THE EFFECTIVENESS OF THE HOMOEOPATHIC PREPARATION TRAUMEEL S IN THE TREATMENT OF DELAYED ONSET MUSCLE STIFFNESS FOLLOWING A STANDARD MARATHON RUN

By:- Roberto Carlo Bondonno

A dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology in the Department of Homoeopathy at the Technikon Natal.

DECLARATION

I, Roberto Carlo Bondonno, do hereby declare that this dissertation represents my own work, both in conception and execution.

Signature of candidate

Approved for final submission

4/06/1996

Dr F. Burger D.Sc (Physiology) (US), D.Sc. (Biochemistry) (PU) Date
Supervisor

Place: Durban

DEDICATION

This dissertation is dedicated to my wife Cathy, my parents and siblings for their endless support.

ACKNOWLEDGEMENTS

A special thank you to my wife Cathy for all her help and support for the entire duration of this research, and for her valuable suggestions and excellent reasoning.

My brother Paul for the use of his room, computer and printer as well as for all the help with the statistics.

My sister Angela great thanks for coming all the way from New Zealand to review this dissertation and provide valuable suggestions.

My parents for all the meals, baby sitting, tea, endless support and love.

Dan Grobler, Karen Green and Irena Nowak for testing the subjects on the Akron machine.

Technikon Natal for financial support.

Dr. F. Burger for critical analysis of this dissertation and valuable advice.

ABSTRACT

Delayed onset muscle stiffness (DOMS), a condition characterised by pain and muscle stiffness, as a result of intense or unaccustomed exercise. The effectiveness of the homoeopathic broad spectrum anti-inflammatory, Traumeel S, in the treatment of DOMS, acquired after a marathon run, was determined. An experimental single variable design before-and-after with control was used. Thirty males between the ages of 20 and 40 years, with previous running experience, were drawn from marathon runners in the Durban and Johannesburg area. They were randomly assigned to either a placebo or treatment group. An intramuscular injection was administered into the hamstring muscle before and after the race. The placebo group was injected with a 0.9% saline solution, while the treatment group was injected with Traumeel S. Before and after completion of a 42.2 km marathon run the following parameters were measured: creatine kinase blood levels, the strength and power output of muscles, values of static jump, flexibility and pain and soreness perception. The data was analysed using Statgraphics plus version 6.0 incorporating the Wilcoxin Signed Rank Test for determining the statistical significance within the treatment and placebo group and the Mann-Whitney U-Test for determining statistical significance between the two groups. No significance difference was observed in the rate of recovery from DOMS of both treatment and placebo groups

as determined by creatine phosphokinase blood levels. This was the only parameter which followed the natural progression of DOMS. The strength and power output of the muscles, measured at extension and flexion, increased from before the race to the day after the race in both groups. With the onset of DOMS there was expected to be a decrease in these values. The values of static jump and flexibility also followed this trend and no statistical difference was observed between the placebo and treatment groups. Further tests, eliminating more variables, are required to determine the efficacy of Traumeel S in the treatment of DOMS. It was determined that insufficient DOMS was produced in many of the subjects insubstantiating any results obtained.

TABLE OF CONTENTS

Dedication i
Acknowledgements. ii
Abstract iii
Table of contents v
List of Tables. vii
Table of Abbreviations ix
Definition of Terms. x
CHAPTER 1: INTRODUCTION 1
CHAPTER 2: REVIEW OF RELATED LITERATURE. 3
2.1 Introduction 3
2.2 Description of delayed onset muscle stiffness (DOMS). 3
2.3 Location 4
2.4 Prevalence 5
2.5 Consequences 5
2.5.1 Muscle Soreness 6
2.5.2 Muscle Strength 9
2.5.3 Range of motion-flexibility 11
2.5.4 Creatine phosphokinase (CPK) 13
2.5.4.1 Introduction 13
2.5.4.2 Function of CPK 14
2.5.4.3 Effects of age on resting blood CPK levels 15
2.5.4.4 Effects of gender on resting blood CPK levels 16
2.5.4.5 Effects of race on resting blood CPK levels. 16
2.5.5 The response of CPK activity to exercise. 16
2.5.5.1Intensity versus duration of exercise. 16
2.5.5.2 The time course for CPK release 17
2.5.5.3 Adaptation of CPK levels following repeated exercise 18
2.6 Structural basis of exercise induced muscle damage 23
2.7 Current methods of treatment. 25
2.8 Homoeopathic treatment of DOMS. 28
CHAPTER THREE: MATERIALS AND METHODS. 30
3.1 The subjects 30
3.2 Method. 31
3.2.1 CPK blood test 33
3.2.2 The vertical jump. 33
3.2.3 Flexibility. 34
3.2.4 Pain and soreness scale. 35

3.2.5 Isokinetic strength 35
3.2.6 Administration of the injection 37
CHAPTER FOUR: RESULTS 39
4.1 Creatine phosphokinase levels 39
4.2 The vertical jump 41
4.3 Flexibility 43
4.4 Pain and soreness scale 44
4.5 Isokinetic strength 47
4.5.1 Flexion 47
4.5.1.1 Work done during flexion 47
4.5.1.2 Total flexion power 48
4.5.2 Extension 50
4.5.2.1 Work done during extension 50
4.5.2.2 Total extension power 51
CHAPTER FIVE: DISCUSSION 53
5.1 Creatine phosphokinase levels 53
5.2 The vertical jump 55
5.3 Flexibility 57
5.4 Pain and soreness scale 58
5.5 Isokinetic strength 60
5.5.1 Flexion 60
5.5.1.1 Work done during flexion 60
5.5.1.2 Total flexion power 61
5.5.2 Extension 62
5.5.2.1 Work done during extension 62
5.5.2.2 Total extension power 63
CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS 65
REFERENCES 67
APPENDICES

LIST OF TABLES

Table 1: Mean blood CPK levels of both placebo and treatment groups 39

Table 2: Statistical significance of CPK values at critical stages in the study 40

Table 3: The mean CPK values and the statistical significance levels of both placebo and treatment groups on Saturday, Monday and Friday 41

Table 4: Mean vertical jump distance obtained by placebo and treatment groups 41

Table 5: Statistical significance of vertical jump distances in the study. 43

Table 6: The mean vertical jump distance and the statistical significance levels of placebo and treatment groups on Saturday, Monday and Friday 43

Table 7: Positive mean flexibility values obtained for both placebo and treatment groups 44

Table 8: Negative mean flexibility values obtained for both placebo and treatment groups 44

Table 9: Mean values obtained for the pain and soreness scale for the treatment and placebo groups. 45

Table 10: Statistical significance of mean pain and soreness scale values at critical stages in the study 46

Table 11: The mean pain and soreness scale values and the statistical significance levels of both placebo and treatment groups of Saturday, Monday and Friday 46

Table 12: The mean work output obtained by both placebo and treatment groups 47

Table 13: Statistical significance of the mean work output during flexion at critical stages in the study 48

Table 14: The mean values for work done during flexion of both placebo and treatment groups 48

Table 15: The mean power output obtained by the placebo and treatment groups 49

Table 16: Statistical significance of values for total flexion power compared at critical stages in the study 49

Table 17: The mean values for total flexion power of the placebo and treatment groups at critical stages in the study 49

Table 18: The mean work output obtained by the placebo and treatment groups 50

Table 19: Statistical significance of values for work done during extension at critical stages in the study 50

Table 20: The mean values for work done during extension of the placebo and treatment groups 51

Table 21: The mean value for the total extension power obtained by the placebo and treatment groups 51

Table 22: Statistical significance for values of total extension power at critical stages in the study 52

Table 23: The mean values for the total extension power of the placebo and treatment groups at critical stages in the study 52

TABLE OF ABBREVIATIONS

C or CH	centismal scale
CPK	creatine phosphokinase
D or XH	decimal scale
DOMS	delayed onset muscle stiffness
EMG	electromyograph
IU/l	international units per litre
J	joules
mm	millimetres
ml	millilitres
MRI	magnetic resonance imaging
NSAIDS	non-steroidal anti-inflammatory drugs
PGE_2	prostaglandin E_2
W	watts

DEFINITIONS OF TERMS

Analgesic: a substance capable of relieving pain.

Antiphlogistic: compound which decreases inflammation

Antithrombotic: substance which decreases thrombus formation in blood vessels

Diapedesis: process where by a white blood cell passes through the vessel wall into the intercellular space

Eccentric: a muscle action in which the body of the muscle lengthens as the force is produced

Haemostasis: stoppage of the flow of blood

Isometric: developing muscle tension while preventing muscle contraction

Phytotherapeutic: using the medicinal properties of plant extracts

Placebo: a substance with no medicinal properties given to the control group of an experiment.

CHAPTER 1 : INTRODUCTION

Delayed onset muscle stiffness (DOMS) is a common experience for those participating in rigorous or unaccustomed physical activity. It is characterised by the sensation of pain and stiffness in the muscles, the onset of which begins in the first 24 hours, with intensity reaching a peak at 48-72 hours after the event (Clarkson et al. 1992).

It can adversely affect muscular performance both from voluntary reduction of effort and from inherent loss of capacity of the muscles to produce force (Armstrong 1984). Other symptoms include reduced mobility and flexibility, muscle swelling, pain and stiffness (Ebbeling 1989). Clinical testing reveals a number of correlates associated with DOMS, these include elevation in plasma enzymes (ceatine phosphokinase CPK most markedly), myoglobinaemia and abnormalities in muscle histology and ultrastructure (Ebbeling 1989). Increasing the intensity and duration of an exercise results in a corresponding increase in serum enzyme activities and muscular soreness (Tiidus and Ianuzzo 1983).

According to Hill (1951) previous training leads to the partial adaptation of the muscles to physical exercise resulting in less damage to the muscles, and thus

reducing the severity of DOMS. The therapies currently employed in the treatment of DOMS include the use of topical applications of thermal agents, ultrasound and orally administered analgesics and anti-inflammatories the therapeutic success of which is questionable (Hasson et al. 1993). The gastrointestinal side effects of anti-inflammatories and analgesics do not justify their use on a continued and supportive basis (John 1991).

In a controlled double blind study by Böhmer et al. (1992), subjects treated with Traumeel indicated a significant difference in recovery compared to those treated in the placebo group. The main focus of the study was sports related injuries, in particular injuries resulting in contusions, sprains, oedema or haemorrhage. The therapeutic objective of the study was the elimination of swelling, inflammation and pain. It is proposed that using Traumeel S, a homoeopathic broad spectrum anti-inflammatory whose therapeutic aim is to alleviate pain, stiffness and inflammation, could effectively treat DOMS. Traumeel S is able to stimulate cell regeneration through improved cell respiration and blood flow with an additional anti-viral action (John 1991).

This study proposes to analyse the effectiveness of the homoeopathic preparation Traumeel S in the treatment of delayed onset muscle stiffness acquired after a

standard marathon run. This is evaluated in terms of creatine phosphokinase blood levels which indicates the extent of muscle damage, an alteration in the strength and power output of muscles, any changes in recorded vertical jump distance and flexibility values of participants and a pain and soreness scale.

CHAPTER TWO : REVIEW OF THE RELATED LITERATURE

2.1 INTRODUCTION

Delayed onset muscle stiffness (DOMS) is a common experience for those who participate in rigorous physical activity, or for others who partake in a bout of unaccustomed exercise. It has been almost a century since Hough (1901) first investigated the phenomenon of DOMS, and at that time he reported that the soreness was due to "ruptures within the muscle". Interest in the topic was renewed only 50 years later, and it has been only in the last 15 years that extensive research has been undertaken (Clarkson et al. 1992).

