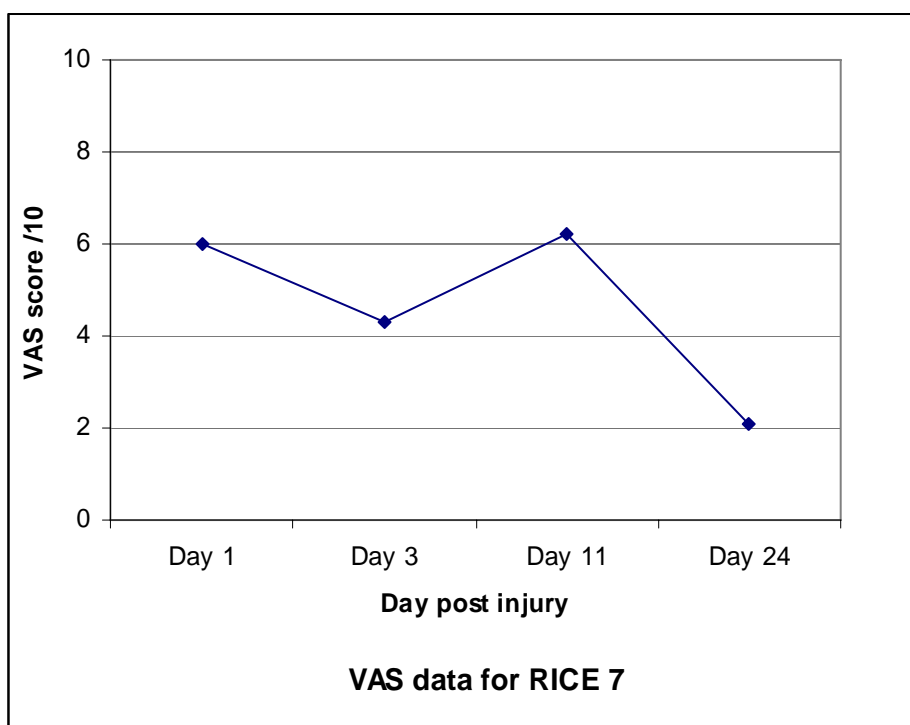


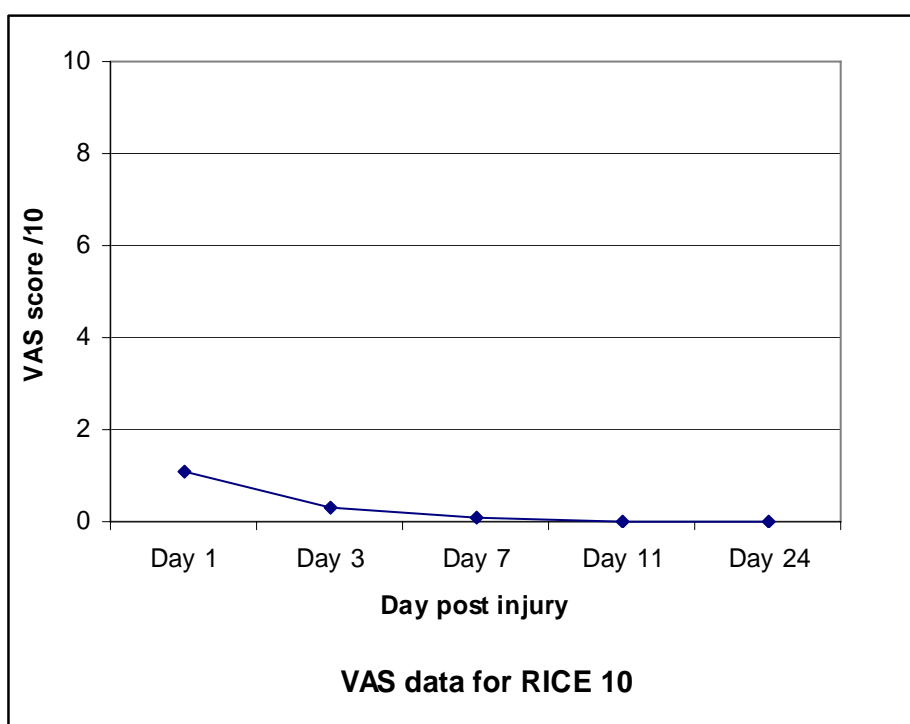
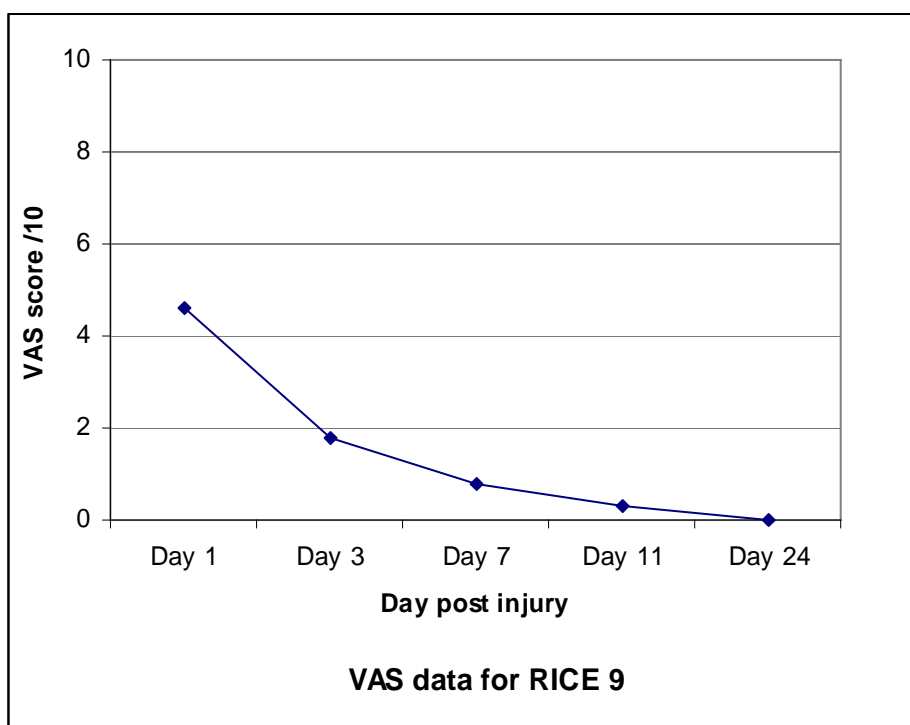


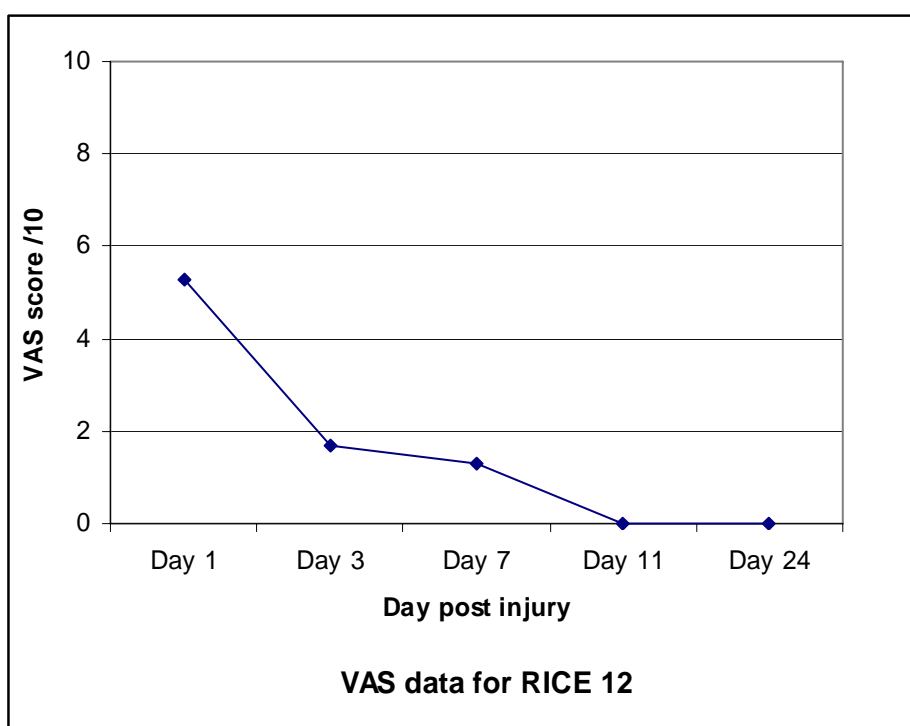
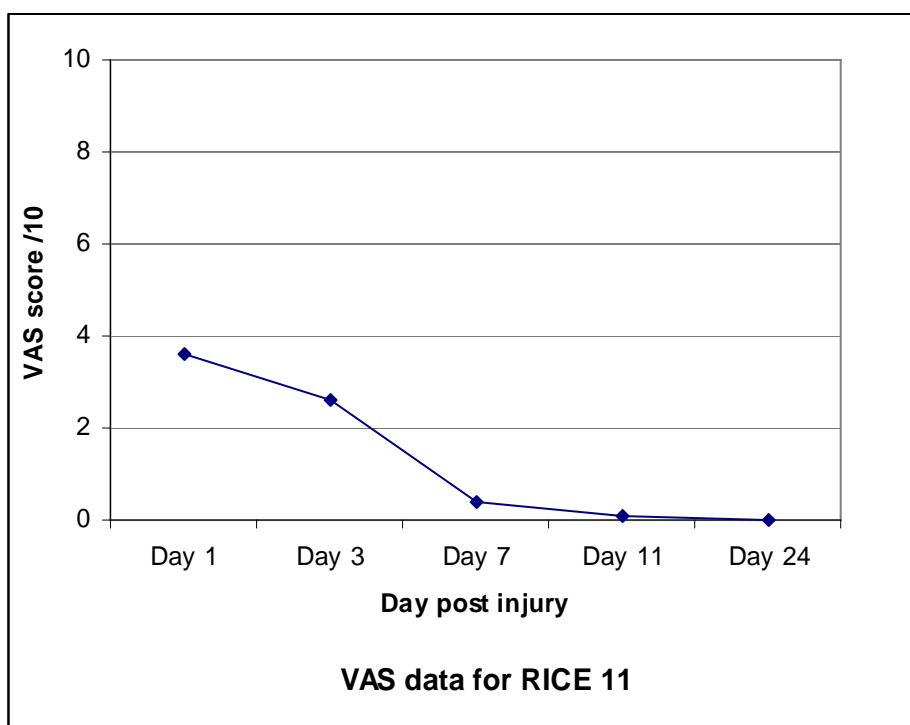






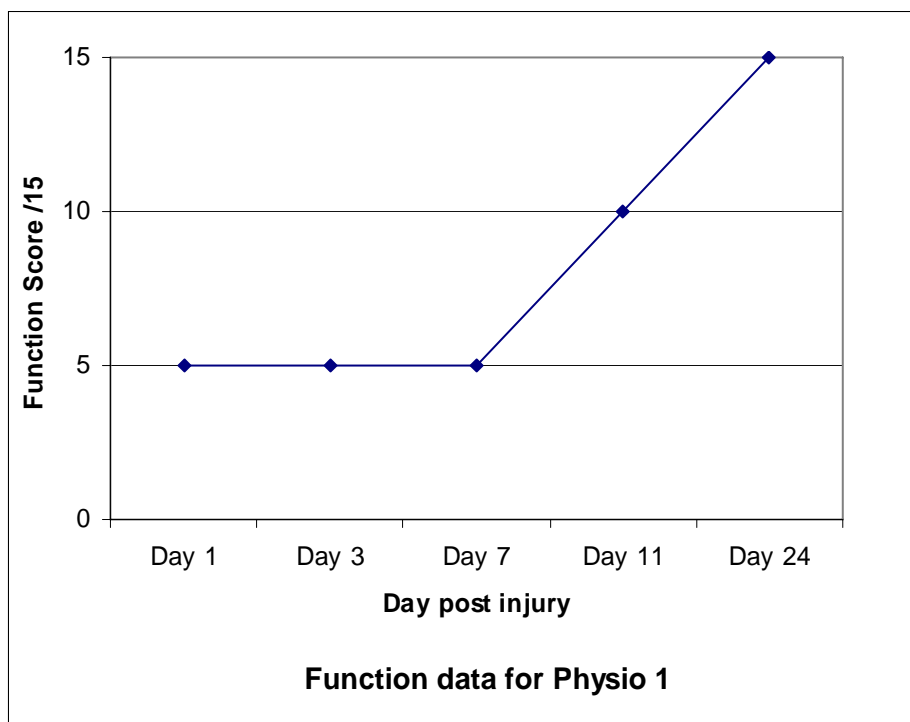


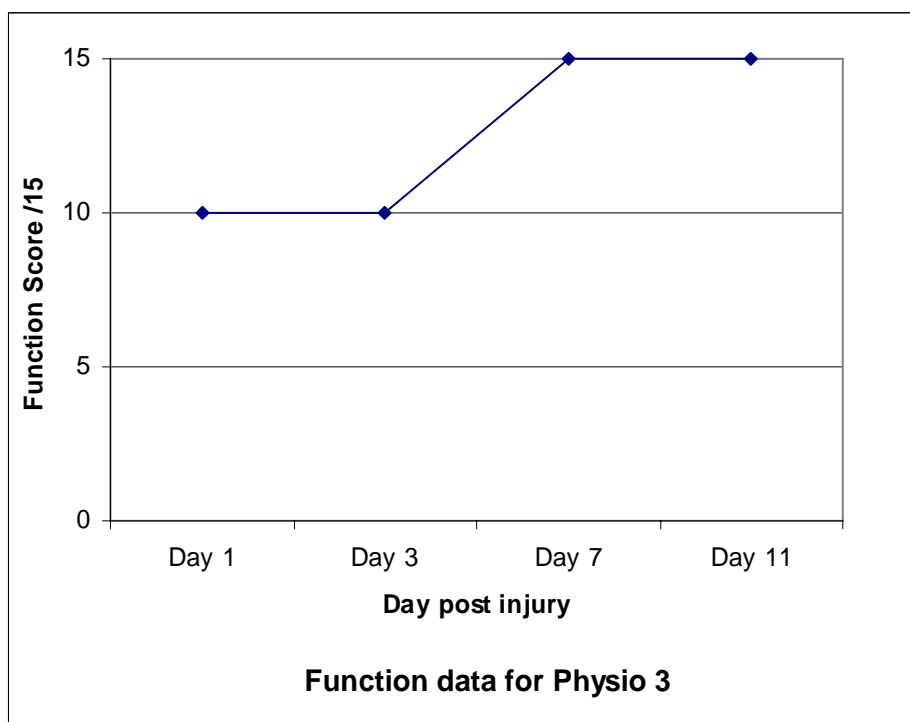
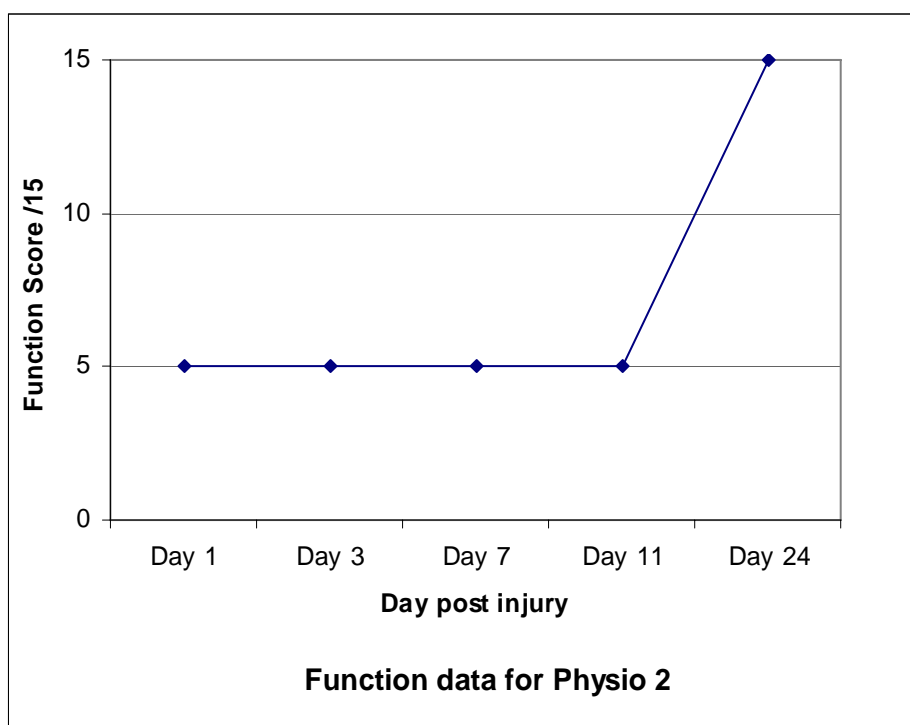


