CHAPTER THREE : METHODS & PROCEDURES

3.1 METHODS

In this chapter we will discuss the methods and procedures used for the testing of the subjects in this study.

3.1.1. SUBJECTS

A Physician or Rheumatologists referred subjects. Participation in the study was voluntary and all participants completed and signed a consent form prior to participating in the study. (Appendix A)

Criteria used to determine the eligibility of a subject, for the study, was as follows:

* INCLUSION CRITERIA

- Ten people diagnosed with RA according to the 1988 revised Arthritis Rheumatology Association (ARA) criteria;
- Diagnosed with RA for more than 2 years;
- Functional class I and II (Steinbrocker criteria for RA classification – classification of functional impairment);
- Ages ranging from 20 to 70 years;
- With stable medication for the last 3 months;

* EXCLUSION CRITERIA

- Unstable cardiopulmonary disease;
- Acute joint symptoms;

- Currently participating in a physical fitness programme or organized sports activity;

The subjects were randomly assigned to a group. Group W being the group participating in the water-based exercise programme. The land-based exercise programme group was group L. Group C was the control group; they were requested to continue with their present lifestyle and did not follow an exercise programme.

TABLE VI: SUBJECT DATA

	Water group x ± SD	Land group x ± SD	Control Group ± SD
Age	58.5 ± 7.5	52.7 ± 8.3	48 ± 7
Height (cm)	161.2 ± 1.5	177 ± 15	168.7 ± 1.8
Body Mass (kg)	79.2 ± 11.5	78.7 ± 26.5	57.3 ± 3.8
Disease duration (yrs)	5.5 ± 4.1	4.5 ± 3.7	11.5 ± 2.1
Functional class	I & II	I & II	I & II
ESR	20.5 ± 21	14.75 ± 10	24 ± 8

3.1.2 EQUIPMENT

TABLE VII : EQUIPMENT

EQUIPMENT USED	
Height (standing)	Harpenden Anthropometer
Body mass	Detecto Standing Scale
Blood pressure and grip strength	Tycos Sphygmomanometer and Sethoscope
50 ft walk test	Komelon.NEO 330 (20 m); tape measure and Avant Sport Timer stop-watch
Physical work capacity	Cybex bicycle ergometer
Knee flexion and extension strength	Cybex Norm 7000 (isokinetic dynamometer
Wrist and knee range of motion (ROM)	Baseline TM Goniometer

Figure 40 : Harpenden Athropometer

Figure 41 : Detecto Standing Scale

Figure 42 : Tycos Sphygmomanometer and Stethoscope

Figure 43 : Komelon NEO 330 (20 m) tape measure and Avant sport timer stop-watch

Figure 44 : Cybex bicycle ergometer

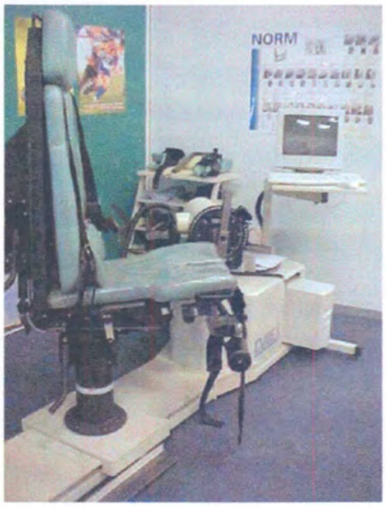

Figure 45: Cybex Norm 7000

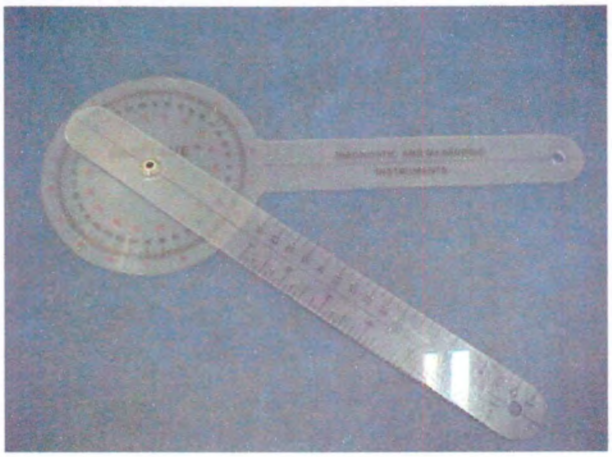

Figure 46 : Baseline TM Goniometer

Equipment required for the execution of the study, which was used specifically for the rehabilitation programmes, is shown in table XI.