2.2 DESCRIPTION OF DOMS

DOMS is the sensation of pain, tenderness, deep aching and stiffness in the muscles that occurs after unaccustomed or rigorous physical activity. The severity of this type of injury is variable, ranging from mild discomfort to extreme soreness that limits the normal use of the muscle. (Jones et al. 1986.)

The onset of DOMS occurs in the first 24 hours following exercise, and the intensity will generally peak by 48 to 72 hours (Clarkson et al. 1992). DOMS tapers off thereafter and may disappear anywhere from 48 hours to two weeks later, depending on the initial severity (Miles 1994). The clinical factors associated with DOMS include increased stiffness, electrically silent muscle shortening (Howell et al. 1985), a decreased range of motion, tenderness, decline in force, swelling, and release of muscle enzymes into the blood (Ebbeling 1989).

2.3 LOCATION

Any skeletal muscle that is `over-exerted` may suffer from DOMS (Armstrong 1984). Previous research has identified that an exercise incorporating more of an eccentric component causes more damage and disruption to the muscle tissue than would the same degree of concentric exercise (Miles 1994). An eccentric action is defined as one in which the muscle body lengthens as the force is produced, such as lowering a weight or downhill running (Scott 1992). This type of eccentric action creates a greater tension per active muscle fibre than corresponding concentric exercise, and this is believed to be the cause of mechanical disruption of the muscle fibres (Armstrong 1984). The aching and associated stiffness is reported to occur in the more distal portions of the muscle in the region of the musculotendinous junction (Edwards 1981; Armstrong et al. 1983 and Friden et al. 1983). Various

theories have been proposed as to why this is the case and none of them are irrefutable (Miles 1994).

2.4. PREVALENCE

Since DOMS is a transient muscular condition with full recovery over a period of two weeks and no long term deleterious effects, persons experiencing this generally do not seek medical attention and simply allow the condition to run its course, this has resulted in incomplete clinical data (Armstrong 1984). DOMS commonly affects persons partaking in unaccustomed sport or exercise but is frequently experienced by elite athletes following rigorous exertion, indicating that a high level of fitness offers no protection against DOMS (Kuipers 1994).

2.5. CONSEQUENCES

Apart from the muscle tenderness and soreness associated with DOMS other accompanying symptoms do arise, these include:

- Increased muscle stiffness and associated decrease in range of motion and flexibility (Miles 1994) due to electrically silent muscle shortening (Howell 1985),
- Decreased strength and force produced by the muscle (Hough 1902; Newham et al. 1983 and Tiidus and Ianuzzo 1983)

- Release of muscle enzymes into the blood with swelling of the tissues (Ebbeling 1989).

The extreme form of DOMS is termed rhabdomyolysis. Extensive muscle damage with myoglobinuria can occur following severe exercise. It is associated with renal, electrolyte and cardiac complications. (Milne 1988.)

2.5.1 MUSCLE SORENESS

Muscle soreness is routinely indicated by means of a pain and soreness perception scale ranging from no pain to extreme pain and stiffness on a variable scale length. In general, soreness appears 24 hours after exercise and peaks at 2-3 days post-exercise, then slowly dissipates over a period of up to 14 days after the event (Clarkson et al. 1992). A study by Tiidus and Ianuzzo (1983) revealed that by increasing the intensity and duration of exercise there was a corresponding increase in the serum enzyme activity and muscular soreness perception. Furthermore the study showed that high-intensity, short-duration exercise resulted in greater serum enzyme activities and muscular soreness than long-duration, low-intensity exercise.

The exact mechanisms of soreness have never been fully established, and the reason for the delay in onset still remains a mystery (Clarkson et al. 1992). An article by

Smith (1991) postulates a sequence of events to explain the generation of soreness following bouts of downhill running :-

The damage of muscles and/or the surrounding connective tissue leads to an increase in circulating neutrophils. It is thought that these neutrophils migrate to the site of injury and are followed by monocytes, these in turn differentiate to become macrophages to phagocytize debris.The number of circulating monocytes peaks at 48 hours post-exercise, about the time of maximum soreness. These macrophages synthesize large amounts of prostaglandins (inflammatory PGE_2), which then sensitize the group III and IV afferent nerve endings in muscles leading to the perception of pain. (Smith 1991.)

This however seems to oppose other observations indicating that prostaglandin inhibiting drugs (NSAIDS) are ineffective in alleviating the perception of soreness (Kuipers et al. 1985; Donnelly et al. 1988). Recent research on the other hand is somewhat more supportive of the inflammatory mechanism of action as results have indicated nominal positive effects for NSAID treatments relative to placebo for aspirin, (Francis and Hoobler 1987), ibuprofen, (Hasson et al. 1993) and dexomethasone iontophoresis (Hasson et al. 1992).

A study by Jones et al. (1986) using a different exercise regimen to Smith (1991), indicated substantial mononuclear cell accumulation 7 days after eccentric exercise - long after peak soreness. In a further study by Round et al. (1987) biopsies were performed on the biceps muscle 9-14 days after maximum force eccentric actions, the results indicated a vast accumulation of mononuclear cells, mainly macrophages. Whether this discrepancy in results signifies that soreness is unrelated to accumulation of macrophages in surrounding tissues, or that the response is different depending on what exercise regimen is performed remains to be determined (Clarkson et al. 1992).

Swelling and oedema have also been implicated as likely factors in causing muscle soreness due to an increase in pressure in such areas as the tibial compartment, this is a likely consideration as the encapsulating structures allow little room for expansion (Friden et al. 1986). However the forearm flexor muscles are contained within an expandable compartment unlike the tibialis muscle (Newham 1985). In their research, Newham and Jones (1985) did not find an increase in muscular pressure after subjects performed eccentric exercise of the forearm flexors. Also of interest in their findings was the fact that swelling in the distal biceps region, determined through girth measurements, was found to increase gradually and peak at 5 days post-exercise. These results indicate that the greatest swelling occurs when

soreness is subsiding.

From the more recent research by Smith (1991) the fact that muscle soreness is only felt on palpation or during movement, and is virtually absent during rest, seems to substantiate the claims made by Jones and Round (1990) that soreness is due to an inflammatory action within the muscle and connective tissue which would then sensitize mechanoreceptors thus facilitating the pain threshold when the muscle is palpated or moved. As mentioned previously, studies by Smith (1991) present a strong case for the involvement of an inflammatory response but as yet the mechanisms of action remain undetermined.

2.5.2. MUSCLE STRENGTH

The reduction in the strength of a muscle following rigorous exercise is one of the indicators of muscle damage associated with DOMS (Balnave and Thompson 1993). Muscle strength is often quantified by measuring the amount of force a group of muscles can generate isometrically (Clarkson et al. 1992). Muscle strength is impaired to the greatest extent immediately after high-force eccentric exercises are performed (Clarkson et al. 1992; Balnave and Thompson 1993), with strength gradually being restored such that after 10 days of recovery a deficit still remains.

A frequent assumption is that there is a voluntary decline in strength production due to the pain and soreness felt during DOMS. Research however has established this to be incorrect, as the time course for pain and soreness does not correlate with that for strength loss since strength is still reduced when soreness is no longer evident (Clarkson et al. 1992).

In a study by Newham et al. (1993) it was determined by using electrical stimulation superimposed onto maximal muscular contractions that muscles are fully recruited during the performance of a maximal effort contraction. Furthermore the study indicated that exercise-damaged muscles were fully recruited during maximal voluntary contractions, and that motivational factors or pain tolerance were not primarily responsible for the reduced ability to generate force. An additional key point uncovered by the same research in refuting that soreness is the cause of reduced strength is that by electrically stimulating the damaged muscles, thereby bypassing voluntary effort, it showed a reduced ability to generate force followed by a slow recovery. The reduced ability of electrically exercised muscle to generate force was particularly evident with the lower frequencies of stimulation, and is considered to be due to a damaged sarcoplasmic reticulum (Clarkson 1988).

A further explanation for the strength reduction observed is that of muscle fibre damage. Studies have shown that eccentric exercise in particular causes a disruption

of the myofibrillar banding pattern (Friden et al. 1983; Friden and Lieber 1992). This concept, however, is doubtful since ultrastructural damage increases progressively in the days following exercise, during the time that strength is recovering (Clarkson et al. 1992). More extensive proof has indicated that a greater degree of damage occurred in muscle biopsies taken 3 days (Friden et al. 1983) and 30 hours (Newham et al. 1983) after eccentric exercise.

An unsubstantiated theory by Vollestad and Sejerstad (1988) who postulated that the calcium released from the sarcoplasmic reticulum decreases as the muscles function to produce force. This decrease in calcium would contribute to muscle fatigue. During both concentric and isometric exercise, which produce less DOMS and show a more rapid recovery rate, the calcium homoeostatic balance would be quickly restored. However if the sarcoplasmic reticulum were to be damaged, as is suspected to occur in eccentric exercise, the restoration of normal sarcoplasmic reticulum calcium levels would be delayed, and so too would be the ability of the muscles to produce force. No direct evidence exists to confirm that the sarcoplasmic reticulum is damaged by eccentric exercise, however the results of a study by Byrd et al. (1989) support the possibility of the scenario.

2.5.3. RANGE OF MOTION - FLEXIBILITY

The flexibility of a muscle is considered by many to be an important aspect to fitness, and furthermore a component that is frequently associated with the incidence of muscular injury (Leach 1982; Shellock and Prentice 1985).

To evaluate the effect of DOMS on the range of motion of a joint, Clarkson et al. (1992) assessed spontaneous muscle shortening following high-force eccentric exercise by observing changes in the relaxed arm angle, which is the angle at the elbow when the subject allows the arms to hang freely by the side. Results showed that the angle became more acute immediately after exercise, and progressively reached its peak at 3 days post-exercise. Stretching of the muscle beyond its newly shortened position elicits a painful response (Howell et al. 1985; Clarkson and Tremblay 1988), followed by a gradual return to normal flexibility over a period of up to 7 days.

The cause of this reduction in relaxed arm angle is possibly due to the shortening of the connective tissue and/or the shortening of the muscle fibres (Clarkson et al. 1992). If the shortening is due to muscle fibre contraction, this occurs by means other than the normal contraction where the motorneuron activates the fibres, as studies have shown that there is no increase in EMG activity associated with the

muscle shortening (Howell et al. 1985). Of further interest is that the time course for muscle shortening coincides with that for ultrastructural damage, in that the damage progressively increases over several days (Clarkson et al. 1992).

If the loss in strength as mentioned before was due to a calcium deficiency in the sarcoplasmic reticulum, it is unlikely that there would be sufficient calcium to allow for adequate continuous cross bridging to yield complete muscle shortening. Whereas the lack of calcium would then occur in the sarcoplasmic reticulum, a relative excess or accumulation would occur in the cell (Ebbeling and Clarkson 1989). This abnormal increase in calcium could affect the degree of association between the actin and myosin filaments as well as activate specific enzymes that could begin to degrade areas of muscle tissue (Armstrong et al. 1991).

2.5.4. CREATINE PHOSPHOKINASE (CPK)

2.5.4.1. Introduction

In the event of muscle disease or damage following long and intense duration physical activities, increased amounts of muscle proteins are recorded in blood samples. This forms the basis of the diagnostic investigation (Dioszeghy and Mechler 1988; Hortobagyi and Denahan 1989). Numerous studies indicate that these proteins are elevated after marathon running (Byrnes et al. 1985; Maresh et

al. 1989; Nuviala et al. 1992) and other forms of eccentric exercise (Tiidus and Ianuzzo 1983; Ebbeling and Clarkson 1990; Karamizrak et al. 1994). The most commonly studied protein is creatine phosphokinase. Its plasma elevation has been used as an indicator of muscle damage following strenuous exercise (Schwane et al. 1983; Manfredi et al. 1991).