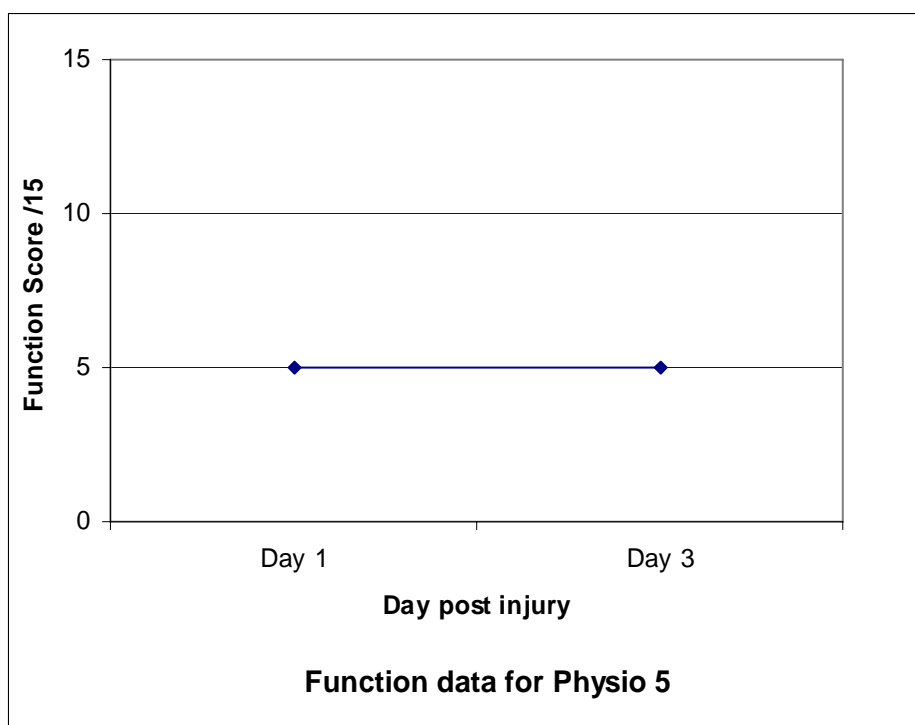
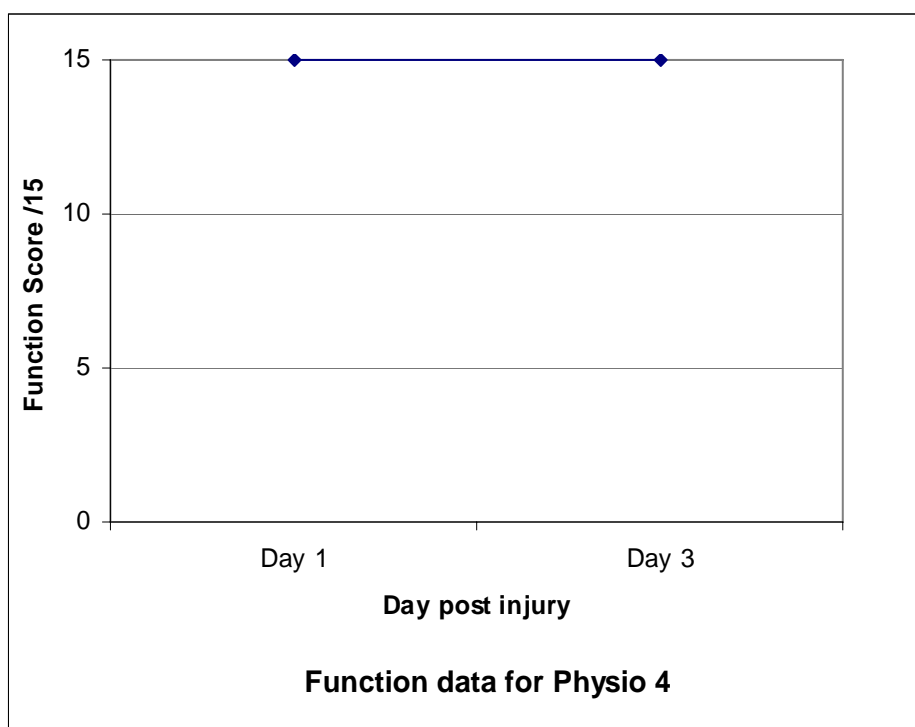


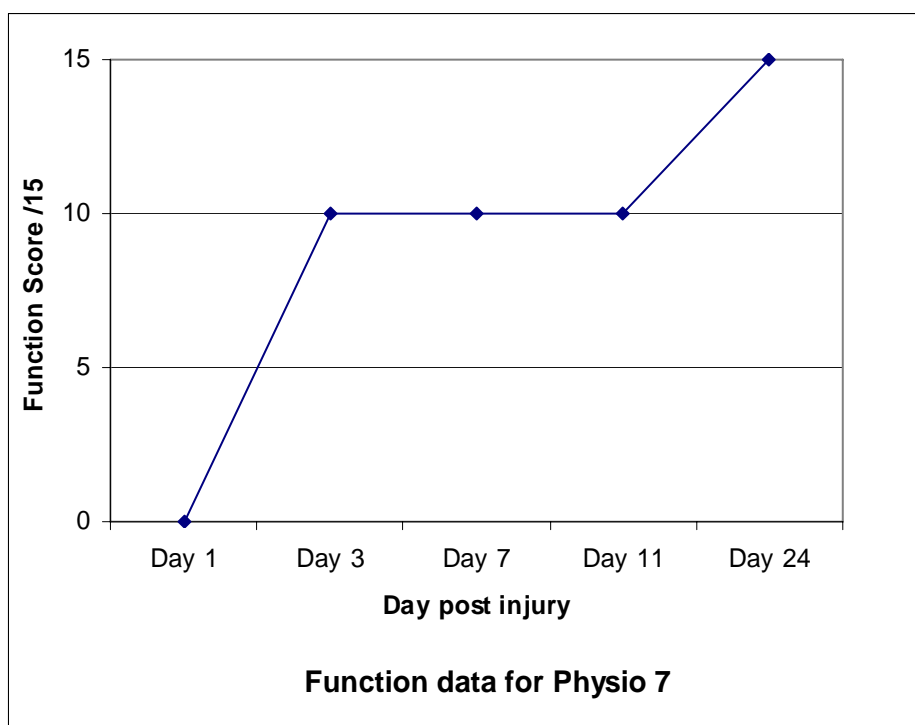
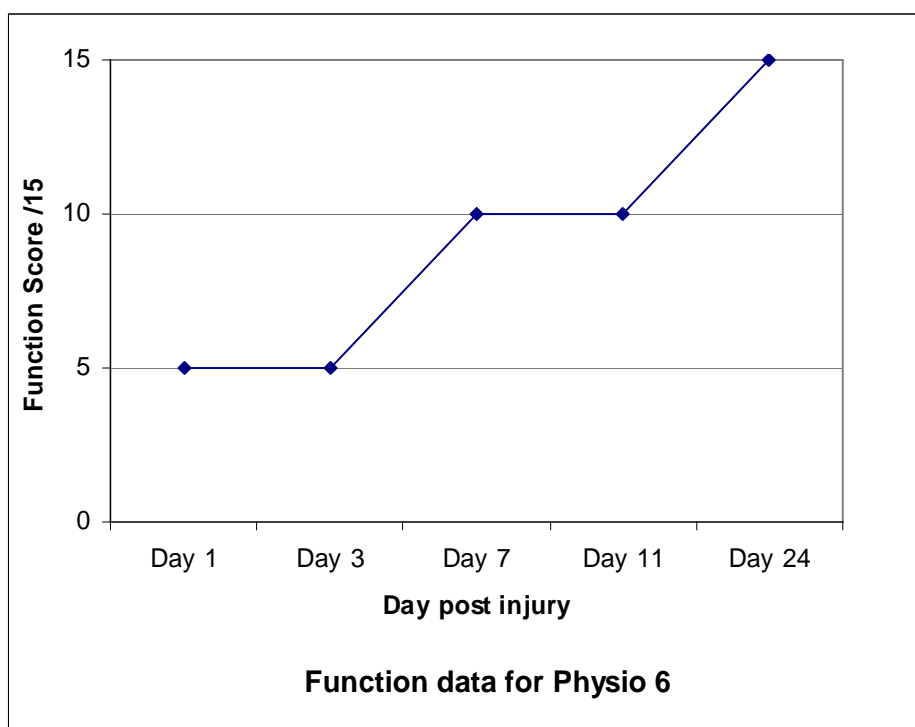
Appendix 11: Graphs of individual function scores

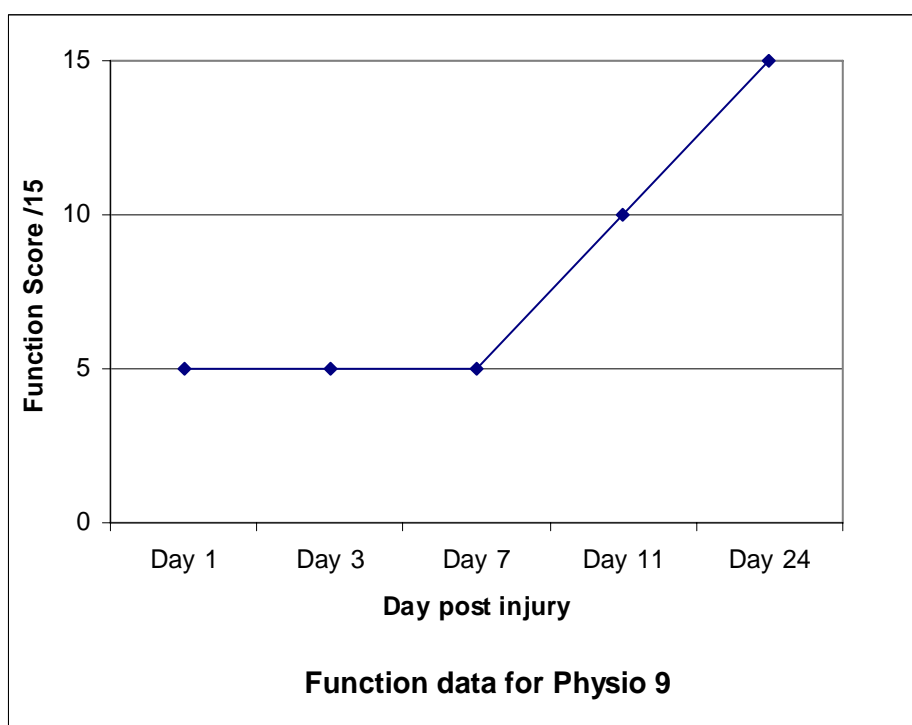
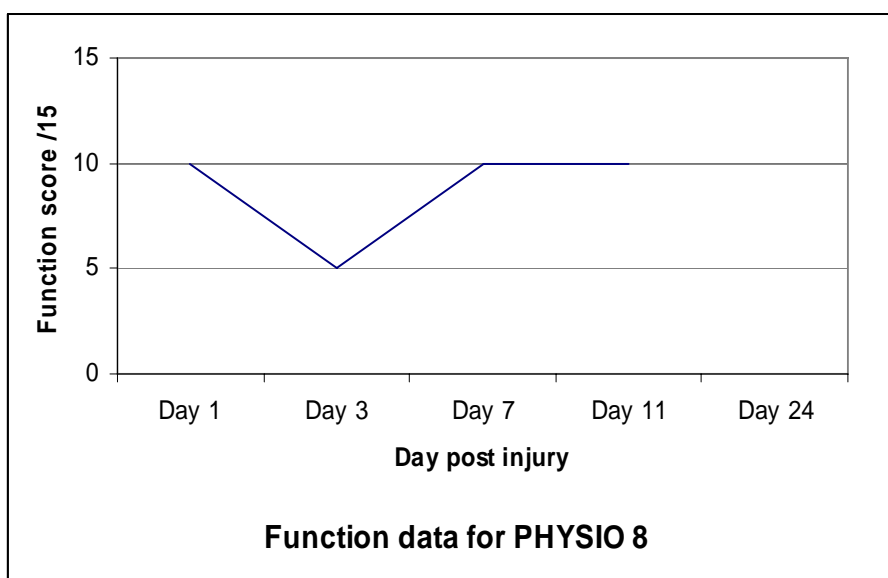
Participants in the physiotherapy intervention are presented as “Physio” and then the corresponding number in that group. The same applies to the RICE group. In the graphs for “Physio 3, 4, 5, 8, 10 and 15” and for “RICE 4, 9, 11, and 12” there is missing data and so these graphs are not complete. The time periods between the days are not shown to scale.

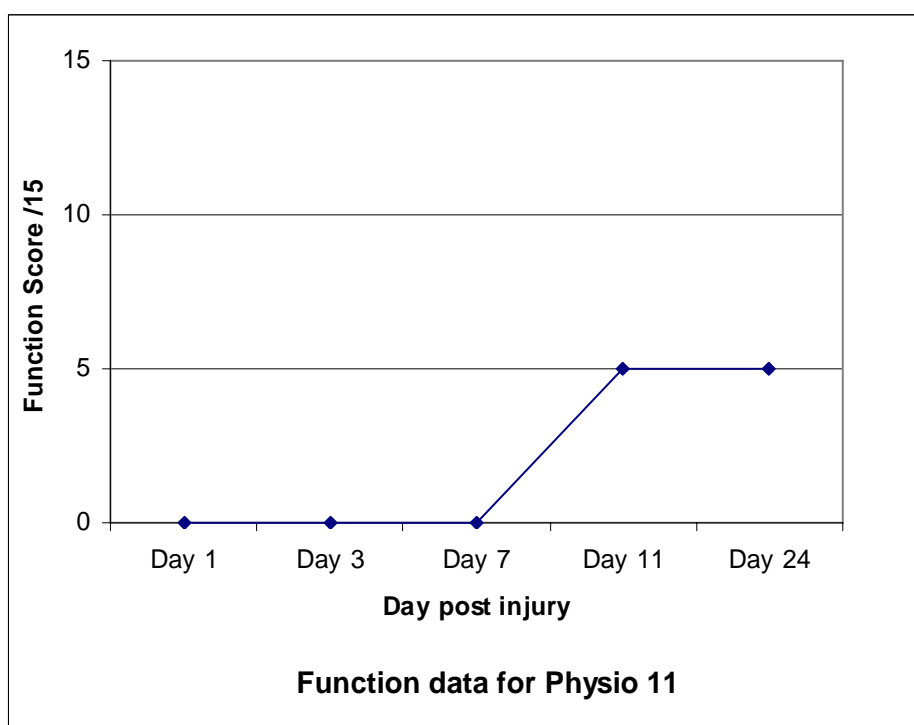
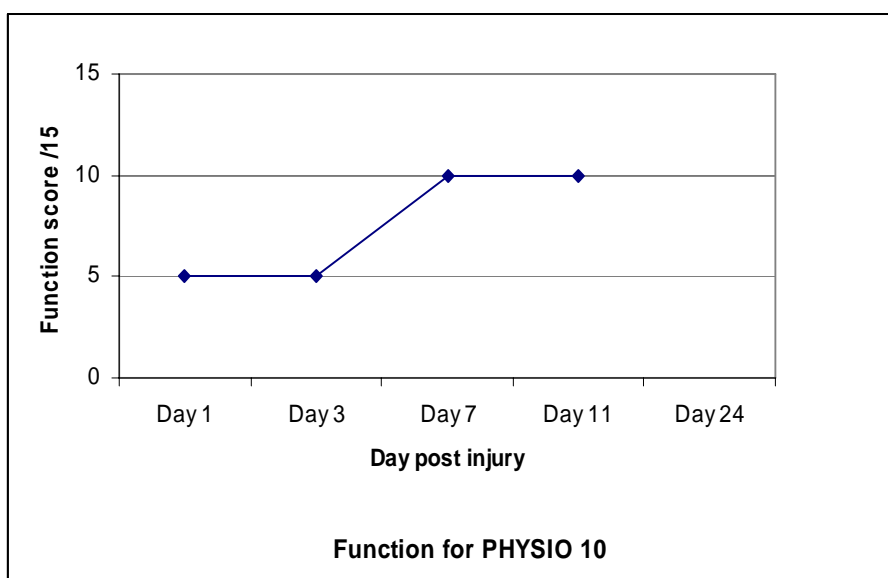