TABLE VIII : WATER AND LAND EXERCISE PROGRAMME EQUIPMENT

WATER EXERCISE PROGRAMME	LAND EXERCISE PROGRAMME
Indoor heated swimming pool (± 30°C)	EC 3200 cat-eye ergoexeciser bicycle; (recumbant and upright)
Water noodles	Health-walker (Gym-Trim)
	Treadmill; (Technogym's Run XT)
	Dumbells; pro-equipment cabel pulley system; Swissball; universal gymnasium apparatus; gymnastic mats; a towel

3.2 PROCEDURES

Each patient was evaluated three times throughout the study. Before the exercise intervention, five to six weeks into exercise intervention, and at the end of the exercise intervention (three months).

3.2.1 CLINICAL ASSESSMENT

All clinical assessments were done by a Rheumatology Specialist. The patient's functional impairment was classified according to Steinbrocker (Ball & Koopman, 1986) (Appendix B). Joints were examined for soft-tissue swelling, tenderness and pain during motion, using the American College of Rheumatology, Rheumatoid Arthritis Clinical Response Criteria – ACR20 (Ritchie et al., 1968) (Appendix C).

Figure 47 : Joint Examination

3.2.2 LABORATORY ASSESSMENT

Blood samples were drawn and standard laboratory procedures were used to estimate Erythrocyte sedimentation rate (ESR) (modified westergren mm/h) and hemoglobin (gm/dl) (Lyngberg et al., 1994).

Figure 48 : Blood sample being drawn

3.2.3 PATIENTS ASSESSMENT

Subjects were required to complete 2 questionnaires :

- Health Assessment Questionnaire (HAQ): The HAQ is the most widely employed measure to evaluate the effect of treatment on functional ability in RA (Fries, 1983) (Appendix D).

- Profile of Mood States (POMS): Measures identifiable mood or affective states. (Educational and Industrial Testing Service, 1971) (Appendix E)

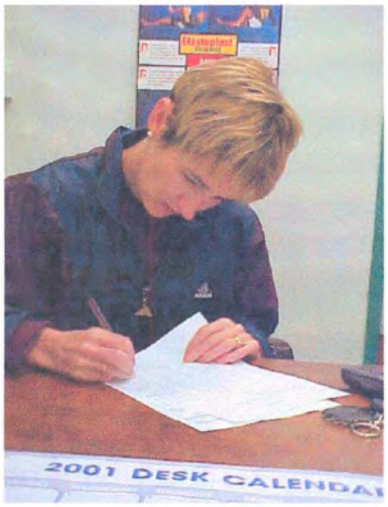

Figure 49 : Questionnaires completed by subjects

3.2.4 FUNCTIONAL ASSESSMENT

Height: Height is calculated to the nearest 0,1 cm with an anthropometer and is defined as the distance between the soles of the feet and the vertex. Height was taken while the subject stands up straight, barefoot with heel, gluteus maximus, and upper-back and back of head against the anthropometer. The ears, acromion, greater trochanter, back of patella and front of calcaneus are in the same vertical line. The angle of the eye and the upper hole of the ear are in the same horizontal level. Measurement is taken while the subjects inhale deeply. No asymmetry was allowed (Smit, 1979; Eston & Reilly, 1996).

Figure 50: Height measurement

Body Mass: Body mass was weighed with minimum clothing. The scale was calibrated before each subject was weighed and subjects mass was calculated to the nearest 0,1 kg. (Eston & Reilly, 1996).

Figure 51 : Body Mass Measurement

Blood Pressure: Measurement of blood pressure at the brachial artery by the ausculatory method. A sphygmomanometer is inflated so its pressure exceeds the systolic pressure. Blood flow is occluded and a brachial pulse cannot be felt or heard. After which the pressure within the cuff is reduced by small increments and the examiner listens until a faint sound occurs. This sound represents blood flowing through the brachial artery. The systolic pressure is the pressure created on the walls of the artery when the 1st soft-tapping sound occurs. As the pressure in the cuff is lowered further distinct sounds continue to be heard as flood flows through the artery for longer portions of the cardiac cycle. The pressure in the artery when the sounds disappear is the diastolic pressure (McArdle et al., 1991).