2.5.4.2. Function of CPK

Creatine phosphokinase, also known as creatine kinase and CPK, is a dimeric enzyme that catalyses the reversible phosphorylation of ADP by creatine phosphate to form ATP and free creatine (Hortobagyi and Denahan 1989). It is a large molecule (80 000 Da) and is therefore unable to enter the blood stream directly. The result of any injury to the muscle causes CPK to pass into the lymph via the interstitial fluid from where it enters the body's blood circulation, thus allowing easy measurement of the CPK levels via a blood test (Lindena et al. 1979).

2.5.4.3. Effects of Age on Resting Blood CPK Levels

According to Meltzer (1971) the resting serum CPK level increases with age. Gale and Murphy (1979) calculated that this increase is approximately 3 IU/l per decade. The normal resting level is extremely variable but should be less than 195 IU/l. There is evidence of reduced muscle fibre numbers in persons over age 60 (Lexell

et al. 1983). This causes a decrease in lean body mass and muscle strength and an increase in ultrastructural damage (Orlander et al. 1978). In a study by Manfredi et al.(1991) the data obtained suggests that older adults experience greater muscle damage following eccentric exercise than young subjects. Furthermore there appeared to be no relationship between CPK activity and the corresponding amount of muscle damage recorded in each subject suggesting that post exercise CPK increase is a manifestation of muscle damage, but not a direct indicator of it. More extensive studies are required to substantiate these results.

2.5.4.4. Effects of Gender on Resting Blood CPK Levels

It would appear from the majority of the research that women have a lower resting serum CPK level than do men, both at rest and in response to equal amounts of exercise. This gender difference in CPK level may also be related to differences in activity levels (Hortobagyi and Denahan 1989).

2.5.4.5. Effects of Race on Resting Blood CPK Levels

A variability has been shown to exist in CPK levels between Black individuals and a similar group of Caucasians (Hortobagyi and Denahan 1989). Black individuals have a higher resting and post-exercise serum CPK than Caucasians which is not fully understood, but may be related to the fact that samples reported in the studies

consistently showed Blacks to have a greater lean body mass and thus greater muscle involvement.

2.5.5. THE RESPONSE OF CPK ACTIVITY TO EXERCISE

2.5.5.1 Intensity versus duration of exercise

Research indicates that the intensity of the exercise is more important than its duration in producing a large post-exercise CPK response (Tiidus and Ianuzzo 1983). Long-distance or marathon running is regarded as a "duration activity" that occurs at 70-90% of maximal oxygen uptake (Astrand and Rodahl 1986).

In marathon runners, there appears to be a distance or duration threshold of the CPK response. Results indicate that CPK increases slightly up to 21km then increases sharply after 42km, but no further for races up to 96 km. These findings could possibly imply that the duration of exercise may be as important as the intensity of a short-term high intensity exercise in eliciting high CPK levels (Hortobagyi and Denahan 1989).

2.5.5.2. The time course for CPK release

The response of CPK to various forms of exercise including isometric exercise, downhill running, marathon running and high-force eccentric exercise has been documented. The research has indicated not only a variation in the time course for

CPK release depending on the exercise undertaken, but also a great variation in the amount of CPK released with the different exercises. For example the results of Byrnes et al. (1985) indicate that the CPK response peaks at approximately 24 hours after downhill running and the average increase in CPK activity between the athletes was approximately 300 IU/l. In comparison, Clarkson et al. (1992) researched muscle damage in 109 subjects after high-force eccentric exercise of the forearm flexors. CPK activity did not demonstrate a precipitous increase for 2 days but reached peak values at about 4 days post-exercise. Furthermore CPK activity increased on average by approximately 2 500 IU/l. This is of great importance when the amount of muscle mass used during the exercises is considered. Marathon running produces a peak CPK response 24 hours after the race, with a substantially increased but variable response (Taylor et al. 1987; Soeder et al. 1989; Nuviala et al. 1992).

The difference in CPK activity may be due in part to the mode of muscle contraction with CPK release related to the overall tension output of the involved muscle (Clarkson et al. 1985). This statement was later confirmed by Byrnes and Clarkson (1986) whose study revealed that eccentric exercise resulted in a greater CPK release with a longer time delay than isometric or concentric exercise.

Due to the extreme variability in both the time course and extent of CPK response among the different exercise models, caution should be used when attempting to derive a mechanism to explain the muscle damage/repair process based on different exercise regimens (Clarkson et al. 1992). Why this should occur, and the possible mechanisms related to it still remain unclear. It is most probable that part of the explanation lies in the extent of injury induced by the various forms of exercise, which will be examined later, but why this would result in a different time course of response is unclear.

2.5.5.3. Adaptation of CPK levels following repeated exercise

Once DOMS appears, there exists no known method of hastening its recovery, and according to the literature the only recognized prevention for DOMS in a particular muscle group is prior training of that same group (Byrnes et al. 1985; Clarkson and Tremblay 1988; Ebbeling and Clarkson 1990; Balnave and Thompson 1993). That is, the DOMS response to a given type of exercise diminishes with repetition of the exercise over time, as the adaptation appears to result in the muscle being more resistant to the damaging effects of a repeated time period of the same exercise. Hill (1951) admitted that training was the only thing he was aware of that would reduce DOMS.

The attenuation of blood CPK levels upon a second attempt of exercise is called the "rapid adaptation" or "repeat bout effect". This effect was first noted in a study by Nuttal and Jones (1968) and is more appropriately documented by Clarkson et al. (1985) for isometric exercises of the arm and by Byrnes et al. (1985) following downhill running. In the latter study, subjects ran for 30 minutes, and repeated the run either 3, 6 or 9 weeks later. The results indicated that the serum CPK was greatly reduced if the second bout occurred within 6 weeks of the initial run, but no significant difference if the run was repeated 9 weeks later. This suggests a temporary adaptation. Clarkson et al. (1987) demonstrated that no central nervous system adaptation occurred in the repeated bout effect, but rather the effect was specific to the exercised muscles themselves.

In a study by Clarkson and Tremblay (1988) their results indicated that adaptation could also be produced when the first exercise was less stressful and produced little change in the indicators of damage compared with the second exercise bout. The experimental design involved subjects performing 24 maximal eccentric actions, followed two weeks later by a second exercise bout consisting of 70 maximal eccentric actions.

Exactly when and how this adaptation is produced is not known, however two

theories have been put forward . Armstrong et al. (1983) reported that one 30 min exercise bout in rats was sufficient to reduce serum CPK response following subsequent exercise. From their results they hypothesised that the first exercise bout would damage a pool of stress susceptible fibres resulting in a large increase in serum CPK and the development of muscle soreness. This process would be followed by a period of repair and regeneration such that fewer stress susceptible fibres would remain when the second bout was repeated. They suggested that these fragile fibres developed due to disuse and ageing. Grimby and Saltin (1983) have presented evidence that throughout life a small percentage of total muscle fibre population degenerates, causing a decrease in the total number of fibres with increasing age. Thus the possibility exists that these degenerating fibres could be the source of the pool of stress susceptible fibres which are damaged at the initial bout of exercise. The fact that both the ageing process (Clarkson et al. 1981; Cress et al. 1984) and eccentric work (Friden et al. 1983) affect mainly type two muscle fibres provides further support for a link between the ageing and stress susceptible fibres. However in a subsequent study, done by Schwane and Armstrong (1983) they were unable to confirm their hypothesis of a pool of stress susceptible fibres. The experimental method involved having rats perform a bout of exercise that did not significantly raise their serum CPK level. Three days later the rats performed a more strenuous bout of exercise. The results indicated a reduced serum CPK response

when compared to the first bout. This experimental method has more recently been modified to the study of adaptation in humans by Clarkson and Tremblay (1988) as mentioned above, and similar results were obtained. The results from this study with regard to adaptation indicate that after exposure to a modest bout of exercise, the muscle becomes more resistant to exercise damage from a more strenuous bout and any damage that does occur is repaired at a faster rate. A mechanism to explain the adaptation could not be directly ascertained from the data of the research, but it seems probable that some strengthening of the surrounding connective tissue or a strengthening of the membrane itself must occur (Clarkson and Tremblay 1988).

If short-term adaptation triggers an attenuated response in the various criterion scores, particularly CPK, upon re-exercise, it is difficult to conceive why elite athletes, who repeat the same activity for many years also experienced elevated CPK levels at rest and after exercise (Roti et al. 1981; Robinson et al. 1982). In light of the proposed theories one would expect that with long-term exposure to daily training, fragile or stress susceptible fibres would be eliminated, and the visco-elastic properties of the muscle-connective tissue complex would be stabilised. However, since athletes are accustomed to their daily activities, it is possible that the mechanisms resulting in high CPK release are different from the one proposed for the repeated bout phenomenon (Hortobagyi and Denahan 1989).

Several possibilities for this occurrence in athletes could be:

a) lower enzyme removal from the serum,

b) permanently disturbed membrane permeability,

c) increased lean body mass,

d) increased protein catabolism, or

e) a combination of all these factors (Hortobagyi and Denahan 1989).

As yet no evidence exists to substantiate the various hypotheses.

2.6. STRUCTURAL BASIS OF EXERCISE INDUCED MUSCLE DAMAGE

Although muscle tissue is extremely resilient, destructive changes to the fine ultrastructure of the muscle may occur in response to unusually strenuous demands (Hoppeler 1986). Structural abnormalities following various types of exercise have been reported in both animal (Armstrong et al. 1983; Kuipers et al. 1983) and human models (Newham et al. 1983; Friden et al. 1983; Friden et al. 1988).

The injuries described in the various studies included:

a) Primary or secondary sarcolemmal disruption (Armstrong 1990; Jenkins 1988),

b) swelling or disruption of the sarcotubular system (Armstrong 1990),

c) distortion of the myofibril contractile components (Armstrong et al. 1983; Friden et al. 1988; Friden et al. 1983; Jones et al. 1986; Newham et al. 1983),

d) cytoskeletal damage (Friden et al. 1984) and

e) extracellular myofiber matrix abnormalities (Stauber 1989).

Pathological changes such as these can occur following either sprint or distance running in athletes (Nimmo and Snow 1982; Kuipers et al. 1983).

Nuremberg et al. (1992) used Magnetic Resonance Imaging (MRI) to determine if there was a correlation between the degree of delayed increase in signal intensity of the muscle after exercise and the amount of ultra-structural damage and delayed onset muscle stiffness. A MR imaging-guided muscle biopsy was performed and tissue samples were obtained at 48 and 96 hours after exercise. On an ultra-structural level, abnormalities of the Z-band were observed in 20% of the sarcomeres examined and included mild degenerative changes, Z-band streaming and in some sarcomeres the Z-band was partially or totally missing. Muscle fibre injury was not uniform along the length of the fibre and showed regions of extensive myofibrillar focal disruption involving the A-bands, I- and Z- bands of the sarcomeres. The data from the study indicated a high correlation between the degree of signal intensity increase 48 hours after exercise and the degree of ultra-structural

injury. There was poor correlation between the perceived peak grade of soreness and the peak CK level. This supports the observation of Newham (1988) who noted no obvious relationship between the magnitude of CPK release and DOMS. Kuipers et al (1985) postulated that although exercise-induced CPK elevation may indicate muscle injury, it may not provide an index of the magnitude of the injury.