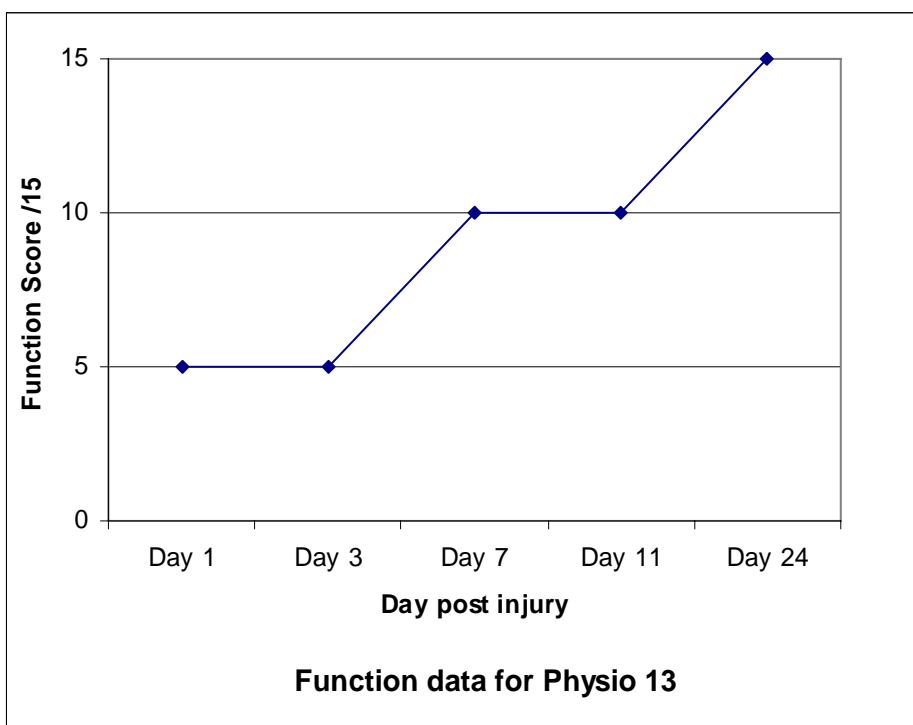
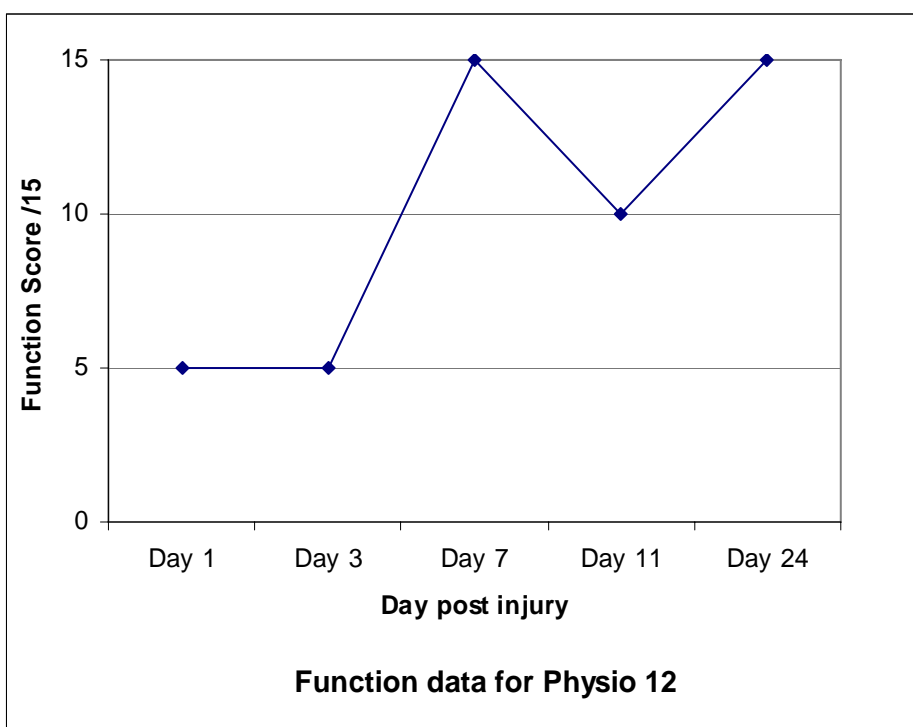


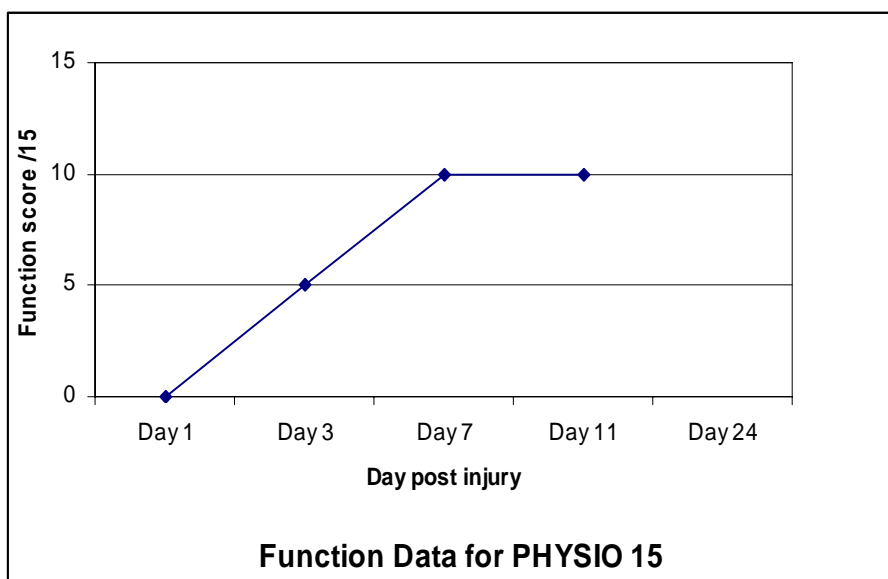
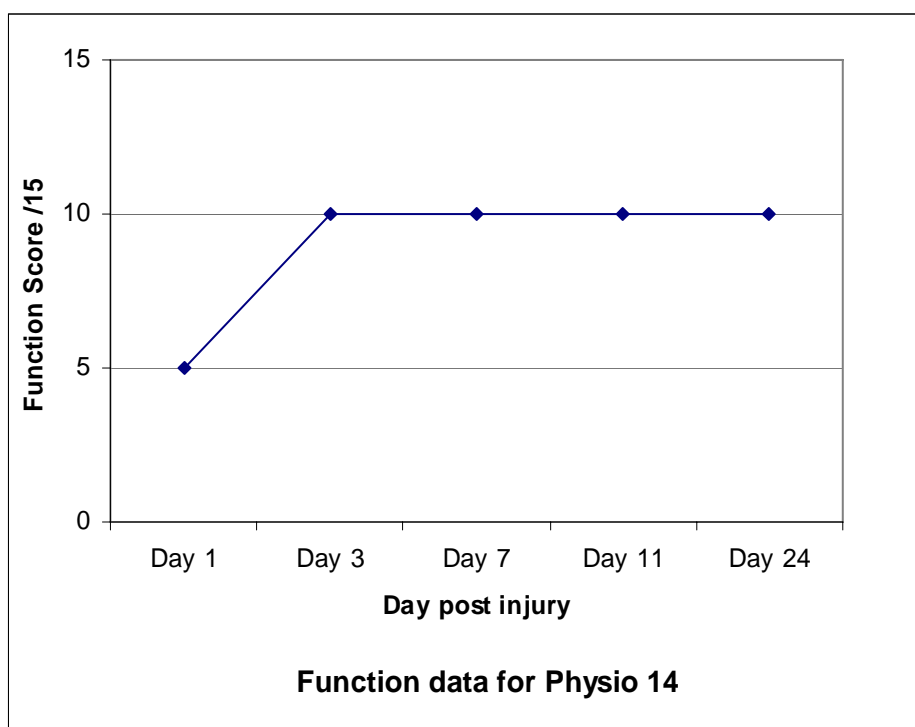


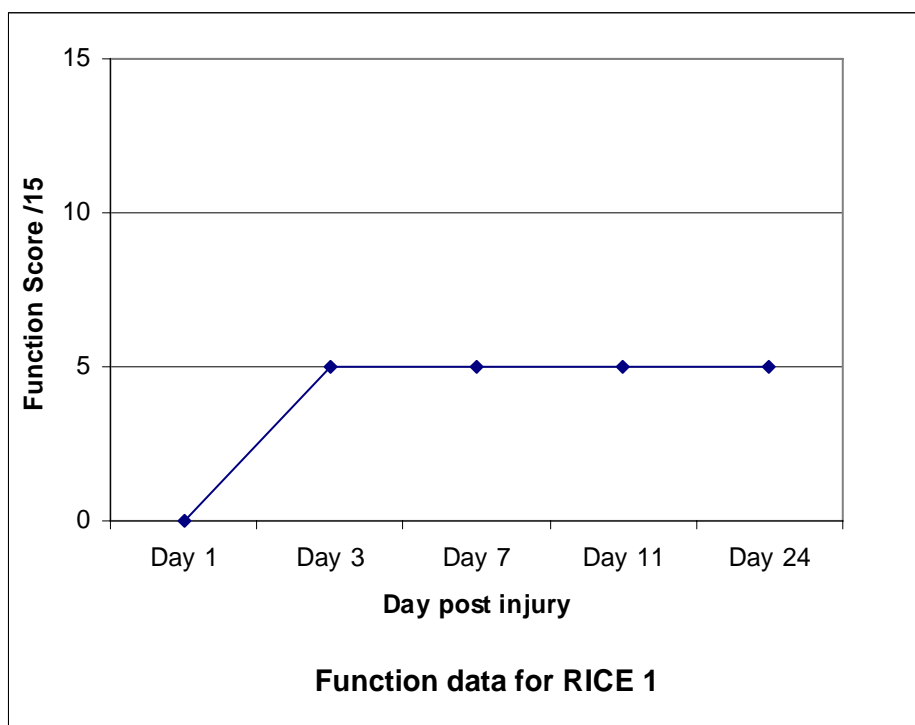
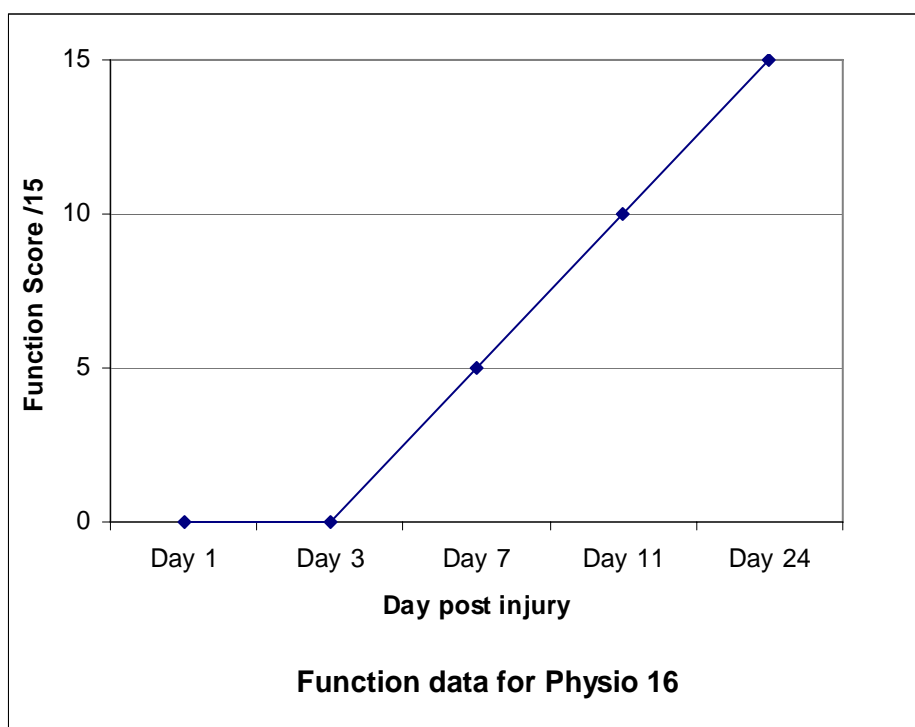


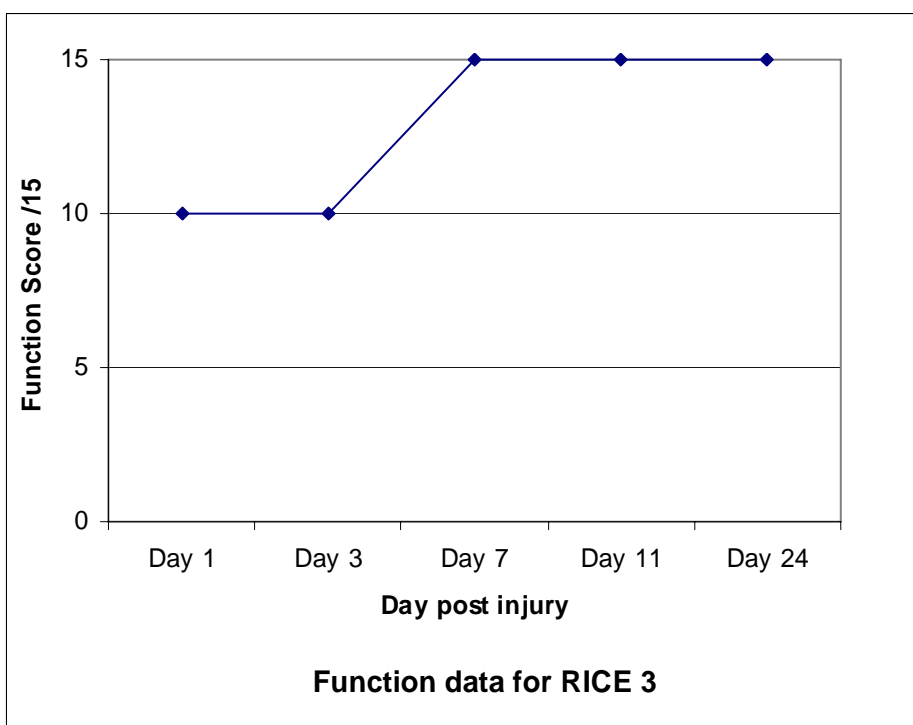
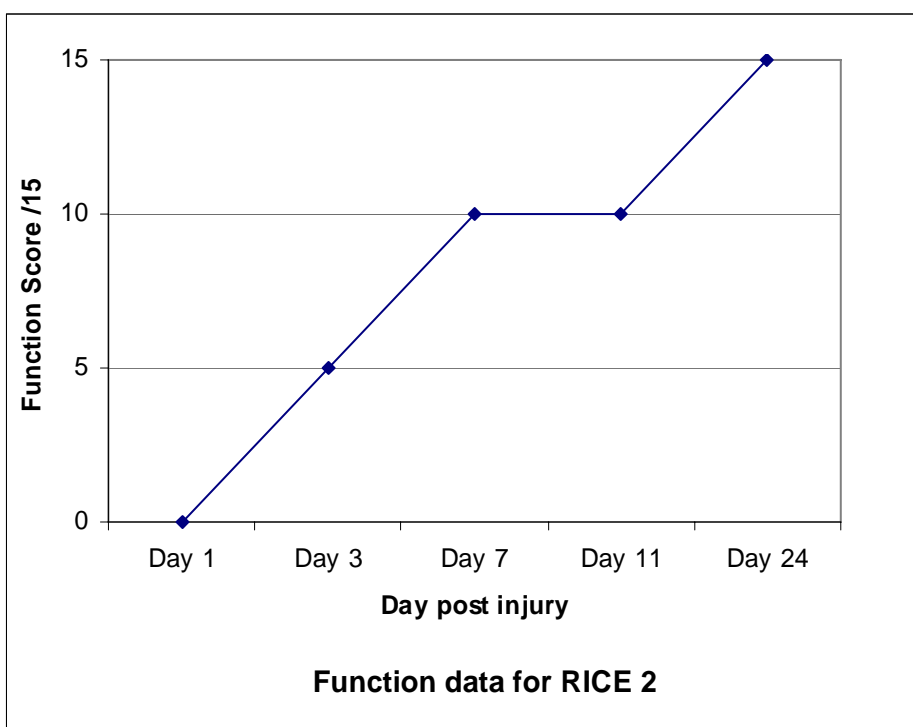