Figure 52 : Blood Pressure Measurement

50-ft Walk Test: Patients had to walk as fast as possible over a distance of 50-ft. Walk-time is the number of seconds it takes a subject to walk 50-ft. Walk-time often increases with more disease activity. Fifty-feet was identified on a flat, straight floor and marked with masking tape. Each subject was instructed to start walking 18 ft prior to the marked area so that stride was established prior to the subject reaching the designated starting point. Time used to walk 50ft was determined by a stop-watch and recorded in seconds (Norceau et al. 1995)

Figure 53 : 50-ft Walk

Grip Strength: Grip strength was measured in each hand at each assessment by using a rolled-up blood pressure cuff connected to a portable sphygmomanometer with a mercury manometer, which was pumped up to 20 mm Hg (the mercury will rise depending on the force of the subject's hand-grip). Subjects performed 3 handgrips for each hand and the mean for each hand will be used (Walker & Heleva, 1996).

Figure 54 : Grip Strength Measurement

Bicycle Ergometer Testing: (Aerobic capacity): The Astrand – Rhyming protocol to obtain data for calculating the estimated VO_2max of each subject was used. The test was started with an initial load of 25W at a cadence of 60 – 70 revolutions s^{-1} with an increment increase of 25 W until exhaustion. This protocol is advantageous in terms of procedures and facilitated eliciting peak VO_2 and maximum power output data in individuals with low exercise tolerance. (Norceau et al.,1995).

Figure 55 : Aerobic Capacity

Muscle Strength: The isokinetic strength of the knee extensors and flexors was tested on a dynamometer. Tests were performed on the Cybex Norm 7000. A speed of 60°/second was used, 3 trial repetitions were given and 5 test repetitions were performed.

- Calibration of the Cybex Norm 7000: The Cybex Norm was calibrated regularly throughout the study. Calibration is a process for adjusting or "fine tuning" the accuracy of the gradations of a measurement system. The NORM system is capable of measuring from 0 to 500 ft-lbs. (678Nm) of torque and of attaining a speed of up to 500 deg/sec. The weight calibration procedure makes use of the principle that "the quantity of weight on an input arm set to a specific, pre-determined length will generate a known amount of torque when it falls". During weight calibration, a quantity of 100 lbs. is dropped.

- Position of the Subjects: The importance of positioning and stabilizing of the subject on the dynamometer, is to isolate the target muscle group and to eliminate contribution from accessory muscles as much as possible (MacDougall et al., 1991; Perrin, 1993). In order to eliminate contribution of the upper extremities during the assessment of the lower extremities, the subject should be stabilized with straps at the waist and the chest and the arms should be across the chest (Perrin, 1993).

  To isolate the performance of single muscle groups, the isokinetic testing usually occurs through the cardinal planes of the body. These movements include rotation through the transverse plane, abduction and adduction through the frontal plane and flexion and extension through the sagittal plan (Roy & Irvin,1983; Perrin, 1993).

  In order to facilitate movement through the planes, the axis of rotation of the joint that is being assessed should be aligned as close as possible with the axis of rotation of the dynometer (MacDougall et al., 1991; Perrin, 1993).

Figure 56 : Muscle Strength Testing

- Wrist Range-of-Motion
  - Wrist Extension: Goniometer placement, axis over the styloid process of the radius

    Stationary arm: Parallel to the long axis of the radius;

    Movable arm: Parallel to the longitudinal axis of the second metacarpal;

    Starting position: The forearm rests on the table in mid-position; the wrist in neutral position; the fingers should be relaxed;

    End position: The hand has moved toward the dorsal forearm to the limit of motion (Trombly, [3rd ed]).

Figure 57 : Wrist Extension Measurement

  - Wrist Flexion: Goniometer placement; axis : over the styloid process of the radius, which is located on the lateral aspect of the wrist at the anatomical snuff box.

Stationary Arm: Parallel to the longitudinal axis of the radius;

Movable Arm: Parallel to the longitudinal axis of the second metacarpal;

Starting Position: Forearm rests on the table in mid-position; wrist in neutral position. The fingers are relaxed;

End Position: The hand has moved toward the valar forearm to the limit of motion (Thormbly, Third Edition).