Nurenberg et al (1992) indicated no correlation between areas of DOMS and areas of signal intensity increase, but a high correlation between areas of ultra-structural damage and those with increased signal intensity. When considering that many previous muscle injury studies focused the biopsy on areas of DOMS assuming the area to possess greatest muscle damage, it is important that future studies make use of MR imaging-guided biopsy.

2.7. CURRENT METHODS OF TREATMENT

As has been previously mentioned, the prevention and treatment of DOMS following conventional methods is a futile attempt.

Not much has changed over the years from when Hill in 1951 conceded he knew of nothing that prevented muscular soreness "...except previous training, nor anything that quickens its disappearance; when others have asked me, I have often been forced with shame to confess my ignorance."

The only possible relief one can have from the effects of DOMS, is that due to the adaptation effect, which as we have seen previously does not play as great a role in trained athletes as it does with untrained persons (Robinson et al. 1982; Roti et al. 1981). Muscular soreness does diminish acutely during exercise (Hough 1901) especially with the performance of precisely the same type exercise that originally caused the soreness. Unfortunately however, according to Hough (1901) with cessation of exercise the soreness returns during the post-exercise period, and this cycle continues until the muscle becomes sufficiently conditioned through training. A probable reason for this reduction in soreness during exercise could be as a result of several neural mechanisms coming into play (Armstrong 1984). The release of endorphins and other central nervous system endogenous opioids (Pargman and Baker 1980; Kelly 1982) act as powerful analgesics, and are secreted by neurons in the brain and spinal cord, the overall effect is inhibition of the transmission of pain (Ignelzi and Atkinson 1980; Nathan 1980; Hansen et al. 1982.). Following the suggestion that endorphin release is increased during exercise (Pargman and Baker 1980; Kelly 1982), this could be a probable cause for decreased sensation of DOMS during the exercise period.

Another neural mechanism that could alleviate muscular soreness during exercise would result from increased afferent input from large, low-threshold sensory units

in the muscles namely the groups Ia, Ib, and II fibres (Armstrong 1984). Elevated activity in these large A fibres may interfere with , or "close the gate" to pain sensations carried by C fibres at the level of the spinal cord through interneurons that presynaptically inhibit ascending pathways (Melzack and Wall 1965). This popular explanation is referred to as the Gate Control Theory of Pain.

Common treatments for the alleviation of the symptoms of DOMS include applied heat, as well as topical linaments, ointments and creams containing methyl salicylate, menthol, thymol and/or camphor (Armstrong 1984). It seems doubtful that significant benefit in terms of tissue repair occurs by means of these applications (Armstrong 1984). However tactile stimulation or massage associated with the salves, or the sensation of warmth imparted by the medication may serve to inhibit pain transmission through the gate control theory as mentioned above (Melzack and Wall 1965).

Evidence remains incomplete as to the efficacy of anti-inflammatory drugs in reducing DOMS (Kuipers et al. 1985; Donnelly et al. 1988). This in particular has brought doubts upon the inflammatory hypothesis as a possible mechanism in causing DOMS. As mentioned before, a few studies have reported only modest positive effects for NSAID treatments relative to placebo and include: aspirin

(Francis and Hoobler 1987), ibuprofen (Hasson et al. 1993) and dexamethasone iontophoresis (Hasson et al. 1992).

It has been suggested that taking NSAIDS may be counterproductive because the inflammatory process, which includes stimulation of protein turnover for repair by prostaglandins, is inhibited (Evans 1987). One of the major drawbacks with long term use of NSAIDS are their gastro-intestinal side effects (John 1991).

2.8. HOMOEOPATHIC TREATMENT OF DOMS

The homoeopathic principle is best summed up by the Latin phrase, "*similia, similibus, curentur*" meaning, "let like substances be used to cure like diseases". This principle is now referred to as the Law of Similars, and states that there is a similarity between the toxic power of a substance and its healing action. (Jouanny 1991.) The similimum remedy therefore is that substance which when given in its natural undiluted (and often toxic form), stimulates a distinct pattern of symptoms which are similar to, but not identical to those of the original illness (Smith 1982).

The homoeopathic remedies are prepared in serial dilutions of the original substance (mother tincture), as this has been found by clinical experience to remove the toxic

effects of the substance and enhance its curative properties (Smith 1982). The dilutions are either made according to the decimal scale where 1 part of the original substance is prepared with 9 parts of 70% alcohol (designated as D or XH), or according to the centesimal scale, where 1 part of the original substance is prepared with 99 parts of 70% alcohol (designated as C or CH). A further feature in the preparation of the remedies is that between each step of serial dilution the successive potency or dilution is strongly agitated.

The mechanism of action of Traumeel arises from a combination effect of the various vegetable and inorganic chemical constituents, which are characterised by the following properties (Heel 1989):

a) Antiphlogistic and antiviral action of mercurials,

b) Improving the tone of the vessels (Aconitum, Arnica), reducing the permeability of the vessels (calcium action). Elimination of venous stases plus an antithrombotic effect (Hamamelis) as well as haemostasis (Millefolium), the two together have a normalizing effect on the prothrombin levels.

c) Support and improvement of the cellular respiration and oxidative processes of the body by means of calcium sulphide and polysulphide (Hepar sulfuris).

d) Stimulating the greater defense system.

e) Encouraging wound healing and decreasing the effects of shock by means of phytotherapeutic agents (Arnica, Calendula, Echinacea and Symphytum).

f) Analgesic action (Aconitum, Arnica, Chamomilla, Hamamelis and Hypericum).

g) Stimulating haemostasis [venous] (Aconitum, Arnica, Hamamelis), [arterial] (Hypericum, Millefolium) and [vessel sealing] (Hepar sulfuris).

For the pharmacological and clinical application of the individual components of Traumeel S, see Appendix D.

CHAPTER THREE - MATERIALS AND METHODS

The purpose of the study was to analyse the effectiveness of Traumeel S in the treatment of DOMS, acquired during a standard marathon run, in terms of changes in creatine kinase blood levels and alteration in strength and power output, as well as determining its effect on values of static jump, flexibility and pain and soreness perception. Values for all the parameters above were recorded before, during and after treatment, thus utilising the experimental design method. This took the form of a single variable design before-and-after with control. The test and control groups were of equal size thus enabling more accurate results to be extrapolated.

3.1 THE SUBJECTS

The subjects used in this study were drawn conveniently from the population of marathon runners in the Durban and Johannesburg areas having easy access to the testing stations used. The subjects were limited to males between the ages of 20 and 40 years who had completed at least two previous marathons. The subjects were instructed not to engage in strenuous training for a week following the marathon while the results were being obtained. Subjects who incurred serious injury during the marathon were disqualified from the research. Due to the financial constraints of such a project, as well as the need for statistical validity, the sample size was

limited to 30 subjects.

The subjects were assigned to either the treatment or control group, by having a predetermined randomised list of either treatment or placebo placings which was constructed by an independant party. As subjects arrived for the initial testing they were assigned to the next placing on the list.. This information was only released to them after the last measurements were taken. It was unfortunately not possible for the research to follow the double blind technique, as the placebo (injectable saline) was unobtainable in 2ml glass ampoules. Only data from subjects attending at least 90% of the testing protocol was admitted. All data used was obtained under supervision of the researcher.

Interested respondents were interviewed and evaluated in terms of the selection criteria as set out above. The research project was then explained to them and those who consented to participating in the research and were able to attend the regular testing sessions were given further information as to when and where the initial testing session would take place.

3.2. METHOD

The initial testing took place either on the Friday or Saturday before the marathon depending on the availability of the testing equipment. This provided base values for all testing parameters. The participants were then given a consent document to sign, (Appendix A). The relevant information of Appendix B was then completed by each subject.

The marathon was run on the Sunday and the participants were re-evaluated on the Monday. Follow up testing on each successive day was done within a time constraint of 4 hours (1pm or 5pm) so as to eliminate further intersubject variability.

On days Tuesday, Wednesday and Thursday all parameters apart from the isokinetic Akron test were repeated. This was due mainly to the financial constraints of the research, and since the Akron test was performed before the marathon, the day after the marathon and finally at the conclusion of the testing and treatment period, the results obtained are adequate to extrapolate meaningful results.

On Friday, the final testing day, all parameters were re-evaluated but the experimental or control injection was not administered.

The data was collected and systematized by means of a computer based spread sheet. The data was then analysed using a computer aided analysis (Statgraphics Plus Version 6.0) The Wilcoxin Signed Rank Test was used to analyse the results within groups and the Mann-Whitney U-Test was used for the analysis of results between groups.

3.2.1. CPK Blood Test

A qualified nursing sister was present to draw a 5ml blood sample from the ante-cubital vein of each subject. Alternate arms were used on each successive day so as not to traumatize the vein. A tourniquet was applied to the upper arm so as to distend the veins distally facilitating the sampling procedure. The area over the ante-cubital vein was sterilized using a 70% isopropyl alcohol swab. The back of a vacutainer multisample sterile needle (0,8mm x 40mm) was then screwed into the vacutainer, the needle was inserted into the vein, and when in position, a red topped (used for clotted blood sampling) vacuumed specimen tube was inserted into the vacutainer allowing the rubber cork to be penetrated by the back of the needle. The tourniquet was removed and the vacuum within the tube drew up the required blood sample. The needle was removed and discarded into a disposable sharps container, a wad of cottonwool was placed over the site of trauma and the subject was told to hold it in place for one to two minutes to prevent further bleeding.

The blood was analysed by staff at a pathology laboratory using a Boerringer Mannheim test kit for CPK analysis. The test was conducted at 37°C.

3.2.2. The Vertical Jump

The vertical jump was performed at each test period and allowed the research to assess whether any changes in the explosive power of the muscles was evident. Equipment required included A3 size white paper, standard tapemeasure and a variety of coloured chalk.

Subjects were required to remove their shoes and while standing flat footed adjacent to the wall, with a piece of coloured chalk in their hand, were required to reach up and mark the highest elevation possible on the paper attached to the wall. They were then allowed one practice attempt, which involved jumping from a stationary position adjacent to the wall, allowing the above-stretched arm to mark the highest point of the jump, with the chalk, on the paper. Following the practice attempt each subject performed three jumps, the highest of which was accepted as being his finest attempt. The distance between the initial standing mark and the accepted highest mark was measured in millimetres, and recorded as the vertical jump distance D.Grobler (personal communication 1994.)

3.2.3. Flexibility

The flexibility of each participants hamstrings was measured at each test session allowing the research to assess the state of contraction or relaxation of the muscles over the treatment period. The equipment required included a standard tape measure, and a gymnastic mat (1.5m x 1.2m).

The subject was instructed to remove his shoes and sit on the mat with his legs together, knees fully extended and locked into position, so that the back of his knees were always in contact with the mat. The feet were 90 degrees dorsiflexed. With the arms outstretched over the legs, hands together, the subject was instructed to flex at the hips, keeping his knees locked in position, and to flex and stretch as far forward over the toes as possible. The position was held while the measurement was taken, in millimetres, from the distal side of the big toe to the tip of the middle finger. The measurement was recorded as a negative value if the subject was unable to reach his toes, and recorded as a positive value if he was able to reach past his toes. D.Grobler (personal communication 1994.)

3.2.4. Pain and Soreness Scale

The pain and soreness scale (Boone et al. 1990) was completed by each subject on each occasion of evaluation, this was done by having the subjects circle the most

appropriate response as to the state of their muscles at the time of testing (see appendix C).