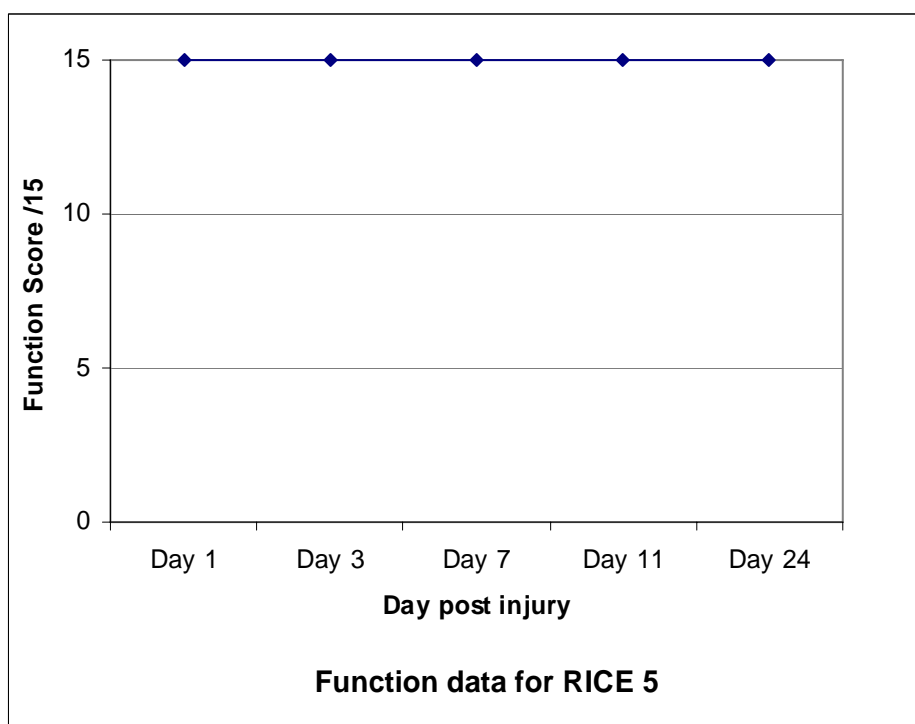
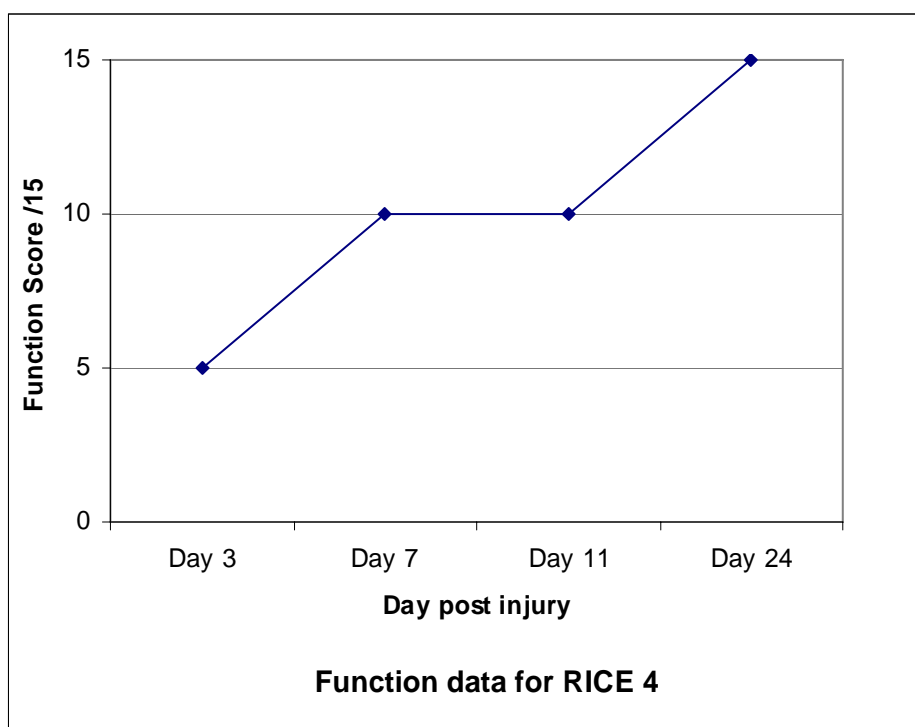


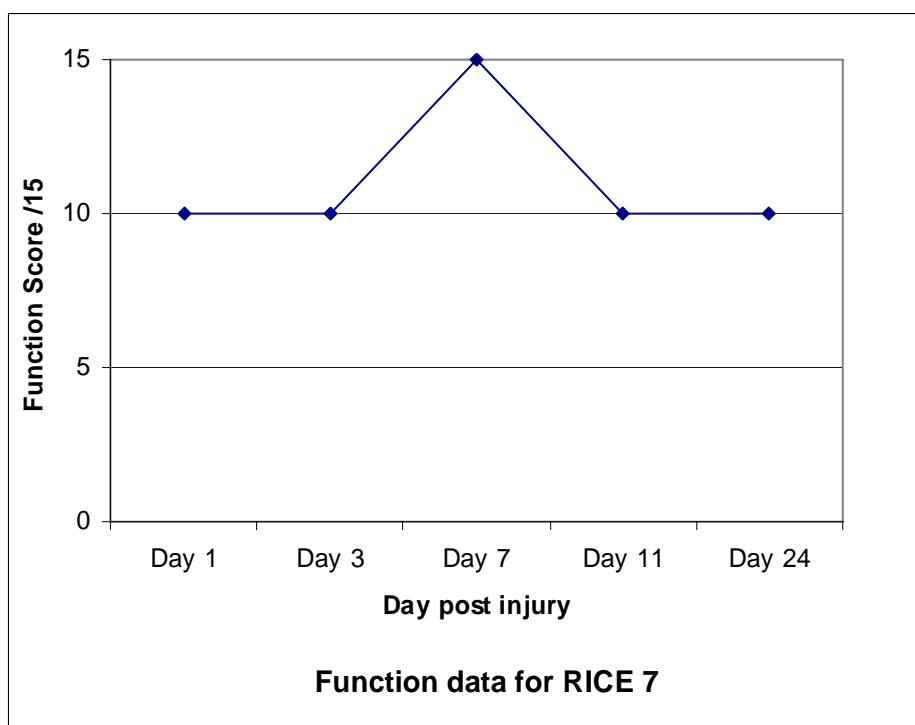
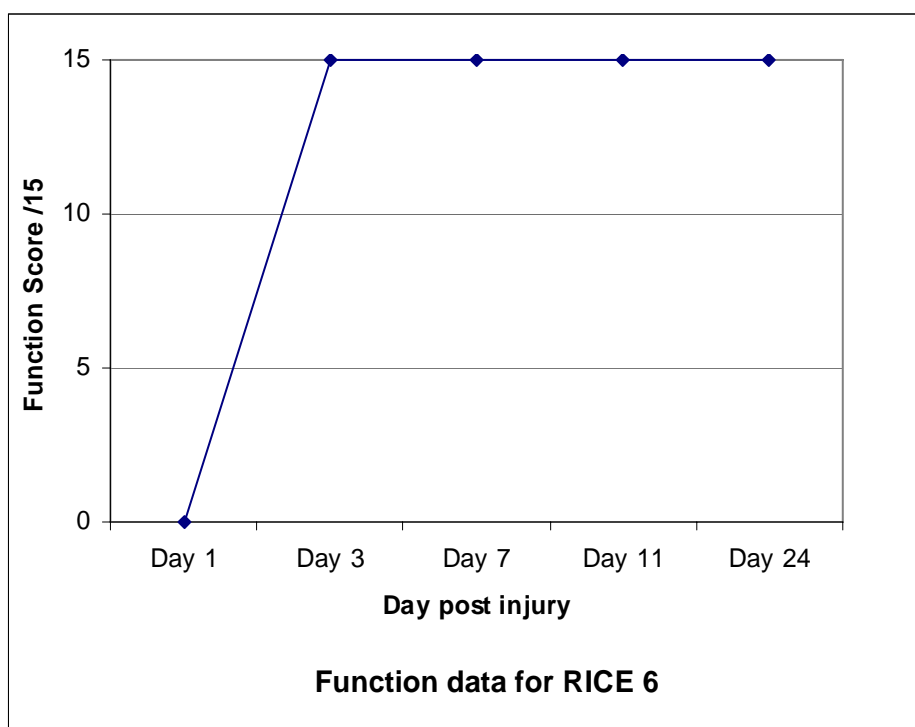


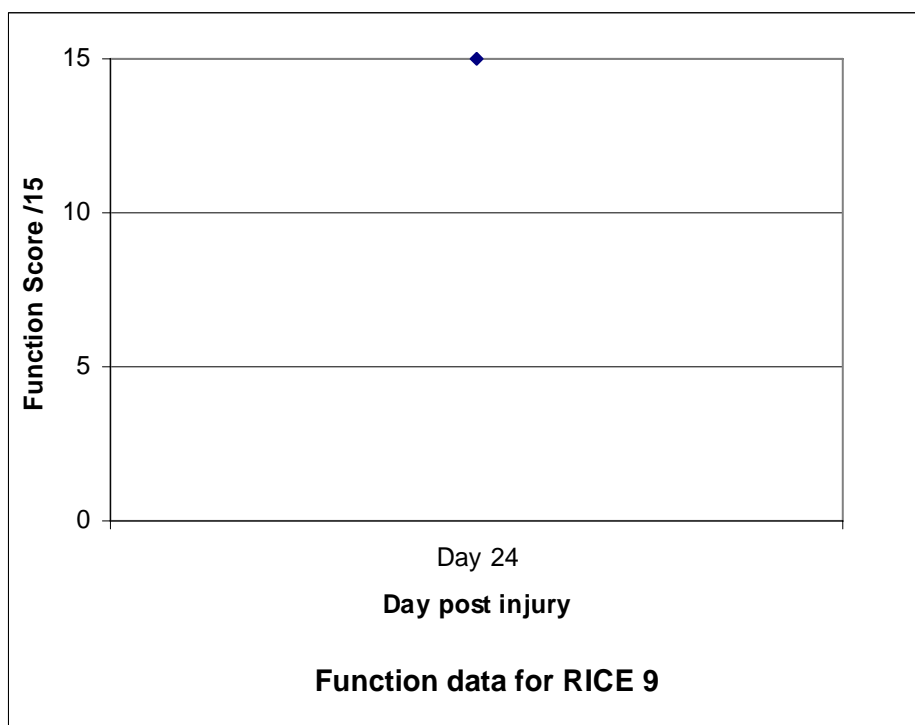
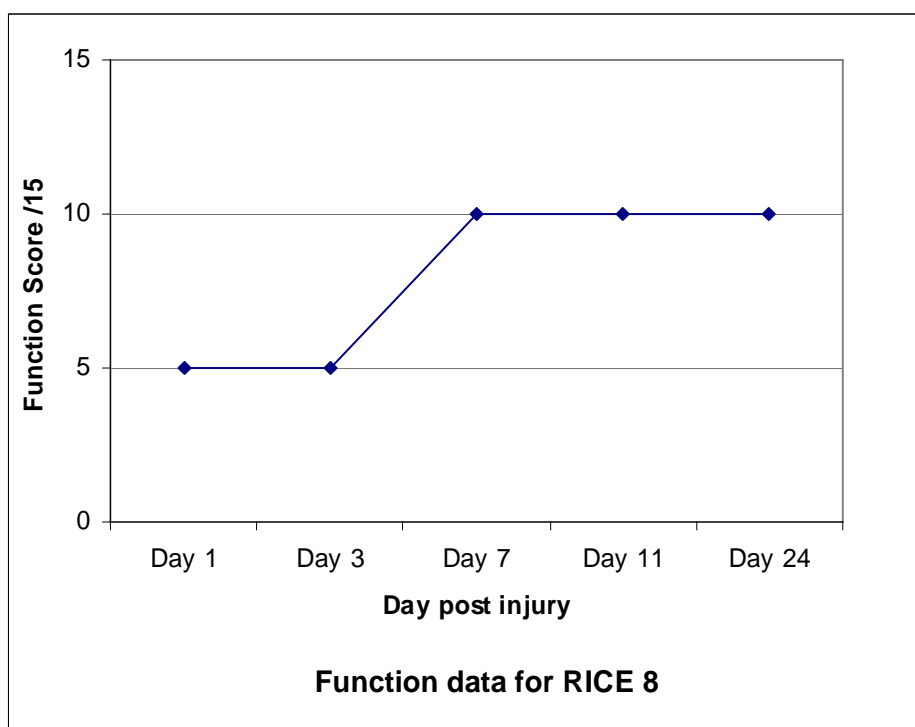


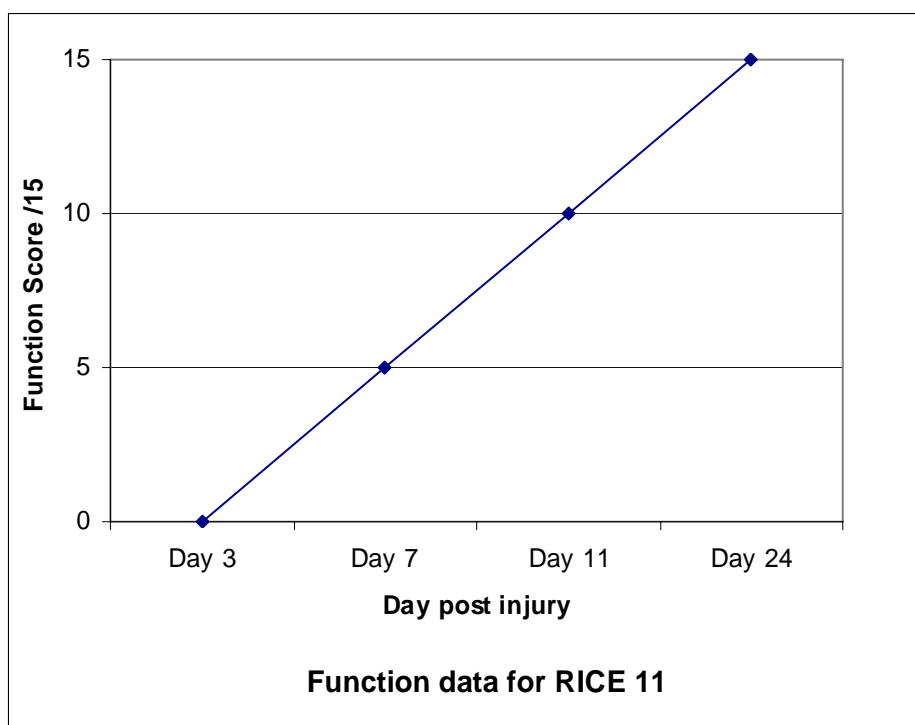
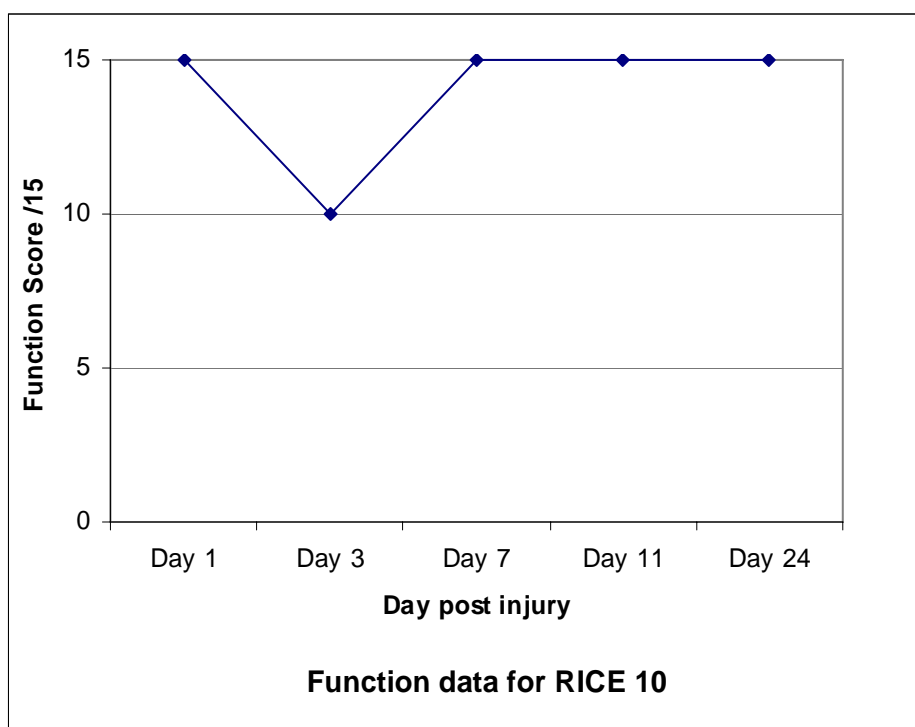


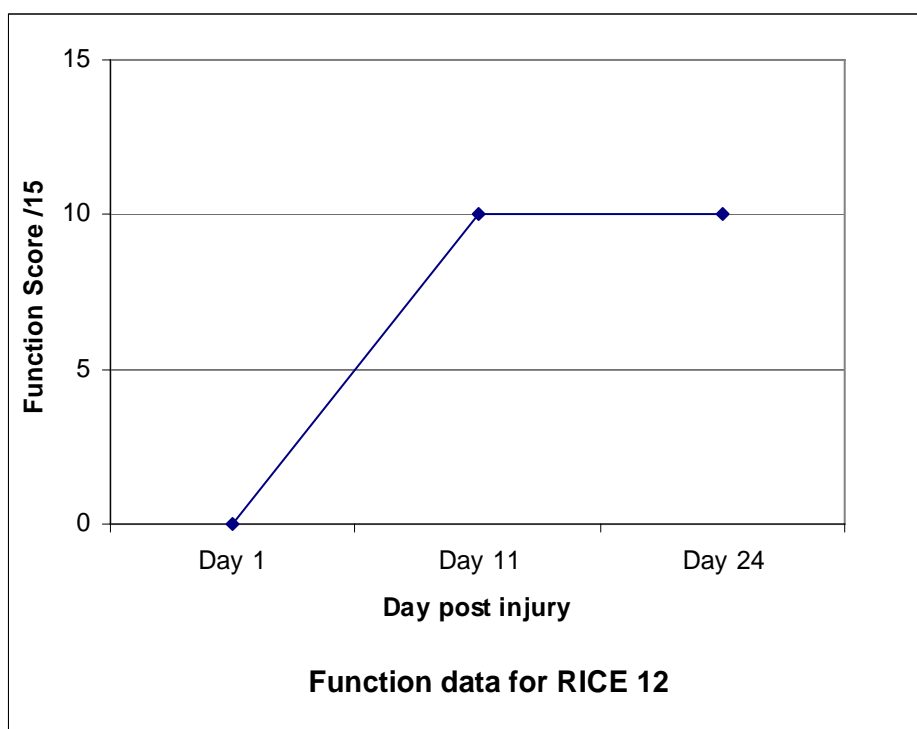






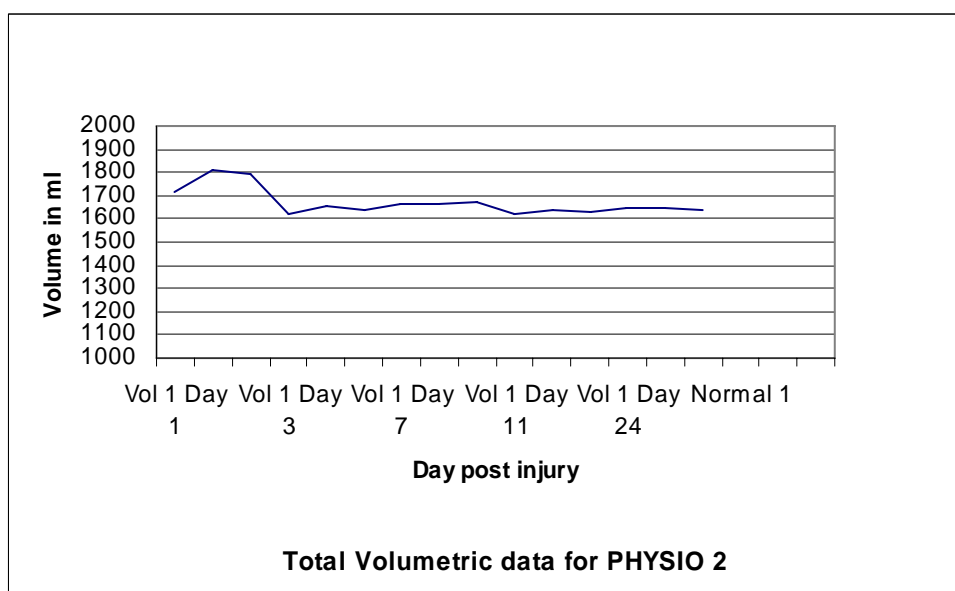
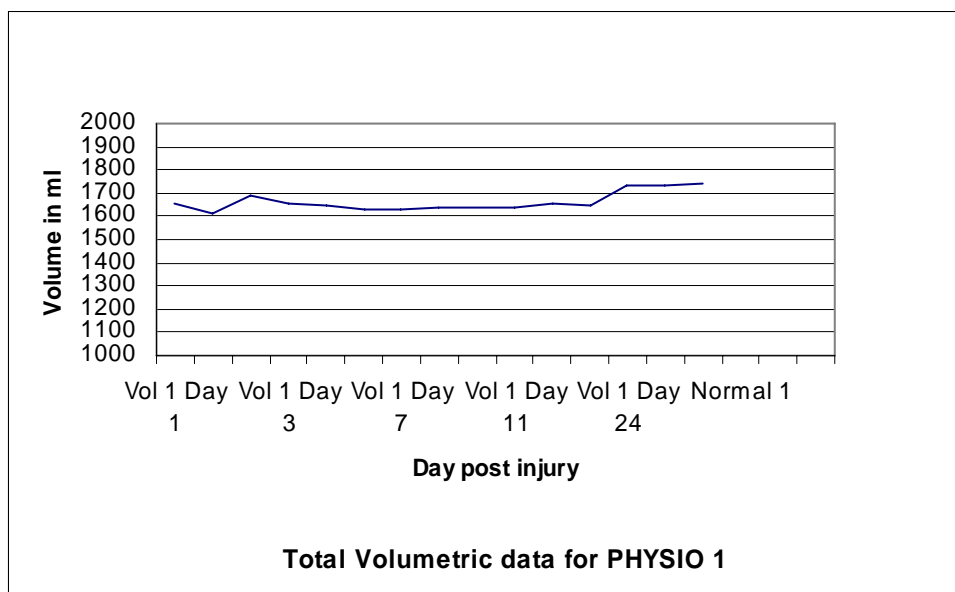


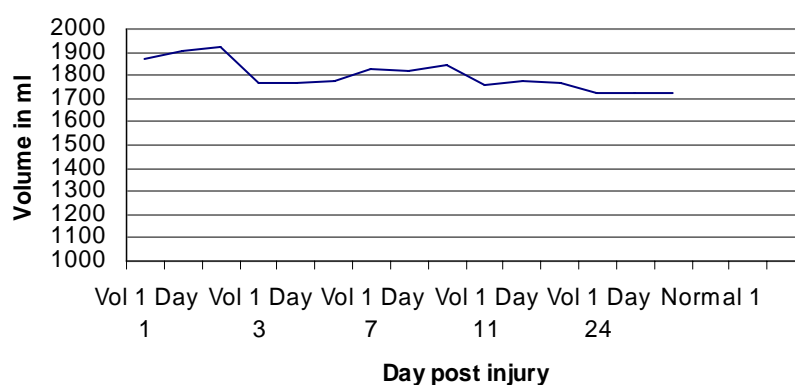




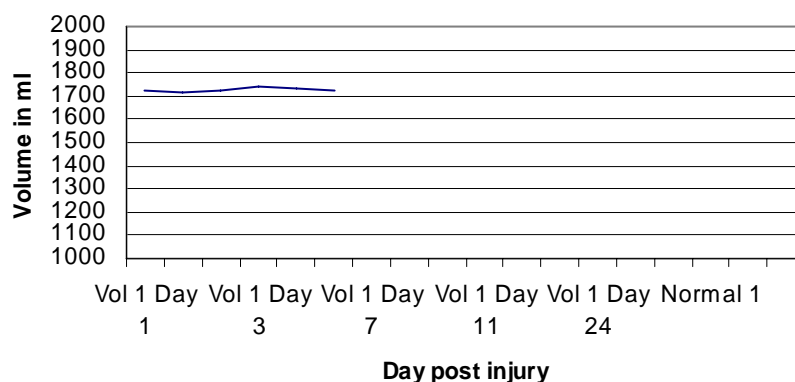
Appendix 12: Graphs of individual volumetric data with outliers removed

Participants in the physiotherapy intervention are presented as “Physio” and then the corresponding number in that group. The same applies to the RICE group. In the graphs for “Physio 4 and 15” there is missing data and so these graphs are not complete. In graphs “Physio 9, and 11” and “RICE 6 and 10” the normal value is given. This value was taken more than three months post injury. The time periods between the days are not shown to scale.