3.2.5. Isokinetic strength

The isokinetic strength and power of each subject was evaluated by means of the Akron machine before the race, the day after the race and on the final day of testing. This allowed the research to assess the effect of administering Traumeel S as compared to the placebo on the above criteria. The equipment required included an Akron Isokinetic machine with link up computer and printer, a short lever arm, shin pad, ankle, thigh and waist strap.

i) Patient positioning

a) Test the dominant leg of the subject,

b) set the backrest to the 90 degree position,

c) the subject is seated with the hips as far back as possible with the nape of the knee at the end of the seat,

d) ensure the axis of the dynamometer lever arm corresponds to the axis of the knee joint,

e) secure the thigh and shin with the velcro straps, and the waist with the belt provided,

f) subject may hold the hand grips provided, but the untested leg must hang free.

ii) Setting up machine

a) Once the subject is securely positioned, 10 warm up repetitions are done at 90 degrees/sec. This involves rapidly flexing and extending the knee against the resistance provided by the machine,

b) the Akron must be anatomically zeroed by pushing stop range button A with the knee in full extension,

c) and by pushing stop range button B with the knee fully flexed.

iii) Testing

a) The test speed is set at 60 degrees/sec, which is the universal testing speed for strength power and work,

b) the test is commenced with the knee in a fully extended position,

b) the subject is instructed to flex and extend as fast as possible between points A and B for 12 seconds,

c) the uninvolved leg must hang free and the subject must remain upright,

d) the subject commences on the "go" command, is encouraged with verbal motivation and ceases with a "stop" command after 12 seconds.

D.Grobler (personal communication 1994.)

3.2.6. Administration of the Injection

Each subject was given an injection at the end of each testing session apart from the last. A new syringe and needle were used for each subject on each occasion. The equipment required included sufficient 1ml insulin, 0.33 x 13mm single use, non pyrogenic syringes, 2.2ml sterilised Traumeel S ampoules, 10ml sodium chloride 0.09g/10ml (Sabax) injectable saline ampoules and sterile 70% V/V isopropyl alcohol prep swabs.

Subjects were required to lie prone on an examination couch, and allow access to the back of the thigh. An area in the centre of the posterior thigh over the semimembranosus muscle was cleaned using the 70% isopropyl alcohol swabs. The sterile syringe was filled with either 1ml Traumeel S or 1ml injectable saline depending on whether the subject was from the control or experimental group. An intramuscular injection was given into the semimembranosus muscle. This procedure was repeated on the opposite leg.

CHAPTER FOUR: RESULTS

Data from subjects attending at least 90% of the testing protocol was admitted. All data used was obtained under supervision of the researcher. The Wilcoxin Signed Rank Test was used to analyse the results within groups and the Mann-Whitney U-Test was used for the analysis of results between groups.

4.1. CREATINE PHOSPHOKINASE LEVELS

The mean CPK levels obtained prior to the race (Saturday, Table 1), provided a baseline reading for each subject. CPK values for both groups increased considerably the day after the marathon then decreased gradually, Monday through Friday indicating the degree of muscle damage and subsequent repair.

TABLE 1: Mean blood CPK levels of both placebo and treatment groups

	Placebo		Treatment	
Day	Mean (IU/l)	Std Deviation	Mean (IU/l)	Std Deviation
Sat	155.9	79.0	191.1	113.0
Mon	979.1	614.9	1074.9	763.0
Tue	512.1	299.1	662.5	409.2
Wed	298.2	171.3	400.7	199.7
Thurs	238.0	155.0	342.9	180.1
Fri	209.4	131.4	272.5	131.7

Mean CPK values were compared within the treatment and placebo groups as well as between these groups at critical stages in the study to determine the statistical significance (Tables 2 and 3).

TABLE 2: Statistical significance of CPK values at critical stages in the study

	Placebo		Treatment	
	P-Value	Significance	P-Value	Significance
Sat - Mon	0.0000449	less than	0.000194	less than
Mon - Fri	0.00000897	greater than	0.000296	greater than
Sat - Fri	0.129	no significance	0.01813	no significance

TABLE 3: The mean CPK values and the statistical significance levels of both placebo and treatment groups on Saturday, Monday and Friday

	Mean Plcb.	Mean Treat.	P -Value	Significance
Saturday	155.9 (IU/l)	191.1 (IU/l)	0.332	no significance
Monday	979.1	1074.9	0.708	no significance
Friday	209.4	272.5	0.207	no significance

4.2. THE VERTICAL JUMP

The vertical jump distance, measured in millimeters, obtained prior to the race (Saturday, Table 4), provided a baseline reading for each subject. The distances obtained Monday through Friday indicate the changes incurred by the marathon run on the explosive power of the muscles, as well as their subsequent repair.

TABLE FOUR: Mean vertical jump distance obtained by placebo and treatment groups

	Placebo		Treatment	
Day	Mean (mm)	Std Deviation	Mean (mm)	Std Deviation
Sat	384.5	53.5	317.7	95.6
Mon	380.7	61.9	349.3	61.8
Tue	404.0	48.6	355.7	65.0
Wed	398.7	70.0	375.0	66.5
Thurs	408.0	49.4	365.2	106.7
Fri	422.1	62.9	385.4	63.6

The mean vertical jump distances of Saturday and Monday, Monday and Friday and Saturday and Friday were compared by determining their statistical significance (Table 5). The statistical significance at the above mentioned stages of the study were compared between groups (Table 6).

TABLE 5: Statistical significance of vertical jump distances at critical stages in the study

	Placebo		Treatment	
	P-Value	Significance	P-Value	Significance
Sat - Mon	0.668	no significance	0.141	no significance
Mon - Fri	0.00186	less than	0.000547	less than
Sat - Fri	0.0178	less than	0.00646	less than

TABLE 6: The mean vertical jump distance and the statistical significance levels of the placebo and treatment groups on Saturday, Monday and Friday

	Mean Plcb.	Mean Treat.	P-Value	Significance
Saturday	384.5	317.7	0.013	greater than
Monday	380.7	349.3	0.176	no significance
Friday	422.1	385.4	0.136	no significance

4.3. FLEXIBILITY

Results for the mean flexibility values of both placebo and treatment group have been divided into those with a positive, and negative mean flexibility value. This provides an indication into the effect a marathon run, and subsequent rest has on the flexibility level (Tables 7 and 8).

TABLE 7: Positive mean flexibility values obtained for the placebo and treatment groups

	Sat +	Mon +	Tue +	Wed +	Thurs +	Fri +
Placebo	49.9	62.2	60.6	65.5	66.0	76.0
Treatment	65.6	70.5	78.9	87.8	92.2	98.9

TABLE 8: Negative mean flexibility values obtained for the placebo and treatment groups

	Sat -	Mon -	Tue -	Wed -	Thurs -	Fri -
Placebo	128.4	135.8	104.2	127.0	124.0	81.7
Treatment	136.4	120.7	150.0	135.0	132.5	115.0

The placebo group has 10 subjects in the positive group, and 5 in the negative group. In the treatment group the figures were 9 in the positive group and 6 in the negative group. Due to the division in the group, no further meaningful statistics could be applied to this set of data.

4.4. PAIN AND SORENESS SCALE

Mean values for the pain and soreness scale obtained prior to the race (Saturday, Table 9), provided baseline readings for each subject. Through the remainder of the week changes to the pain perception were recorded and their mean was calculated.

TABLE 9: Mean values obtained for the pain and soreness scale for the treatment and placebo groups

	Placebo	Treatment
	Mean	Mean
Sat	0.07	0.07
Mon	2.13	2.2
Tue	1.33	1.47
Wed	0.53	0.6
Thurs	0.13	0.27
Fri	0.2	0.07

The mean pain and soreness values of Saturday and Monday, Monday and Friday and Saturday and Friday were compared by determining their statistical significance (Table 10). The significance levels were then determined at critical stages between the groups themselves (Table 11).

TABLE 10: Statistical significance of mean pain and soreness scale values at critical stages in the study

	Placebo		Treatment	
	P-Value	Significance	P-Value	Significance
Sat - Mon	0.00169	less than	0.00289	less than
Mon - Fri	0.00237	greater than	0.00194	greater than
Sat - Fri	0.285	no significance	0.655	no significance

TABLE 11: The mean pain and soreness scale values and the statistical significance levels of both placebo and treatment groups of Saturday, Monday and Friday

	Mean Plcb.	Mean Treat.	Z-Value	Significance
Saturday	15.5	15.5	0	no significance
Monday	15.77	15.23	- 0.149	no significance
Friday	16.03	14.97	- 0.597	no significance

4.5. ISOKINETIC STRENGTH

4.5.1. FLEXION

4.5.1.1. WORK DONE DURING FLEXION

The mean for the amount of work done (measured in Joules) during flexion of the hamstring muscles was recorded for both the placebo and treatment groups (Table 12). The statistical significance of these mean values was compared at critical stages in the testing period within each group as well as between the groups (Tables 13 and 14).

TABLE 12: The mean work output obtained by the placebo and treatment groups

	Placebo		Treatment	
Day	Mean (J)	Std Deviation	Mean (J)	Std Deviation
Sat	762.9	171.2	683.5	210.3
Mon	858.2	181.3	734.6	219.8
Fri	1284.2	518.3	820.7	386.9

TABLE 13: Statistical significance of the mean work output during flexion at critical stages in the study.

	Placebo		Treatment	
	P-Value	Significance	P-Value	Significance
Sat - Mon	0.01480	less than	0.2056	no significance
Mon - Fri	0.00101	less than	0.9565	no significance
Sat - Fri	0.00045	less than	0.5132	no significance

TABLE 14: The mean values for work done during flexion of placebo and treatment groups at critical stages in the study

	Mean Plcb.	Mean Treat.	P-Value	Significance
Saturday	0.2659	683.5	0.253	no significance
Monday	0.1455	734.6	0.134	no significance
Friday	0.0012	820.7	0.00075	greater than

4.5.1.2. TOTAL FLEXION POWER

The mean power output (measured in Watts) during flexion of the hamstring muscles was recorded for both the placebo and treatment groups (Table 15). The statistical significance of these mean values was compared at critical stages in the testing period within each group as well as between the groups (Tables 16 and 17).

TABLE 15: The mean power output obtained by the placebo and treatment groups

	Placebo		Treatment	
Day	Mean (w)	Std Deviation	Mean (w)	Std Deviation
Sat	122.2	13.01	247.5	230.2
Mon	131.0	18.6	117.6	24.9
Fri	187.2	56.6	142.3	40.8

TABLE 16: Statistical significance of values for total flexion power compared at critical stages in the study

	Placebo		Treatment	
	P-Value	Significance	P-Value	Significance
Sat - Mon	0.00932	less than	0.05214	no significance
Mon - Fri	0.00067	less than	0.00714	less than
Sat - Fri	0.00024	less than	0.11895	no significance

TABLE 17: The mean values for total flexion power of the placebo and treatment groups at critical stages in the study

	Mean Plcb.	Mean Treat.	P-Value	Significance
Saturday	122.2	247.4	0.022	less than
Monday	131.0	117.6	0.123	no significance
Friday	187.2	142.3	0.0095	greater than

4.5.2. EXTENSION

4.5.2.1. WORK DONE DURING EXTENSION

The mean for the amount of work done (measured in Joules) during extension of the quadriceps muscles was recorded for both the placebo and treatment groups (Table 18). The statistical significance of these mean values was compared at critical stages in the testing period within each group as well as between the groups (Tables 19 and 20).

TABLE 18: The mean work output obtained by the placebo and treatment groups

	Placebo		Treatment	
Day	Mean (J)	Std Deviation	Mean (J)	Std Deviation
Sat	914.5	383.0	896.9	203.7
Mon	972.8	332.6	863.2	221.2
Fri	154.3	711.5	1175.0	620.7

TABLE 19: Statistical significance of values for work done during extention at critical stages in the study.