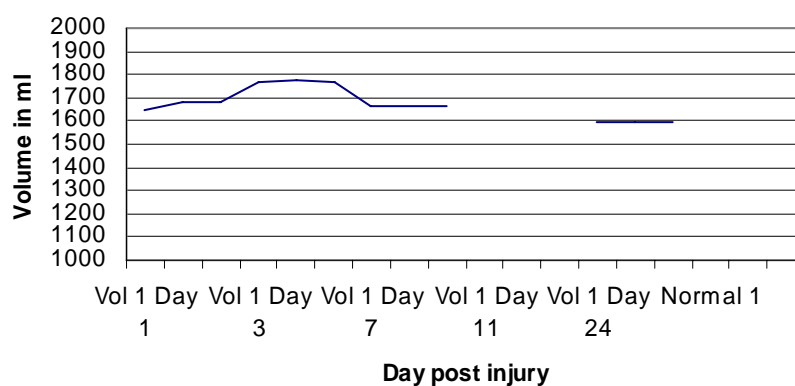




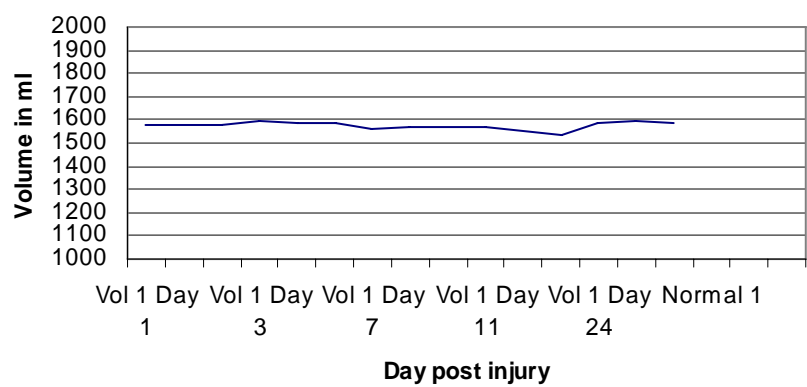
Total Volumetric data for PHYSIO 3



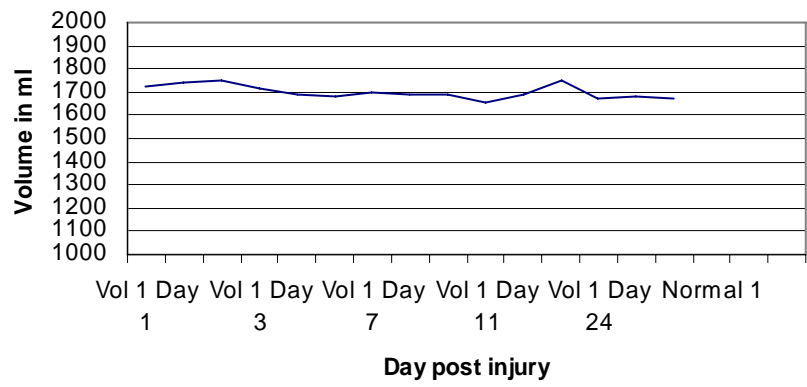
Total Volumetric data for PHYSIO 4



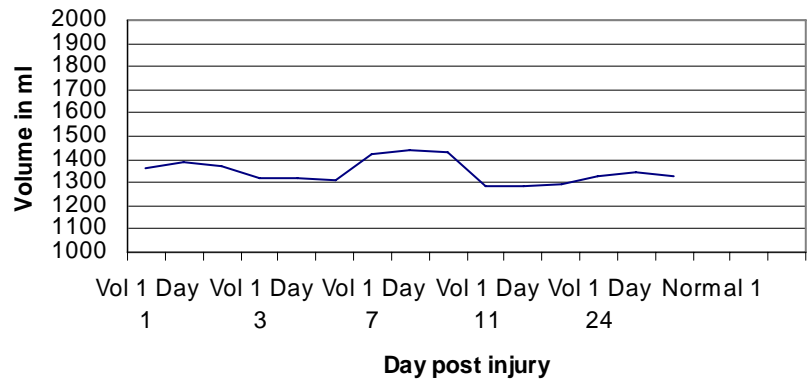
Total Volumetric data for PHYSIO 5



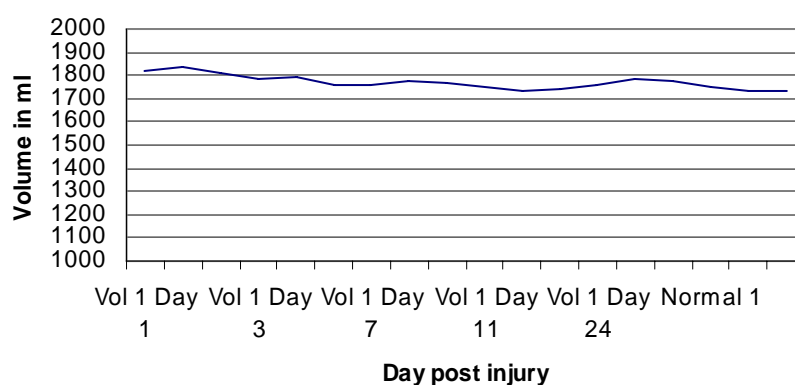
Total Volumetric data for PHYSIO 6



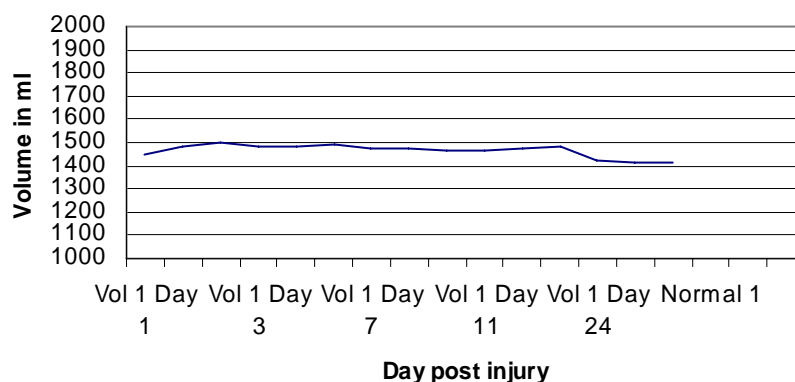
Total Volumetric data for PHYSIO 7



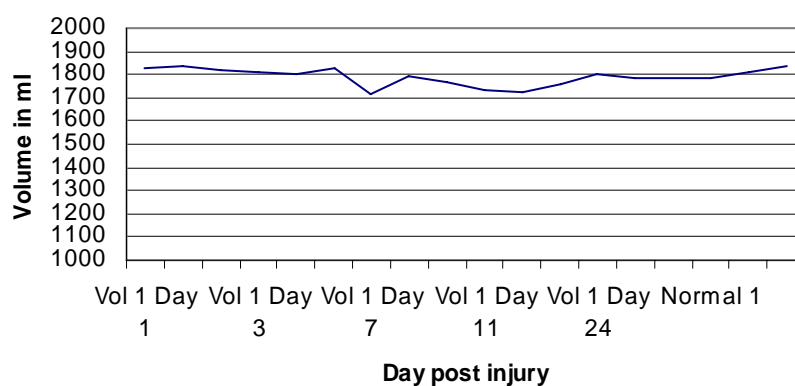
Total Volumetric data for PHYSIO 8



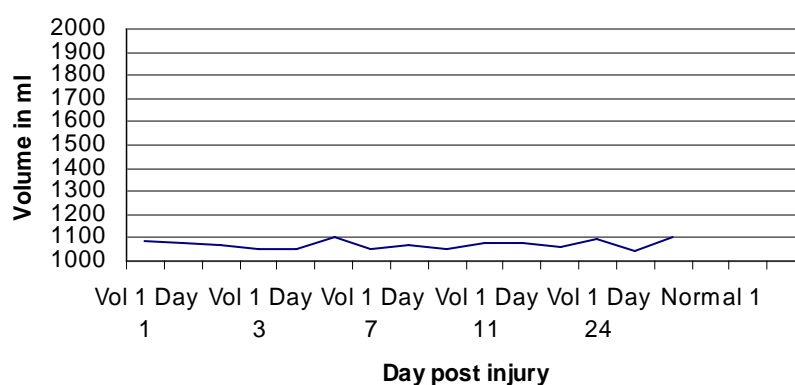
Total Volumetric data for PHYSIO 9



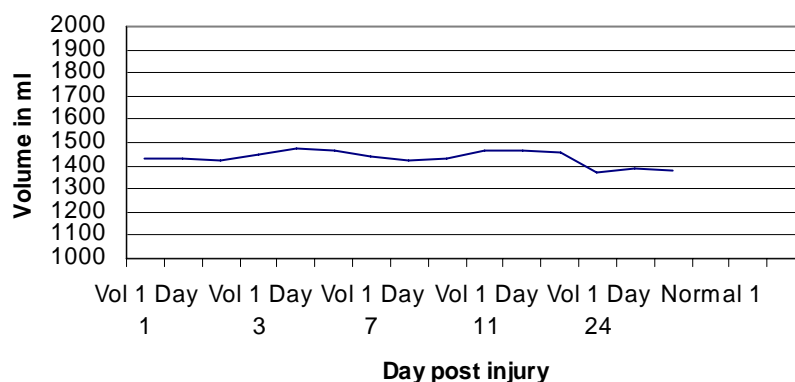
Total Volumetric data for PHYSIO 10



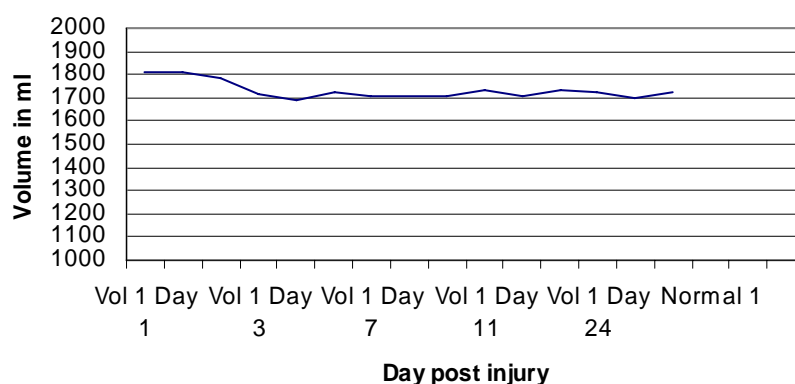
Total Volumetric data for PHYSIO 11



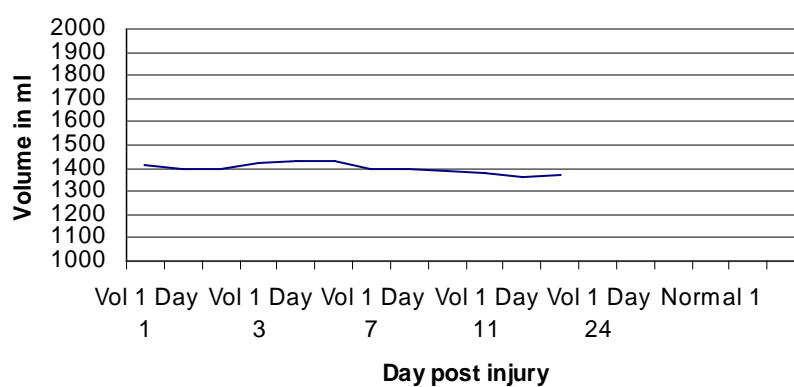
Total Volumetric data for PHYSIO 12



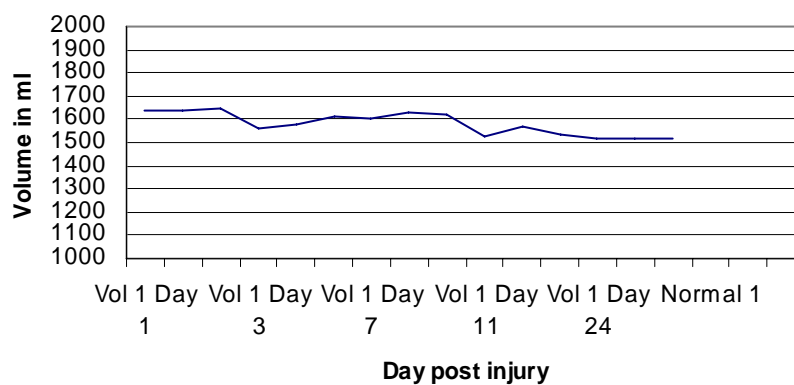
Total Volumetric data for PHYSIO 13



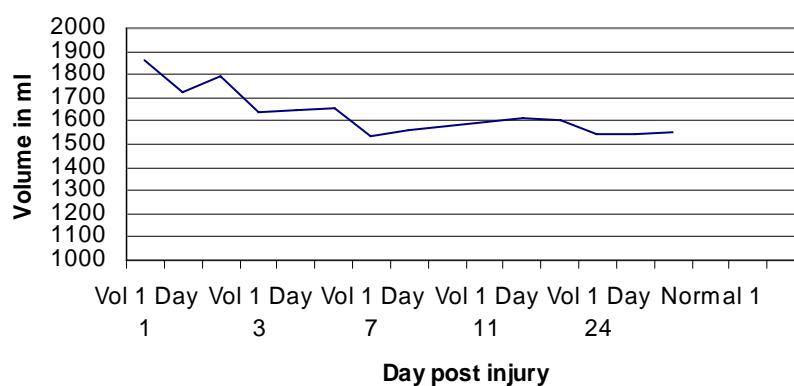
Total Volumetric data for PHYSIO 14



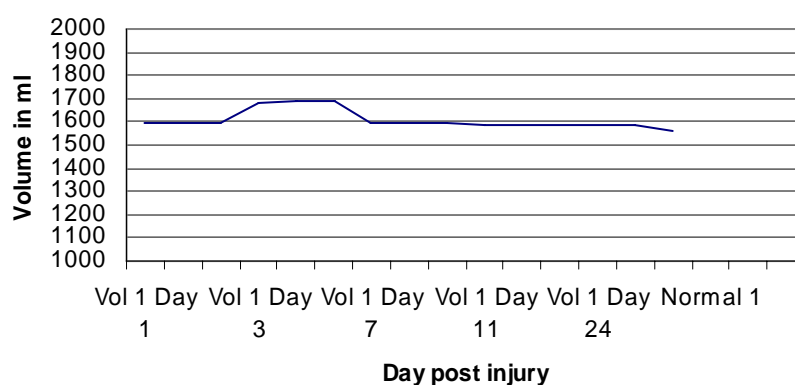
Total Volumetric data for PHYSIO 15



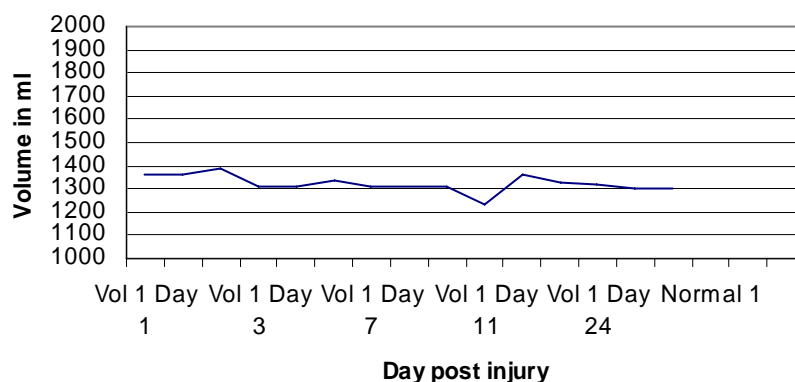
Total Volumetric data for PHYSIO 16



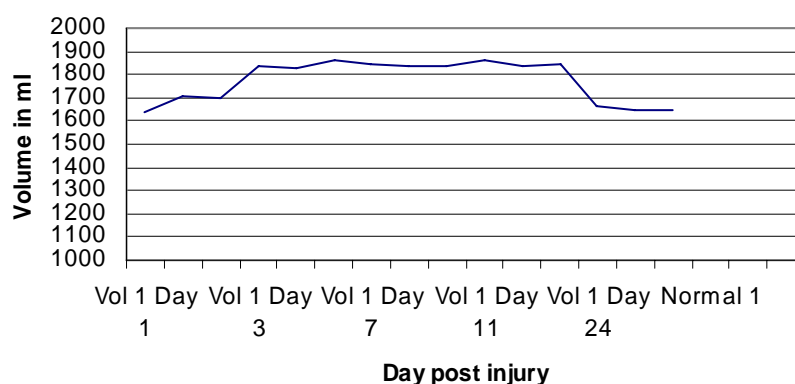
Total Volumetric data for RICE 1



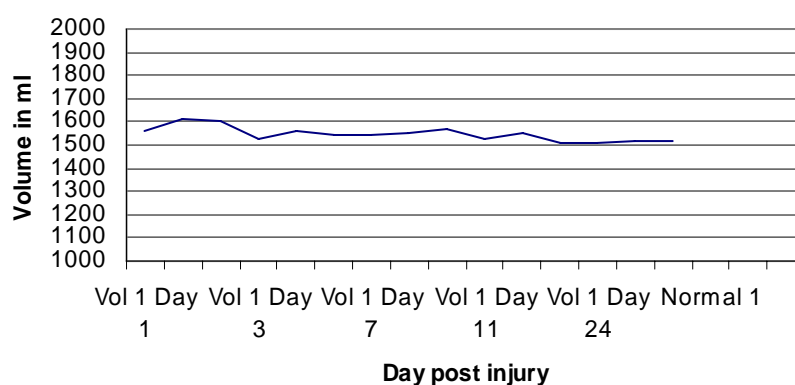
Total Volumetric data for RICE 2



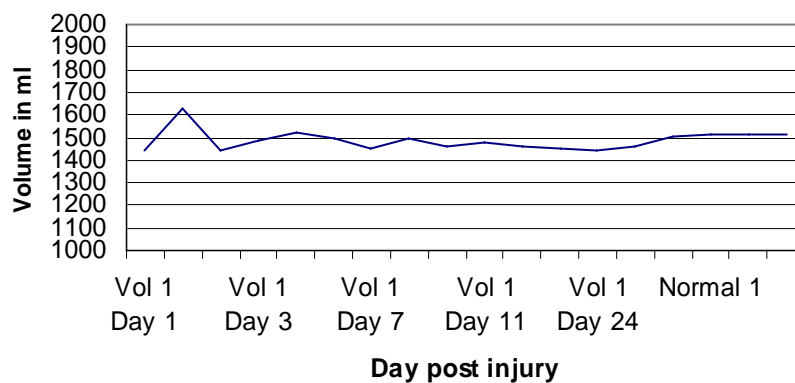
Total Volumetric data for RICE 3



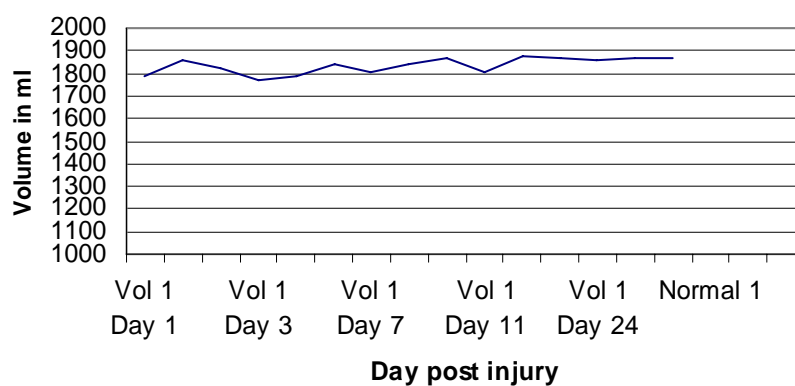
Total Volumetric data for RICE 4



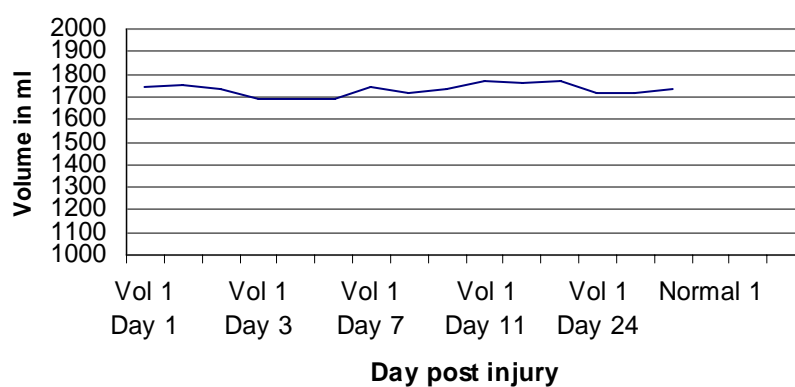
Total Volumetric data for RICE 5



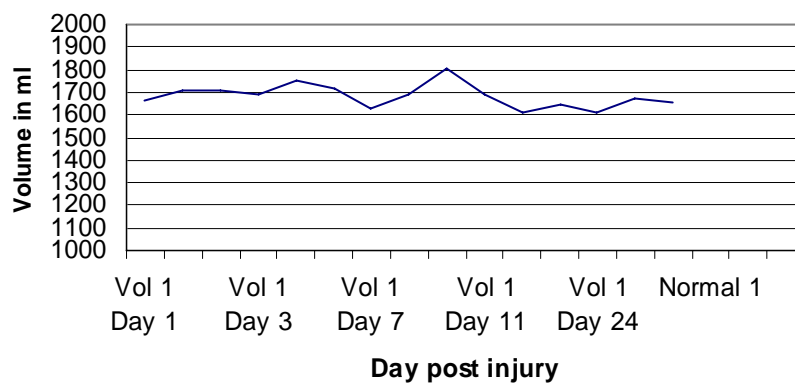
Total Volumetric data for RICE 6



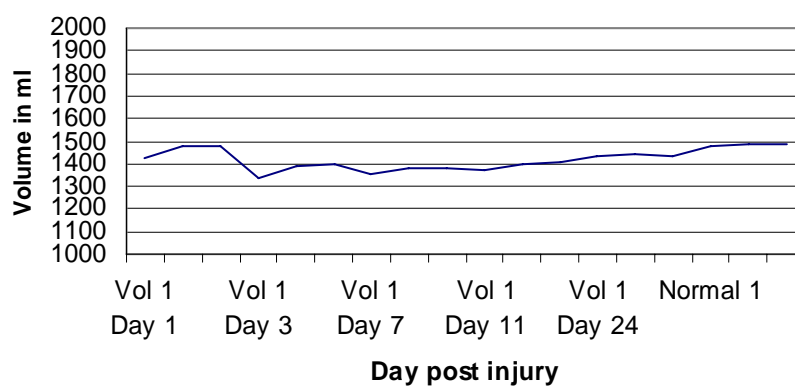
Total Volumetric data for RICE 7



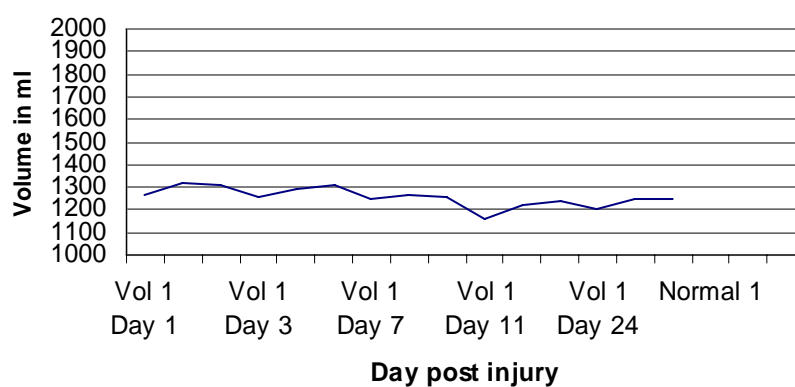
Total Volumetric data for RICE 8



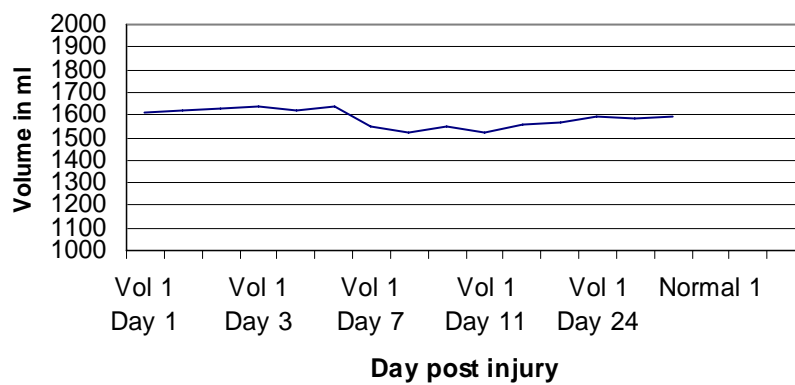
Total Volumetric data for RICE 9



Total Volumetric data for RICE 10



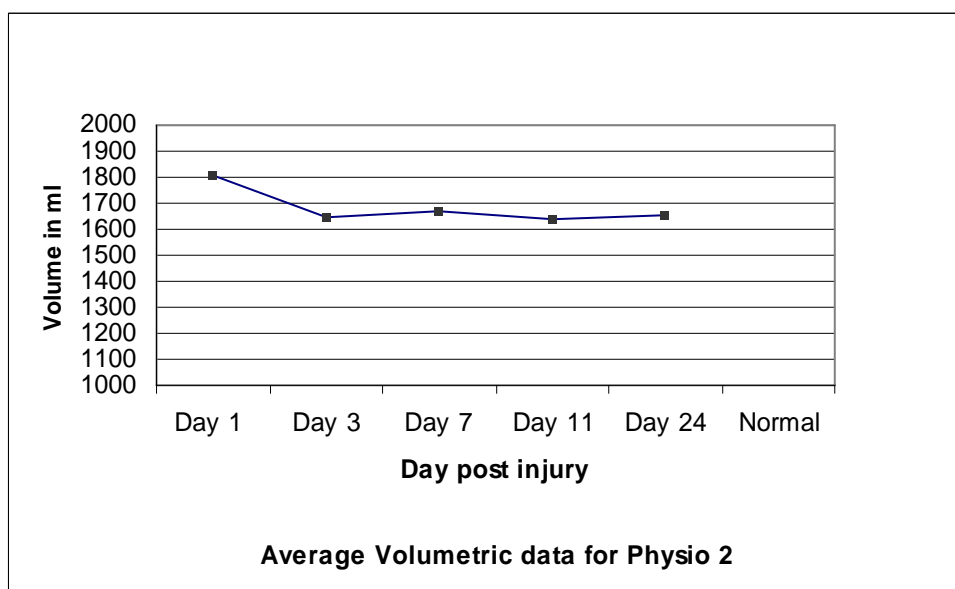
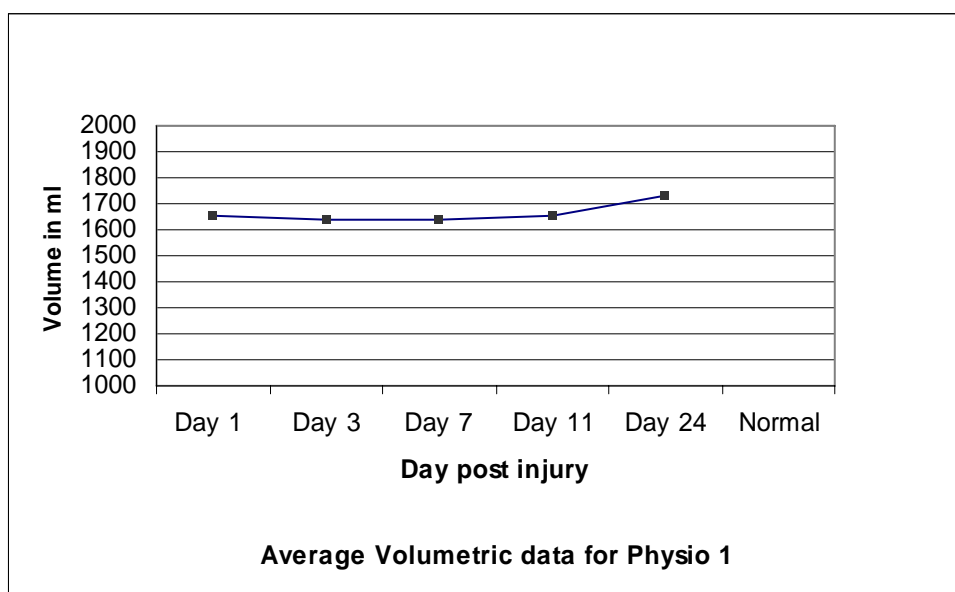
Total Volumetric data for RICE 11

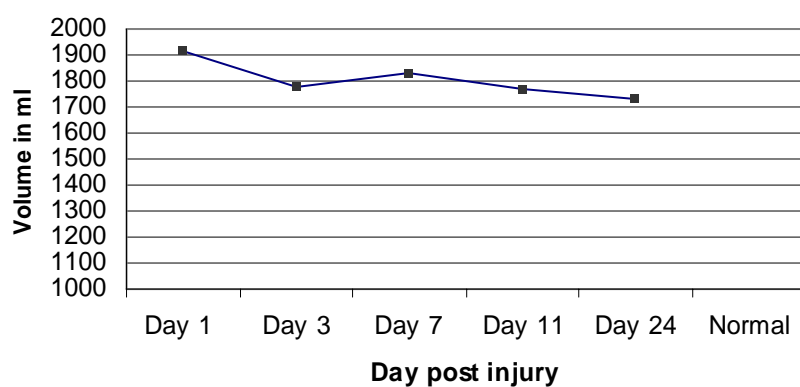


Total Volumetric data for RICE 12

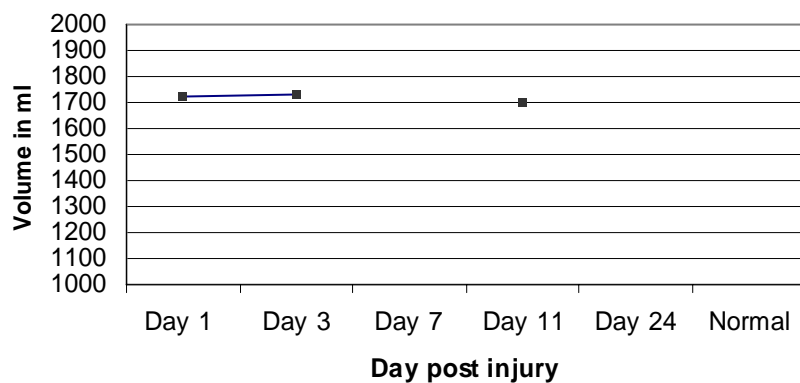
Appendix 13: Graphs of the individual participants average volumetric data

Participants in the physiotherapy intervention are presented as “Physio” and then the corresponding number in that group. The same applies to the RICE group. In the graphs for “Physio 4 and 15” there is missing data and so these graphs are not complete. In graphs “Physio 9, and 11” and “RICE 6 and 10” the normal value is given. This value was taken more than three months post injury. The time periods between the days are not shown to scale. The dots represent the average data from measurements 2 and 3 on each day.