	Placebo		Treatment	
	P-Value	Significance	P-Value	Significance
Sat - Mon	0.5160	no significance	0.5554	no significance
Mon - Fri	0.00023	less than	0.0217	less than
Sat - Fri	0.00154	less than	0.0625	no significance

TABLE 20: The mean values for work done during extention of the placebo and treatment groups at critical stages in the study

	Mean Plcb.	Mean Treat.	P-Value	Significance
Saturday	914.5	896.9	0.876	no significance
Monday	972.8	863.2	0.297	no significance
Friday	1542.8	1174.9	0.143	no significance

4.5.2.2. TOTAL EXTENSION POWER

The mean for the total extension power (measured in Watts) of the quadriceps muscles was recorded for both the placebo and treatment groups (Table 21). The statistical significance of these mean values was compared at critical stages in the testing period within each group as well as between the groups (Tables 22 and 23).

TABLE 21: The mean value for the total extension power obtained by the placebo and treatment groups

	Placebo		Treatment	
Day	Mean (w)	Std Deviation	Mean (w)	Std Deviation
Sat	153.4	27.7	145.5	24.0
Mon	144.1	35.1	137.4	25.4
Fri	225.6	85.7	181.6	73.0

TABLE 22: Statistical significance for values of total extention power at critical stages in the study

	Placebo		Treatment	
	P-Value	Significance	P-Value	Significance
Sat - Mon	0.0696	no significance	0.02871	no significance
Mon - Fri	0.0002	less than	0.01484	less than
Sat - Fri	0.0009	less than	0.05031	no significance

TABLE 23: The mean values for total extention power of the placebo and treatment groups at critical stages in the study

	Mean Plcb.	Mean Treat.	P-Value	Significance
Saturday	152.7	145.5	0.453	no significance
Monday	144.1	137.4	0.600	no significance
Friday	225.6	181.6	0.141	no significance

CHAPTER FIVE : DISCUSSION

5.1. CREATINE PHOSPHOKINASE LEVELS

The first day of testing, the day before the race, provides a baseline CPK reading for each subject. Results from subsequent days are used to indicate the levels of muscle damage and the rate of their repair. Monday's CPK level reflects the extent of DOMS incurred by the race. Values detected Tuesday through Friday reveal processes of muscle repair. Results show an initial increase in CPK levels followed by a gradual decrease in the value through the week (Table 1). This is expected and conforms to the results of previous research (Hortobagyi and Denahan 1989) in that CPK levels decline as the tissues repair following DOMS.

The baseline mean CPK value of the treatment group on the first day of testing is higher than that of the placebo group. This trend is observed throughout the testing period in that the mean CPK values of the treatment group are always higher than that of the placebo group (Table 1). Despite the difference in values, the rate of muscle repair after the race, indicated by the decline in CPK values through the week, is similar between both groups.

The large standard deviation recorded, particularly on the Monday, is an indication that each subject responded differently to the race, and although as many variables as possible were eliminated, there remains a vast intersubject variability.

Results of the Wilcoxin Signed Rank Test from both the placebo and treatment groups has been compared at critical stages in the recovery process in order to evaluate whether the results are significantly different between the days of evaluation. The mean CPK level for both the placebo and treatment groups on Saturday was significantly less than their respective means on Monday (Table 2). This indicates that DOMS had ocurred in the subjects as a result of the race. The mean for Monday in both groups was significantly greater than that for Friday (Table 2). This can be attributed to the gradual repair of the muscles over the testing period. When comparing the means for the Saturday before the race as opposed to Friday, the end of the testing period, no significant difference in their value was found (Table 2). By Friday the state of the muscle tissue is, therefore, not significantly different to that prior to the race. Muscles damaged as a result of the race had seemingly been restored to prerace condition.

The Mann-Whitney U-Test is used to compare the statistical significance of the mean results obtained for the placebo and treatment group at three critical stages namely Saturday, Monday and Friday (Table 3). These three days were selected because Saturday CPK values provide the baseline levels, Monday CPK values reveal the extent of postrace DOMS and Friday CPK values are indicative of the degree of muscle repair. This comparison is performed to determine if there is any significant difference between the mean CPK values of the placebo and treatment groups on these days. Even though mean CPK values for the treatment group were higher than that for the placebo group on each respective day, this difference is not significant (Table 3).

5.2. THE VERTICAL JUMP

The mean results of the vertical jump distance, measured in millimeters, obtained from the first day of testing provide an initial baseline to which subsequent test days have been compared (Table 4). Results on the first day of testing indicate that the mean vertical jump distance for the placebo group is greater than that for the treatment group (Table 4) as seen previously with the CPK baseline values. The mean vertical jump distance for the placebo group after the race, Monday, has a lower value than that before the race. The mean for the treatment group, however, has an increased value. By Friday the overall

increase in the mean vertical jump distance as compared to Saturday has increased only marginly for the placebo group and rather more substantially for the treatment group (Table 4).

The results of the Wilcoxin Signed Rank Test, indicating the statistical significance of the vertical jump distances for both the placebo and treatment groups, are compared at critical stages of the study in Table 5. From the mean vertical jump distance for the Saturday before the race to the mean distance of the Monday after the race, no statistical significance is noted for either the placebo or the treatment group. The marathon, therefore, did not have any deleterious effect on the muscle groups required for the vertical jump test. For the placebo group and treatment group, the mean jump distance of Monday is significantly less than than that for the Friday at the end of the testing period. In determining the overall effect the marathon had on the mean vertical jump distance, the figures for the Saturday before the race are compared to those for Friday (Table 5). Results indicate that, for both placebo and treatment group, the mean for Saturday is significantly less than the mean for Friday. The treatment group, however, has a greater significance than the placebo group. This further indicates that the explosive power of the muscles is not greatly affected by an endurance run. The increase in the mean of the vertical jump

over the testing period could be due to improved technique of the subjects, enhancing their ability to jump.

The Mann-Whitney U-Test in used to compare the statistical significance of the mean results obtianed for the placebo group with that of the treatment group at three critical stages in the study namely Saturday, Monday and Friday (Table 6). The reasons for selecting these days are as discussed previously. The mean baseline reading on Saturday for the placebo group is found to be statistically greater than that for the treatment group. However, mean values between the two groups taken on Monday and Friday indicate no statistical significance. The reason for this can only be attributed to subject variability.

5.3. FLEXIBILITY

The results of the flexibility test are difficult to interpret due to the fact that both placebo and treatment groups need to be further divided into those classed with a positive flexibility value, and those classed with a negative flexibility value. This reduces the ability to perform meaningful statistical analysis on the data. Table 7 and 8 provide a summary of the comparison between the mean positive and negative flexibility values respectively . The mean positive value for the placebo group showed a greater increase from the Saturday before the

race to the Monday after the race, than that of the treatment group. However the overall increase from Saturday to Friday is only slightly higher than that for the treatment group than it is for the placebo group (Table 7). The mean negative values for the placebo group decreased between Saturday and Monday, whereas those for the treatment group increased. The overall increase in the flexibility values between Saturday and Friday is greater for the placebo group than for the treatment group. Due to the variability in the results obtained in comparing the negative and positive groups as well as the treatment and placebo groups no meaningful conclusions can be drawn from this test.

5.4. PAIN AND SORENESS SCALE

The first day of testing provides a baseline reading of pain and soreness for each subject (Saturday, Table 9). Results of subsequent days indicate the effect the marathon run has on the subjects level of pain and soreness (Monday, Table 9), and on the rate of recovery from the subjects perspective. On Saturday the subjects of both the placebo and treatment group have the same mean pain and soreness rating. On the Monday after the race, both groups have an increased mean pain and soreness value, which is expected with the onset of DOMS. The rate with which these values decrease, as the recovery process occurs, is similar for both placebo and treatment groups (Table 9).

The Wilcoxin Signed Rank Test is used to compare the mean values of both the placebo and treatment groups at the same critical stages as selected previously (Table 10). When the results of Saturday are compared with those of Monday, the mean values of both placebo and treatment groups are significantly less on Saturday, the day before the race. This is expected as none of the subjects experienced pain until after the race. The mean rank for pain and soreness obtained the day after the race, Monday, for the placebo and treatment group is significantly greater than that obtained for Friday, the last day of testing (Table 10). This correlates with the fact that repair processes have occurred Monday through Friday. The comparison of mean results between Saturday and Friday, for both groups, show no significant difference. The muscles have returned to their pre-race state.

The Mann-Whitney U-Test is used to compare the mean rank of the placebo group to that of the treatment group at the afore mentioned critical stages (Table 11). At each stage no significant difference is observed. There is, therefore, no difference in the subjects perception of pain and soreness between both the placebo and treatment groups.

5.5. ISOKINETIC STRENGTH

5.5.1. FLEXION

5.5.1.1. Work done during flexion.

The first day of testing provides a baseline reading for the amount of work done during flexion (Saturday, Table 12). On subsequent days the results indicate the amount of work done by muscles both affected (Monday) and recovering (Friday) from DOMS. On the initial day of testing the placebo group has a higher mean work output during flexion than the treatment group. This difference, however, is not significant (Table 14) according to the Mann-Whitney U-Test. On Monday the mean for each group shows a proportional increase (Table 14). By Friday the mean for the placebo group has increased significantly while the increase in the mean for the treatment group is not significant (Wilcoxin Signed Rank Test). In other words the placebo group has a greater work output during flexion. This seems to indicate that the placebo group has a more significant recovery rate from DOMS than the treatment group. However, when these results are compared with the levels of CPK detected on the respective days this conclusion cannot be drawn. The difference in CPK levels, an indicator of the extent of DOMS, between the placebo and treatment group is not significant. The increase in the mean work output for flexion of the placebo group must therefore be attributed to an

unknown factor.

The increase in the mean work output during flexion from the first day of testing (Saturday) to the day after the race (Monday) for the placebo and treatment group, does not correlate with previous research. Clarkson et al. (1992) and Balnave and Thompson (1993) found that there was a notable decrease in strength associated with DOMS. As the subjects recovered from DOMS their work output increased. This trend is also observed in this study as the mean work output for flexion for both placebo and treatment groups increased as both groups recover from DOMS (Monday to Friday). The gain in the mean work output from Saturday to Monday can be due to the subjects becoming familiar with both testing procedure and apparatus.

5.5.1.2. Total flexion power

Power is a measure of work done over time and is determined in this study over a period of 12 seconds. A reading of the power output is taken on the first day of testing (Saturday) and provides a baseline reading against which all subsequent results are compared (Table 15). The mean total flexion power of the placebo group is noticably less than that of the treatment group before the race. The Mann-Whitney U-Test shows this difference to be significant (Table

17). Using the same test no significant difference is noted for Monday's values. At the end of the testing period the mean total flexion power for the placebo group is significantly greater than that of the treatment group, the opposite of results obtained before the race. This can be attributed to the large standard deviations observed in the treatment group (Table 15).

For each day of testing in the placebo group there is a significant increase in total power. In the treatment group there is an initial significant decrease in the mean after the race followed by a non significant increase over the recovery period (Table 16, Wilcoxin Signed Rank Test). This again cannot be related to the onset of DOMS and subsequent recovery for reasons mentioned previously.

5.5.2. EXTENSION

5.5.2.1. Work done during extension

As before, the first day of testing provides a baseline reading of the mean work output during extensions, against which all subsequent results are measured (Table 18). The mean of the placebo group on the first day of testing is higher than that of the treatment group however this difference is not significant (Table 20). There is an increase in the mean of the placebo group after the race which continues through the recovery period (Table 19). The treatment group,

however, shows a decrease in the mean values after the race, which is not significant (Wilcoxin Signed Rank Test), followed by a significant increase to the end of the testing period (Table 19). These results, in particular those of the placebo group, do not follow the trend of the CPK values on the respective days and therefore do not seem follow the natural progression of DOMS. This introduces the possibility of unaccounted variables.