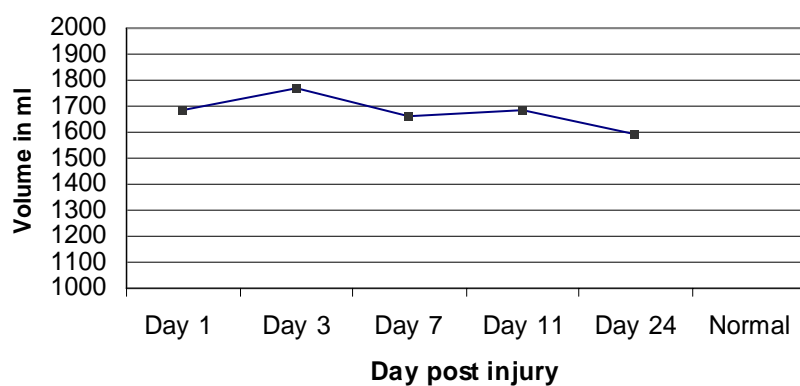




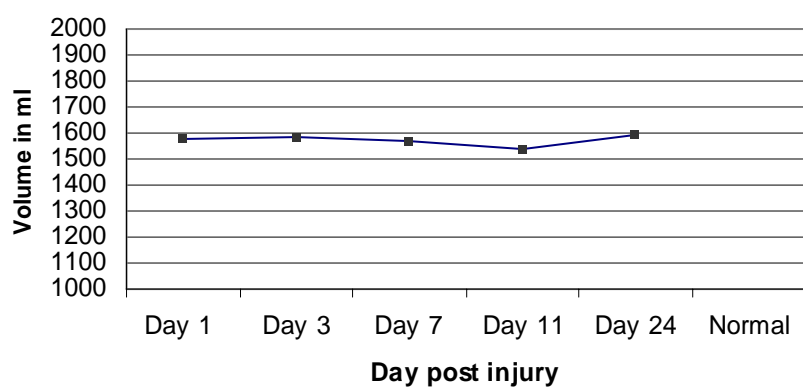
Average Volumetric data for Physio 3



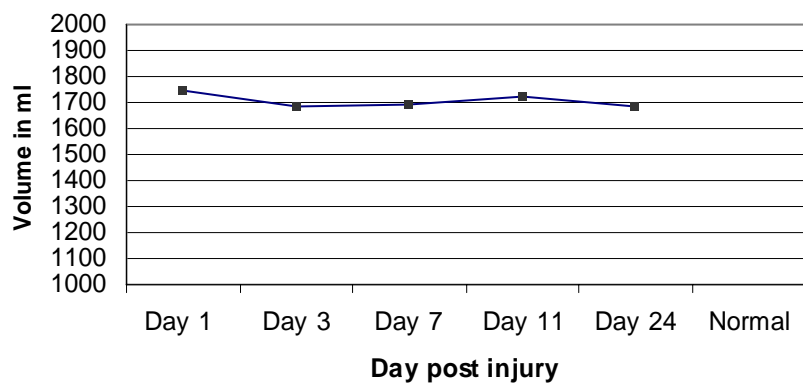
Average Volumetric data for Physio 4



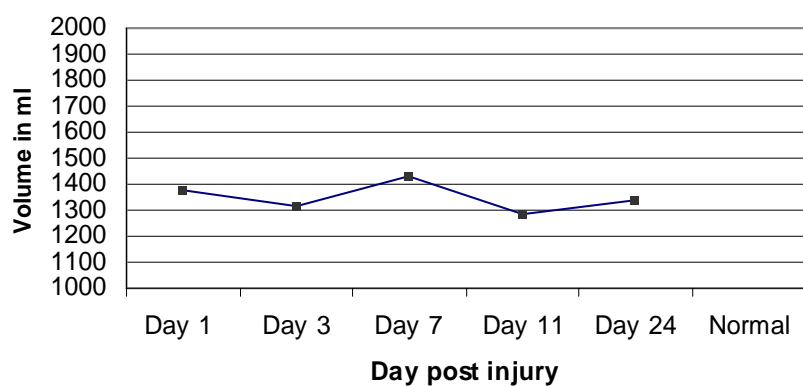
Average Volumetric data for Physio 5



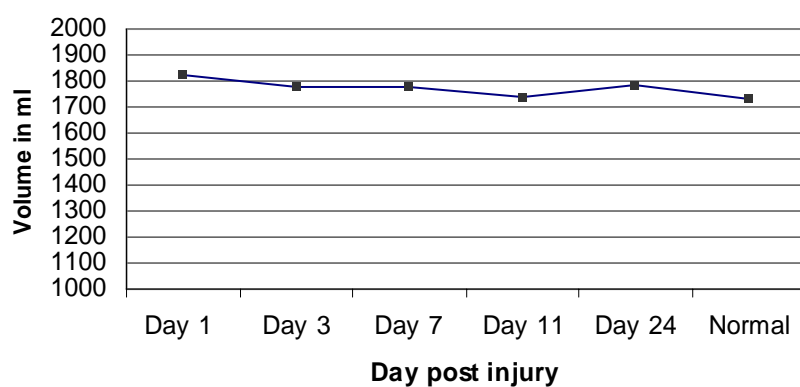
Average Volumetric data for Physio 6



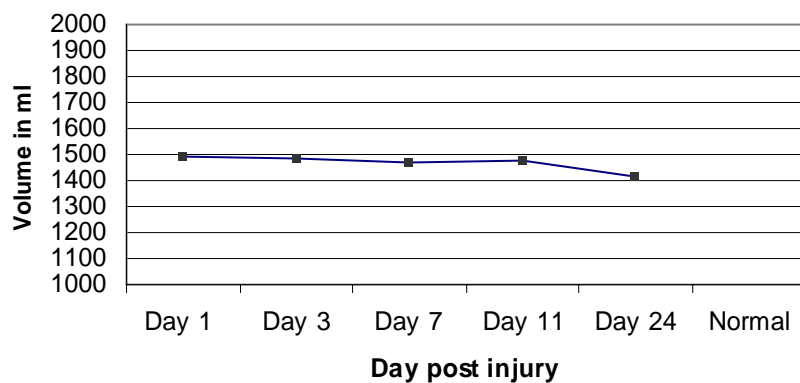
Average Volumetric data for Physio 7



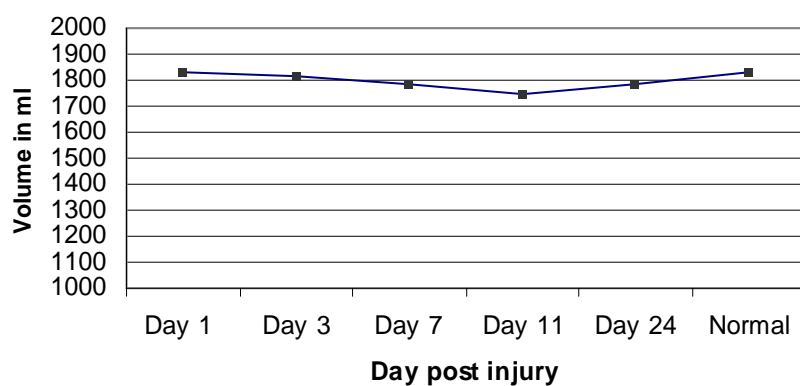
Average Volumetric data for Physio 8



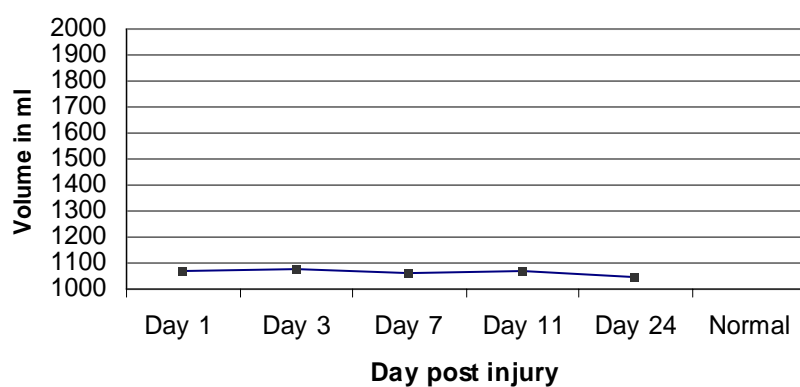
Average Volumetric data for Physio 9



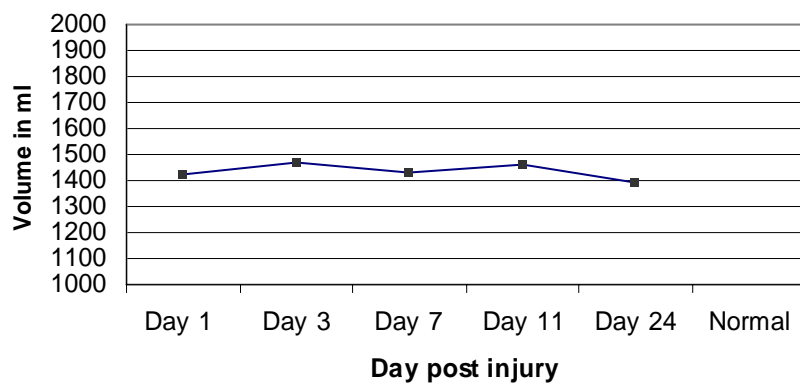
Average Volumetric data for Physio 10



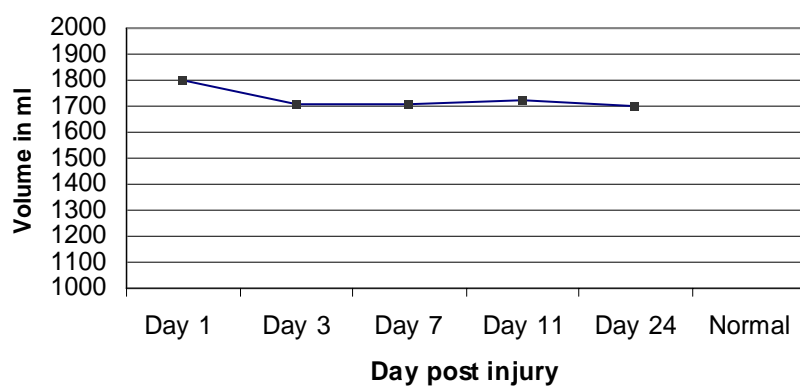
Average Volumetric data for Physio 11



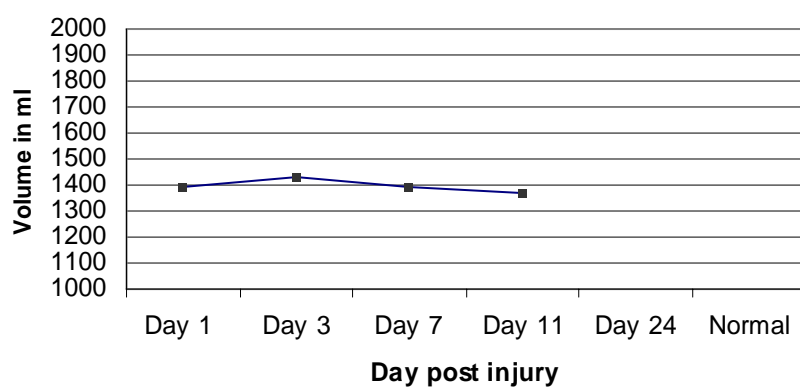
Average Volumetric data for Physio 12



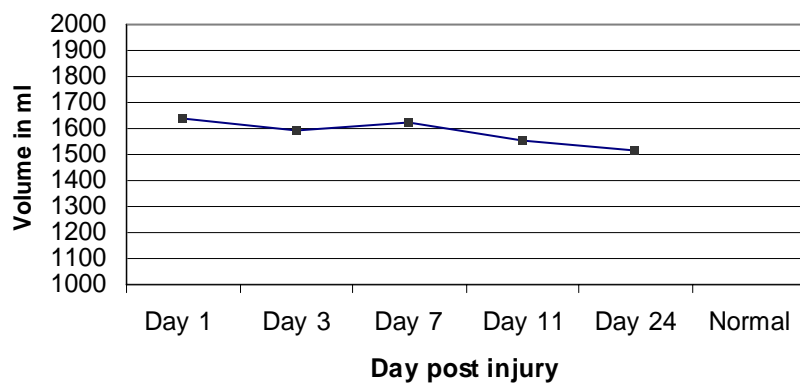
Average Volumetric data for Physio 13



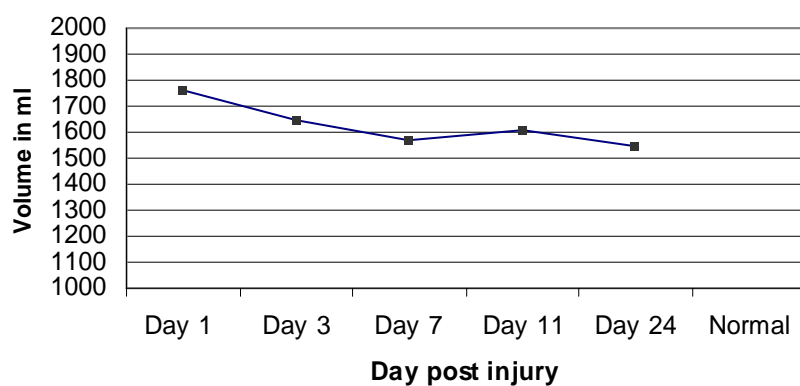
Average Volumetric data for Physio 14



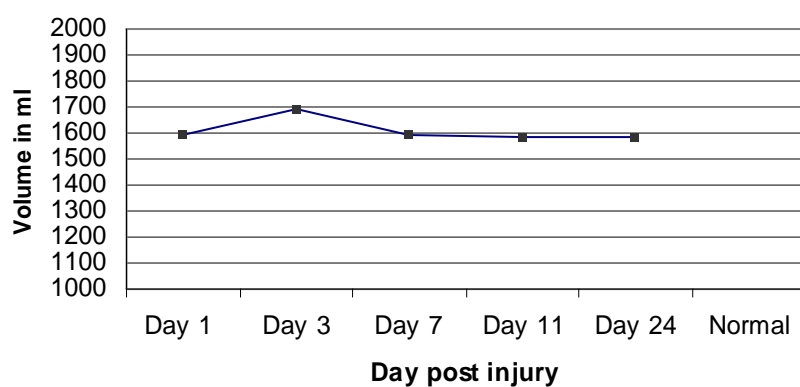
Average Volumetric data for Physio 15



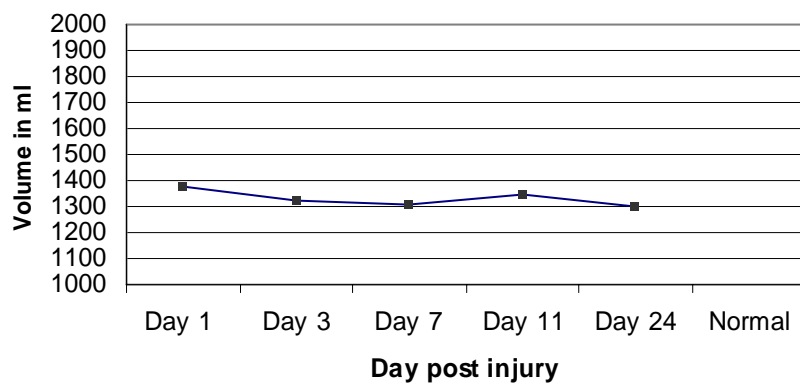
Average Volumetric data for Physio 16



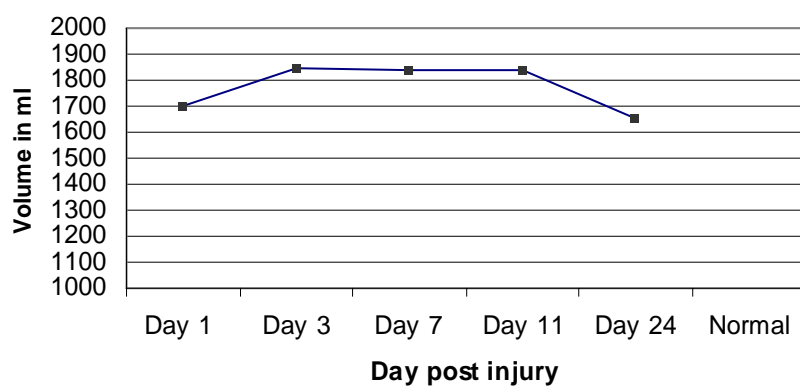
Average Volumetric data for RICE 1



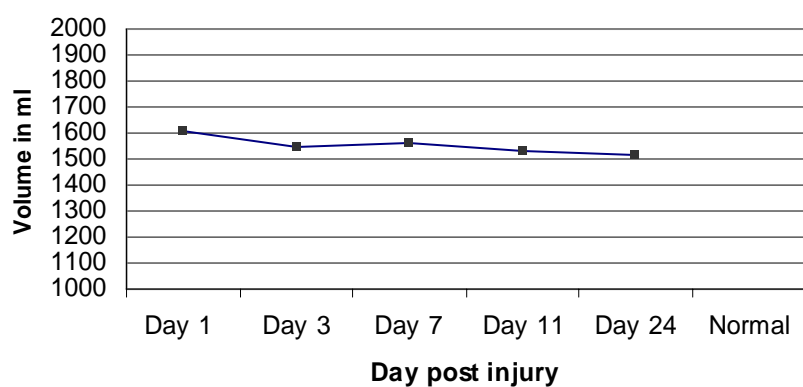
Average Volumetric data for RICE 2



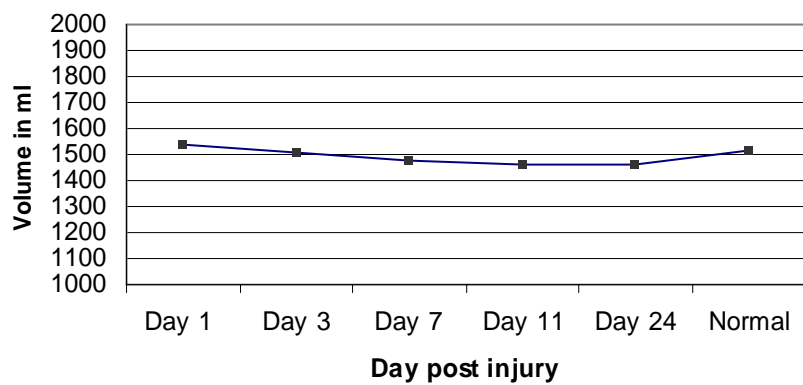
Average Volumetric data for RICE 3



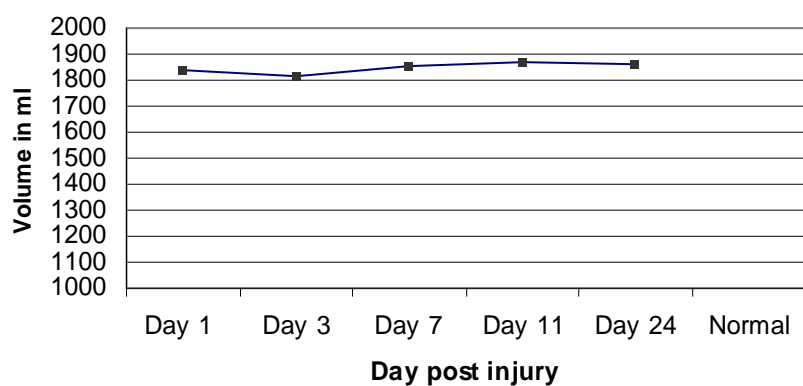
Average Volumetric data for RICE 4



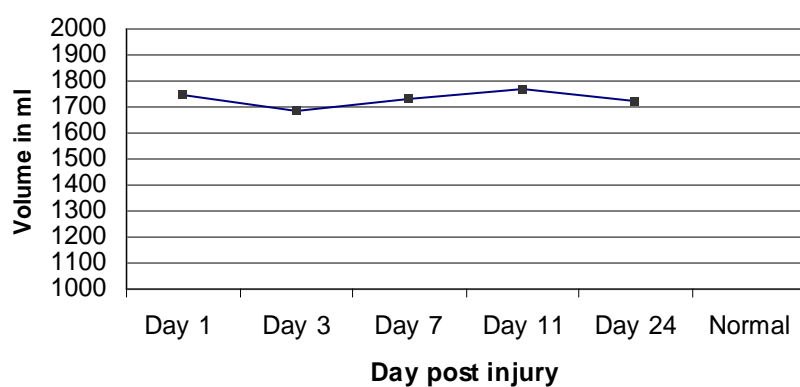
Average Volumetric data for RICE 5



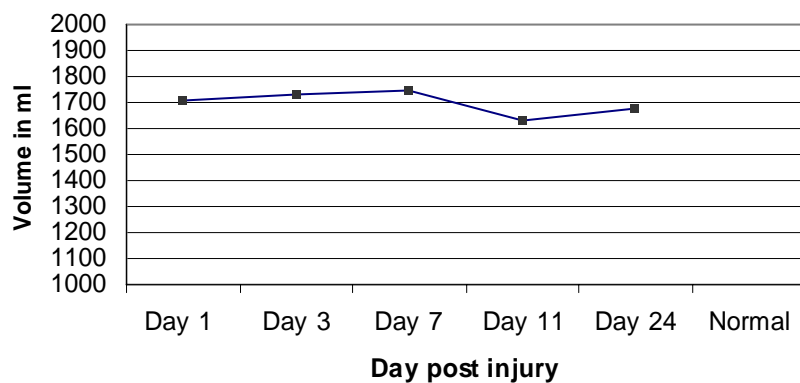
Average Volumetric data for RICE 6



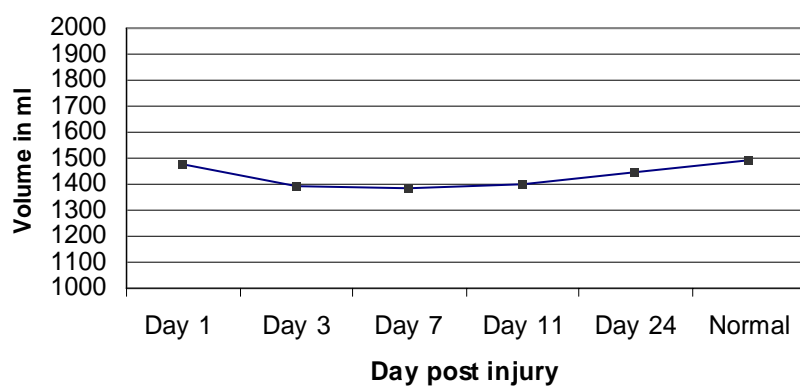
Average Volumetric data for RICE 7



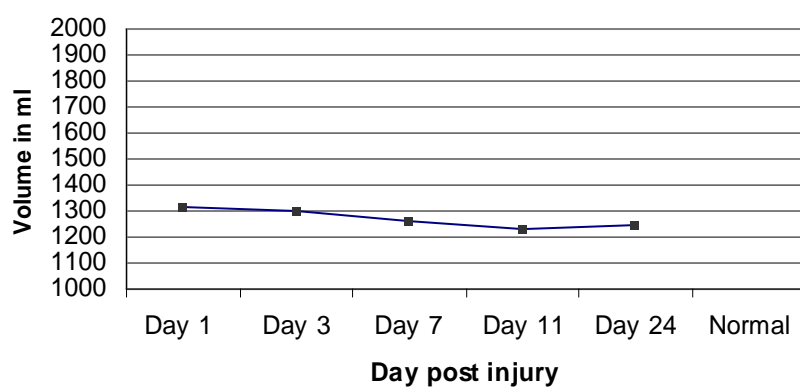
Average Volumetric data for RICE 8



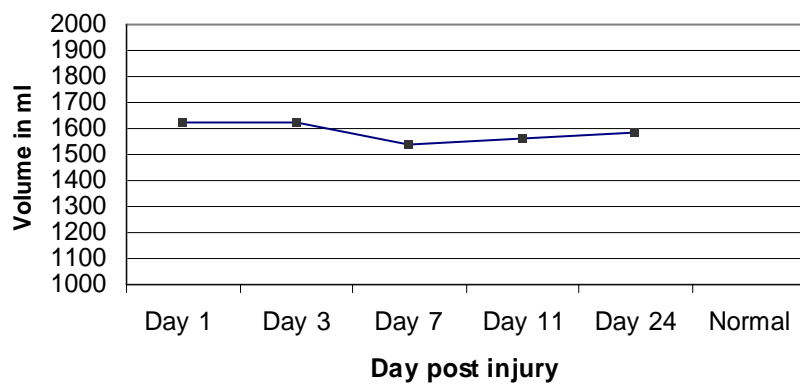
Average Volumetric data for RICE 9



Average Volumetric data for RICE 10



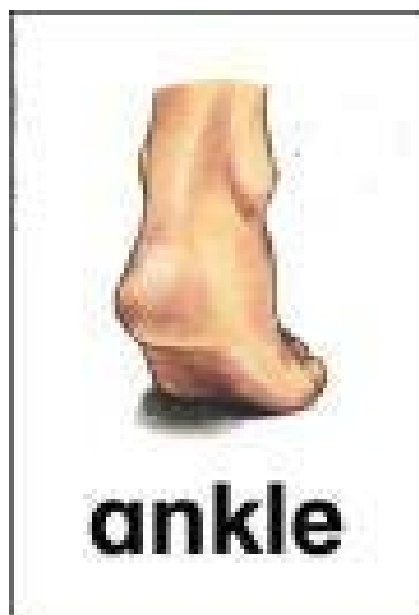
Average Volumetric data for RICE 11



Average Volumetric data for RICE 12

Appendix 14: Recruitment advertisements for study

AFC PLAYERS AND FAMILIES



HAVE YOU RECENTLY SPRAINED YOUR ANKLE
within the last 48 hours and are aged between 16 to 49 years?

If so, you may be eligible to participate in an AUT physiotherapy research study, which aims to compare two treatment methods for acute ankle sprain injuries.

If eligible you will receive at no cost:

- **Treatment**
- **Ice pack**
- **Compression bandage**

You may be eligible for a travel allowance too.

Please contact your club's physiotherapy clinic to see if you are eligible for the study.

Physiotherapist

Justin Lopes
Roland Jeffery's Sport Physiotherapy Clinic
22 Chartwell Ave, Glenfield
(09) 444-7643
021673732
justin.lopes@xtra.co.nz

Supervisor

Wayne Hing
AUT
School of Physiotherapy
(09) 917 9999 (x7800)
wayne.hing@aut.ac.nz

Appendix 15: Functional Question Form

Day	Ankle Questionnaire	Participant ID
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Please tick ONE box in each section that best describes your ankle.

Section	Degree
1. Pain	<input type="checkbox"/> None <input type="checkbox"/> During exercise (training etc.,) <input type="checkbox"/> Walking on uneven surface <input type="checkbox"/> Walking on even surface <input type="checkbox"/> Constant (severe)
2. Swelling	<input type="checkbox"/> None <input type="checkbox"/> Worse after exercise <input type="checkbox"/> Constant
3. Instability	<input type="checkbox"/> None <input type="checkbox"/> When standing <input type="checkbox"/> When walking <input type="checkbox"/> Constant (severe)
4. Stiffness	<input type="checkbox"/> None <input type="checkbox"/> Moderate (morning or after exercise) <input type="checkbox"/> Marked (constant or severe)
5. Stair climbing	<input type="checkbox"/> No problems <input type="checkbox"/> Impaired (instability) <input type="checkbox"/> Impossible
6. Running	<input type="checkbox"/> No problems <input type="checkbox"/> Impaired <input type="checkbox"/> Impossible
7. Work activities, sport, leisure activities	<input type="checkbox"/> Same as pre-injury <input type="checkbox"/> Same work, less sports, normal leisure activities <input type="checkbox"/> Lighter work, no sports, normal leisure activities <input type="checkbox"/> Severely impaired work capacity, decreased leisure activities
8. Support	<input type="checkbox"/> None <input type="checkbox"/> Ankle support during exercise <input type="checkbox"/> Ankle support during daily activities
9. Weight bearing ability	<input type="checkbox"/> Full weight bearing possible and not painful <input type="checkbox"/> Full weight bearing possible but painful <input type="checkbox"/> Partial weight bearing is possible <input type="checkbox"/> Impossible to weight bear