5.5.2.2 Total extension power

In both the placebo and treatment groups there is an intial decrease in the mean total extension power after the race due to the onset of DOMS (Table 21). This is followed by an increase over the recovery period. This follows the expected progression of DOMS which is characterised by an initial decrease of strength after the race correlating with muscle damage. There is a gradual increase in strength as DOMS is repaired. When comparing the means of the placebo and treatment groups using the Wilcoxin Signed Rank Test (Table 22), it is noted that although there is no significant difference between the values recorded on Saturday as opposed to Monday, both groups show a significant increased power output by Friday. This increase is statitically more substantial for the placebo group, possibly due to reasons as described previously.

Given hindsight, the structure of the research project would be modified in order to decrease the variables which may have accounted for the large standard deviation in the results. Firstly, so as to reduce the variability of individual fitness levels, subjects with no previous training history over the past six months would be chosen. The second important variable to eliminate is that which determines the subjects level of exertion or effort . This could be done by having each subject run on a treadmill at a particular speed and gradient for a specified period of time so as to ensure that an effective and similar level of DOMS would occur in each subject. It appeared from the results that the recovery rate from DOMS was too rapid to determine the efficacy of Traumeel S in its treatment. With previously untrained individuals there would be no competitive reason for one subject to excell over another and no need for individuals to carbo-load or take other performance enhancing substances. Finally, a larger sample group would be chosen so as to reduce the standard deviation.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

With the analysis of the effectiveness of Traumeel S in the treatment of delayed onset muscle stiffness it was found that the only parameter that followed the natural progression of DOMS was the measurement of CPK in the blood. It was determined during the course of the research that there were additional, unaccounted for variables which resulted in a higher than expected standard deviation. No significant difference was observed between the placebo and treatment group over all parameters measured. In some instances a trend was observed in which the placebo group showed a higher statistical significance than the treatment group. It cannot be concluded that Traumeel S is ineffective in the treatment of DOMS because the sample size consisted of only 15 subjects per group, there was a variability in the marathon times, a difference between the individual pre-race fitness levels and subsequent performances as well as the study being conducted over three different marathons of varying difficulty.

It is therefore recommended that these variables be removed for future studies by:

1. Increasing the sample group to at least 20 subjects per group would aid in reducing the effect of the variability of the results and highlight the major trends.

2. Using subjects with no previous training or running experience,

3. Testing each subject on a treadmill at a set speed and gradient for a specified length of time.

REFERENCES

Armstrong, R.B., Ogilvie, R.W. and Schwane, J.A. 1983. Eccentric exercise-induced injury to rat skeletal muscle. Journal of Applied Physiology, 54:90-93.

Armstrong, R.B. 1984. Mechanisms of exercise-induced delayed muscular soreness: a brief review. Medicine and Science in Sport and Exercise, 16 :529-38.

Armstrong, R.B. 1990. Initial events in exercise-induced muscular injury. Medicine and Science in Sports and Exercise, 22:429-35.

Armstrong, R.B., Warren, G.L. and Warren, J.A. 1991. Mechanisms of exercise-induced muscle fibre injury. Sports Medicine, 12:184-207.

Armstrong, R.B. 1990. Initial events in exercise-induced muscular injury. Medicine and Science in Sports and Exercise, 22:429-35.

Astrand, P.O. and Rodahl, K. 1986. A Textbook of Work Physiology, ed 3. New York : McGraw-Hill.

Balnave, C.D. and Thompson, M.W. 1993. Effect of training on eccentric excercise-induced muscle damage. Journal of Applied Physiology, 75(4):1545-51.

Böhmer, D. and Ambrus, P. 1992. Treatment of sports injuries with Traumeel ointment. Biological Therapy, 4: 290-300.

Boone, J.B.Jr., Lambert, C.P., Flynn, M.G., Michaud, T.J., Rodriguez-Zayas, J.A. and Andres, F.F. 1990. Resistance exercise effects on plasma cortisol, testosterone and creatine kinase activity in anabolic-androgenic steroid users. International Journal of Sports Medicine, 4: 293-97.

Byrnes, W.C. and Clarkson, P.M. 1986. Delayed onset muscle soreness and training. Clinical Sports Medicine, 5:605-14.

Byrnes, W.C., Clarkson, P.M., White, S.J., Hsieh, S.S., Frykman, P.N. and Maughan, R.J. 1985. Delayed onset muscle soreness following repeated bouts of downhill running. Journal of Applied Physiology, 59:710-15.

Clarkson, P.M., Byrnes, W.C., Gillisson, E. and Harper. E. 1987. Adaptation to exercise-induced muscle damage. Clinical Science, 73:383-86.

Clarkson, P.M., Litchfield, P., Graves, J., Kirwan, J. and Byrnes, W. 1985. Serum creatine kinase activity following forearm flexion isometric exercise. European Journal of Applied Physiology, 53:368-71.

Clarkson, P.M. and Tremblay, I. 1988. Exercise-induced muscle damage, repair and adaptation in humans. Journal of Applied Physiology, 65:16-17.

Clarkson, P.M., Nosaka, K. and Braun, B. 1992. Muscle function after exercise-induced muscle damage and rapid adaptation. Medicine and Science in Sport and Exercise, 24:512-20.

Clarkson,P.M., Kroll, W. and Melchionda, A. 1981. Age, activity level, isometric strength and fibre type composition. Journal of Gerontology, 36:648-53.

Cress, M.E., Byrnes, W.C., Dickinson, A.L. and Foster, V.L. 1984. Modification of Type II fibre atrophy and LDH isoenzymes consequent of an 8 week endurance training program in elderly women. Medicine and Science in Sports and Exercise, 16:105-8.

Dioszeghy, P. and Mechler, F. 1988. The significance of simultaneous estimation of

serum creatine kinase and myoglobin in neuromuscular diseases. Journal of Neurology, 235:174-76.

Donnelly, A.E., McCormick, K., Maughan, R.J., Whiting, P.H. and Clarkson, P.M. 1988. Effects of a non-steroidal anti-inflammatory drug on delayed onset muscle soreness and indices of damage. British Journal of Sports Medicine, 22:325-38.

Ebbeling, C.B. and Clarkson, P.M. 1989. Exercise-induced muscle damage and adaptation. Journal of Sports Medicine, 7:207-34.

Ebbeling, C.B. and Clarkson, P.M. 1990. Muscle adaptation prior to recovery following eccentric exercise. European Journal of Applied Physiology, 60:26-31.

Edwards, R.H.T., Mills, K.R. and Newham, D.J. !981. Measurement of severity and distribution of of experimental muscle tenderness. Journal of Physiology, 317:1P-2P.

Evans, W.J. 1987. Exercise-induced skeletal muscle damage. Physical Sports Medicine, 15:89-100.

Francis, K.T. and Hoobler, T. 1987. Effects of asprin on delayed muscle soreness. Journal of Sports Medicine, 27:333-37.

Friden, J., Kjorrel, U. and Thornell, L.E. 1984. Delayed muscle soreness and cytoskeletal alterations: an immunological study in man. International Journal of Sports Medicine, 5:15-18.

Friden, J. and Lieber, R.L. 1992. Structural and mechanical basis of exercise-induced muscle injury. Medicine and Science in Sports and Exercise, 24 (5):521-30.

Friden, J., Sjostrom, M. and Ekblom, B. 1983. Myofibrilar damage following intense eccentric exercise in man. International Journal of Sports Medicine, 4:170-76.

Friden, J., Seger, J., Sjostrom, M. and Ekblom, B. 1983. Adaptive response in human skeletal muscle subjected to prolonged eccentric training. International Journal of Sports Medicine, 4:177-83.

Friden, J., Sfakianos, P.N. and Hargens, A.R. 1986. Muscle soreness and intramuscular fluid pressure: comparison between eccentric and concentric load. Journal of Applied Physiology, 61:2175-79.

Friden, J., Seger, J. and Ekblom, B. 1988. Sublethal muscle fiber injuries after high-tension anaerobic exercise in man. European Journal of Applied Physiology, 57:360-68.

Gale, A.N. and Murphy, E.A. 1979. The use of serum creatine phosphokinase in genetic counselling for Duchenne muscular dystrophy. Journal of Chronic Disease, 32:639-51.

Grimby, G. and Saltin, B. 1983. The ageing muscle. Clinical Physiology, 3:209-18.

Hansen, K.N., Bjerre-Knudsen, J., Brodthagen, U., Jordal, R. and Paule, P.E. 1982. Muscle cell leakage due to long distance training. European Journal of Applied Physiology, 48:177-88.

Hasson, S.M., Wible, C.L., Reich, M., Barnes, W.S. and Williams, J.H. 1992. Dexamethasone iontophoresis: effect on delayed onset muscle soreness and muscle function. Canadian Journal of Sports Science, 17:8-13.

Hasson, S.M., Daniels, J.C., Divine, J.G., Niebuhr, B.R., Richmond, S., Stein, P.G. and Williams, J.H. 1993. Effect of ibuprofen use on muscle soreness, damage, and performance: a preliminary investigation. Medicine and Science in Sports and Exercise, 25 (1):9-17.

Hill, A.V. 1951. The mechanics of voluntary muscle. Lancet, 261:947-54.

Hoppeler, H. 1986. Exercise-induced ultrastructural changes in skeletal muscle. International Journal of Sports Medicine, 7:76-92.

Hortobagyi, T. and Denahan, T. 1989. Variability in creatine kinase: methodological, exercise and clinically related factors. International Journal of Sports Medicine, 10:69-80.

Hough, T. 1902. Ergographic studies in muscular soreness. American Journal of Physiology, 7:76-92.

Howell, J.N., Chila, A.G., Ford, G., David, D. and Gates, T. 1985. An electromyographic study of elbow motion during postexercise muscle soreness. Journal of Applied Physiology, 58: (5):1713-18.

Howell, J.N., Chila, A.G., Ford, G., David, D. and Gates, T. 1985. An electromyographic study of elbow motion during postexercise muscle soreness. Journal of Applied Physiology, 58:1713-18.

Ignelzi, R.J. and Atkinson, J.H. 1980. Pain and its modulation: Part 2. Efferent mechanisms. Neurosurgery, 6:584-87.

Jenkins, R.R. 1988. Free radical chemistry. Sports Medicine, 5:156-70.

Jones, D.A., Newham, D.J., Round, J.M. and Tolfree, S.E.J. 1986. Experimental human muscle damage: morphological changes in relation to other indices of damage. Journal of Physiology, 375:435-48.

Jones, D.A., Newham, D.J., Round, J.M. and Tolfree, S.E.J. 1986. Experimental human muscle damage: morphological changes in relation to other indices of damage. Journal of Physiology, 375: 435-48.

Karamizrak, S.O., Ergen, E., Tore, R.I. and Akgun, N. 1994. Changes in serum creatine kinase, lactate dehydrogenase and aldolase activities following supramaximal exercise in athletes. The Journal of Sports Medicine and Physical Fitness, 34:141-46.

Kelly, D.D. 1982. The role of endorphins in stress-induced analgesia. Annals of the New York Academy of Science, 398:260-70.

Kuipers, H., Keizer, H.A., Verstappen, F.T.J. and Costill, D.L. 1985. Influence of a prostaglandin-inhibiting drug on muscle soreness after eccentric work. International Journal of Sports Medicine, 6:336-39.

Kuipers, H., Janssen, E., Keizer, H. and Verstappen, F. 1985. Serum CPK and amount of muscle damage in rats. Medicine and Science in Sports and Exercise, 17:195-99.

Kuipers, H., Drukker, J., Fredrik, P.M., Geurten, P. and von Kranenburg, G. 1983. Muscle degeneration after exercise in rats. International Journal of Sports Medicine, 4:45-51.

Kuipers, H. 1994. Exercise-induced muscle damage. International Journal of Sports Medicine, 15 (3):132-35.

Leach, R.E. 1982. The prevention and rehabilitation of soft tissue injuries. International Journal of Sports Medicine, 3:18-20.

Lexell, J., Hendrikson-Larsen, J., Winblad, B. and Sjostrom, M. 1983. Distribution of different fibre types in human skeletal muscles. Effects of aging studies in whole cross sections. Muscle and Nerve, 6:588-95.

Lindena, J., Kupper, W., Friedel, R. and Trautschold, I. 1979. Lymphatic transport of cellular enzymesfrom muscle into the intravascular compartment. Enzyme, 24:120-31.

Manfredi, T.G., Fielding, R.A., O'Reilly, K.P., Meredith, C.N., Lee, H.Y. and Evans, W.J. 1991. Plasma creatine kinase activity and exercise-induced muscle damage in older men. Medicine ans Science in Sports and Exercise, 23 (9):1028-34.

Maresh, C.M., Allison, T.G., Noble, B.J., Drash, A. and Kraemer, W.J. 1989. Substrate and hormone responses to exercise following a marathon run. International Journal of Sports Medicine, 10 (2):101-106.

Meltzer, H.Y. 1971. Factors affecting serum creatine phosphokinase levels in the general population: the role of race, activity and sex. Clin Chim Acta, 33:165-72.

Melzack, R. and Wall, P.D. 1965. Pain mechanisms: a new theory. Science, 150:971-79.

Miles, M.P. and Clarkson, P.M. 1994. Exercise-induced muscle pain, soreness and cramps. Journal of Sports Medicine and Physical Fitness, 34:203-16.

Milne, C.J. 1988. Rhabdomyolysis, myoglobinuria and exercise. Journal of Sports Medicine, 6:93-106.

Nathan, P. 1980. Recent advances in understanding pain. British Journal of Psychiatry, 136:509-12.

Newham, D.J. and Jones, D.A. 1985. Intra-muscular pressure in the painful human bisceps. Journal of Clinical Science, 69:27-29.

Jones, D.A. and Round, J.M. Skeletal Muscle in Health and Disease: A Textbook of Muscle Physiology. New York: Manchester University Press. 1990. pp158-74.

Newham, D.J., McPhail, G., Mills, K.R. and Edwards, R.H.T. 1983. Ultrastructural changes after concentric and eccentric contractions of human muscle. Journal of Neurological Science, 61:109-22.

Newham, D.J., Mills, K.R., Quigley, R. and Edwards, R.H.T. 1983. Pain and fatigue after concentric and eccentric muscle contractions. Journal of Clinical Science, 64:45-52.

Newham, D.J. 1988. The consequences of eccentric contractions and th/ir relationships to delayed onset muscle pain. European Journal of Applied Physiology, 57:353-59.

Nimmo, M.A. and Snow, D.H. 1982. Time course of ultrastructural changes in skeletal muscle after two types of exercise. Journal of Applied Physiology, 52:910-13.

Nurenberg, P., Giddings, C.J., Stray-Gundersen, J., Fleckenstein, J.L., Gonyea, W.J. and Peshock, R.M. 1992. MR imaging-guided muscle biopsy for correlation of increased signal intensity with ultrastructural change and delayed onset muscle soreness after exercise. Radiology, 184:865-869.

Nuttal, F.Q. and Jones, B. 1968. Creatine kinase and glutamic oxylacetic transaminase activity in serum: Kinetics of change with exercise and effect of physical conditioning. Journal of Laboratory and Clinical Investigation, 71:847-54.

Nuviala, R.J., Roda, L., Lapieza, M.G., Boned, B. and Giner, A. 1992. The Journal of Sports Medicine and Physical Fitness, 32:180-86.

Orlander, J., Kiessling, K.H., Larsson, L., Karlsson, J. and Aniansson, A. 1978. Skeletal muscle metabolism and ultrastructure in relation to age in sedentary men. Acta Physiology Scandinavia, 104:249-61.

Pargman, D. and Baker, M.C. 1980. Running high: enkephalin indicated. Journal of Drug Issues, 10:341-49.

Robinson, D., Williams, P.T., Worthington, D.J. and Carter, T.J.N. 1982. Raised creatine kinase activity and the presence of creatine kinase MB isoenzyme after exercise. British Medical Journal, 285:1619-20.

Roti, S., Iori, E., Guidicci, U., Emanuele, R. and Robuschi, G. 1981. Serum concentrations of myoglobin, creatine phosphokinase, and lactic dehydrogenase after exercise in trained and untrained athletes. Journal of Sports Medicine and Physical Fitness, 21:113-18.

Schwane, J.A. and Armstrong, R.B. 1983. Effect of training on skeletal muscle injury from downhill running in rats. Journal of Applied Physiology, 55:969-75.

Schwane, A.J., Johnson, S.R., Vandenakker, C.B. and Armstrong, R.B. 1983. Delayed onset muscle soreness and plasma CPK and LDH activities after downhill running. Medicine and Science in Sports and Exercise, 15:51-56.

Shellock, F.G. and Prentice, W.E. 1985. Warming up and stretching for improved performance and prevention of sports-related injuries. Sports Medicine, 2: 267-78.

Soeder, G., Golf, S.W., Graef, V. et al., 1989. Enzyme catalytic concentrations in human plasma after a marathon. Clinical Biochemistry, 22:155-59.

Stauber, W.T. 1989. Eccentric action of muscles: physiology, injury and adaptation. Exercise Sports Science Review, 17:157-85.

Taylor, C., Rogers, C., Goodman, C. et al., 1987. Haematologic, iron-related, and acute-phase protein responses to sustained strenuous exercise. Journal of Applied Physiology, 62 (2):464-49.

Tiidus, P.M. and Ianuzzo, C.D. 1983. Effects of internsity and duration of muscular exercise on delayed soreness and serum enzyme activities. Medicine and Science in Sport and Exercise, 15:461-65.

APPENDIX A

INFORMED CONSENT FORM

(To be completed in duplicate by patient/subject*) *delete non aplicable

Title of Research Project

Name of Supervisor

Name of Research Student

PLEASE CIRCLE THE APPROPRIATE ANSWER

1. Have you read the research information sheet ? yes/no
2. Have you had an opportunity to ask questions regarding this study ? yes/no
3. Have you received satisfactory answers to your questions ? yes/no

4. Have you had an opportunity to discuss this study ? yes/no
5. Have you received enough information about this study ? yes/no

6. Who have you spoken to ? ----------
7. Do you understand the implications of your involvement ? yes/no

8. Do you understand that you are free to withdraw from this study ? yes/no
a) at any time
b) without having to give a reason for withdrawing, and
c) without affecting your future health care.

9. Do you agree to voulntarily participate in this study ? yes/no

Patient/Subject* Name ---------- Signature ----------

Parent/Guardian* Name ---------- Signature ----------

Witness Name ---------- Signature ----------

Research Student Name ---------- Signature ----------

APPENDIX B

Name:- Date:-

Address:-
Tel:- (w) (h)

Age (yrs):-
Height (cm):-
Weight (kg):-

Years running experience:-

Best marathon time:-

Average training distance per week:-

Do you suffer from any health or medically related problems?

1. Did you carbo-load before the marathon?
2. Average training distance for the last 6 weeks?
   Distance per week:-
3. Training distance during the week before the marathon?
4. Last long run before the marathon (more than 21km)
   Date:- Distance:- Time:-

APPENDIX C

Day:- Date:-

Name:-

Marathon Time (Monday only):-

CPK blood level:- Time of sampling:-

Vertical jump distance (mm):-

Flexibility (mm):- positive negative

Isokinetic Muscle Testing (if applicable to that day)
Dominant leg:- R / L

Work done during flexion:- Total flexion power:-
Work done during extention:- Total extention power:-

Injection:- Traumeel S / Placebo

Pain and Soreness Scale:-
Circle the one that best applies at this moment.

0 Not sore
1 Tight
2 Sore
3 Sore and tight
4 Very sore
5 Very sore and very tight

APPENDIX D

Pharmacological and Clinical Application of the Individual Components of Traumeel S

Aconitum napellus D2:

a) Analgesic, antineuralgic,
b) haemostatic due to attack on the arterial vascular system; raising the tone of the vessels; reducing the emergence of erythrocytes by diapedesis and avoiding the formation of erythromas,
c) acute anti-inflammatory.

Arnica montanna D2:

a) Stimulation of wound healing,
b) stimulation to the healing process of fractures, dislocations, contusions and haematomas,
c) haemostatic action similar to Aconitum,
d) overcoming feelings of total exhaustion,
e) reducing oversensitivity towards movement or vibration,
f) overcoming restlessness and shock.

Bellis perennis D2:

Has a similar action to Arnica in particular,
a) decreasing exudative processes such as contusions and bruises,
b) increased resorption of oedemas and haematomas,
c) reducing myalgic complaints.

Belladonna D2:

a) Reduction in congestion especially arterial hyperaemia,
b) localised reaction phases without softening,
c) reduction in symptoms of rubor, dolor, calor, tumor.

Calendula officinalis D2:

a) Antiphlogistic with stimulation of wound healing by promoting granulation,
b) stimulates healing of badly contused wounds and abrasions,
c) analgesic.

Chamomilla D3:

a) Similar antiphlogistic action to Calendula, with promotion of granulation,
b) analgesic and antispasmodic, decreases restlessness,
c) promotes the healing of wounds and ulcers.

Echinacea angustifolia D2:

a) Stimulates the bodies own defense system,
b) reduces inflammation of any type and at any localisation in the body,
c) reduces septic processes,
d) has an anti-inflammatory effect by inhibiting hyaluronidase activity,
e) promotes wound healing.

Echinacea purpurea D2:

a) Activation of the histogenic and haematogenic defense in inflammatory processes and general infection,
b) stimulation of fibroblastic activity.

Hamamelis D1:

a) Reduces parenchymatous multiple venous haemorrhages,
b) inhibits inflammation and heightens analgesia,
c) antithrombotic effect by eliminating venous stasis.

Hepar sulfuris D6:

a) Reduces the inclination to suppurations (furuncles, pyodermia, phlegmons etc.),
b) reduces vessel permeability,
c) regenerating action on sulfide group containing oxidation-reduction systems (coenzyme A, gluthion etc.),
d) supports and improves the oxidative processes and vesicular breathing in traumatised tissue.

Hypericum perfoliatum D2:

a) Haemostatic action,
b) promotion of wound healing,
c) restores function after nerve damage by contusion or lesion.

Mercurius solubilis D6:

a) Anti-suppurative action, especially at the start of iinflammation
b) reduction of lymph vessel and node swelling,
c) reduction of oedematous swellings ie: the pathological sol-condition of the tissue colloids is brought back to the physiological gel state by the mercurial compounds.

Millefolium D3:

a) Haemostatic, especially in arterial and precapillary as well as arterial-venous (anastomotic) seeping haemorrhages and other micro-haemorrhages.

Symphytum D6:

a) Bruises, haematomas, contusions and distortions,
b) causal complaints,
c) stimulation of wound healing,
d) stimulation of callus formation in bone injuries,
e) primary site of action on the periosteum.