<u>Figure 58</u> : Wrist Flexion Measurement

- Knee Range-of-Motion
  - <u>Knee Extension</u>: Goniometer placement; axis: The knee joint at the lateral tibial condyle

    Stationary arm: Along the mid-line of the femur on the lateral aspect of the thigh;

    Moveable Arm: Along the lateral mid-line of the lower leg in line with the lateral malleolus

    Starting Position: Patient sits with knees flexed and the lower legs over the table edge.

    End Position: Leg is extended (Thrombly, Third Edition)

Figure 59: Knee Extension Measurement

Knee Flexion: Goniometer placement: axis: The knee joint at the lateral tibial condyle;

Stationary Arm: Along the mid-line of the femur on the lateral aspect of the thigh;

Movable Arm: Along the lateral mid-line of the lower leg in the line with the lateral malleolus

Starting Position: Patient sits with knees flexed and the lower legs over the table edge;

End Position: The lower leg is moved so that the calf approximates the posterior thigh to the limit of flexion (Trombly, [3rd ed])

Figure 60 : Knee Flexion Measurement

3.3 EXERCISE PROGRAMMES

Subjects were randomly assigned, either to the water based exercise group, land based exercise group, or to the control group. Subjects in the exercise groups were required to exercise 2 – 3 times per week for a 3-month period. While those in the control group were instructed to continue with their normal sedentary lifestyle. The land based exercise group and water based exercise group attended the exercise classes at the University of Pretoria Rehabilitation Gymnasium and Hydrotherapy pool, respectively. Groups were instructed and supervised by the Candidate.

Both the land and water based exercise programmes were aimed at improving range-of-motion (ROM), muscle strength and cardiovascular endurance. The exercise intervention consisted of warm-up exercises, strengthening exercises, aerobic exercises and cool-down exercises with stretches. The duration of the 2 programmes were approximately 45 minutes each.

3.3.1 PROGRAMME I : LAND-BASED EXERCISE PROGRAMME

A combination of non-weight bearing and weight bearing exercises were used. The exercise regimen consisted of warm-up exercises, strengthening exercises, aerobic exercises and cool-down exercises with stretching. Initially, the duration of the warm-up and strengthening phases were longer, in order to build muscle strength. Aerobic time was gradually increased as cardiovascular fitness improved.

BASIC PROGRAMME (It is important to note that the basic programme was adjusted according to individual needs, abilities and limitations due to the RA of the patient. In addition the exercises were adjusted as the patient progressed).

Figure 61 : Cycling

- **WARM-UP EXERCISE**

  Cycling: A recumbant or upright bicycle was used. The duration of the warm-up was 3 to 5 minutes – the speed and resistance varied according to the patients capabilities.

- **STRENGTHENING EXERCISE** (2 sets of 15 – 20 repetitions were performed by each patient)

LOWER BODY STRENGTHENING EXERCISES

Standing Hip Abduction (Pulley-system): The ankle strap of the pulley was placed around the right ankle of the patient. The starting position was that of an upright posture, feet placed next to each other. The patient lifted the right leg upwards and outwards (hip abduction) against the resistance of the cable. The end position (in abduction of approximately 50° - 60° was held for a moment and then controlled back to the starting position. Emphasis was placed on correct posture and controlled movement. A weight, permitting 15 repetitions, was used. The same was repeated with the left leg.

Figure 62: Standing Hip Abduction

Standing Hip Adduction (Pulley-system): The ankle strap of the pulley was placed around the right ankle. The starting position was that of an upright posture with weight supported on the left leg and the right leg slightly elevated to the side. The leg was pulled inwards (adduction) against the resistance of the cable until the legs came together. Once again posture was stressed and the supporting knee remained 'soft'. A weight, permitting 15

Figure 63 : Standing Hip Adduction

repetitions was used. The same was repeated with the left leg.

Figure 64 : Wall Squats

Wall Squats (Swiss ball): The patient was instructed to lean with his/her back against the ball with the ball being pressed onto the wall. Feet were well forward and placed approximately hip width apart. The patient slowly bent his/her knees (depth of knee bend depended on severity of knee involvement and the patients capabilities). Knees were not allowed to pass toes and knee bend was not allowed to be more than 90°; legs were then straightened and returned to starting position.

Figure 65: Standing calf raises

Standing Calf Raises: The patient stood on the edge of a step, feet, hip width, apart. Patient lifted-up onto toes as high as possible. Heels where then lowered to starting position.

- ABDOMINAL STRENGTHENING EXERCISES

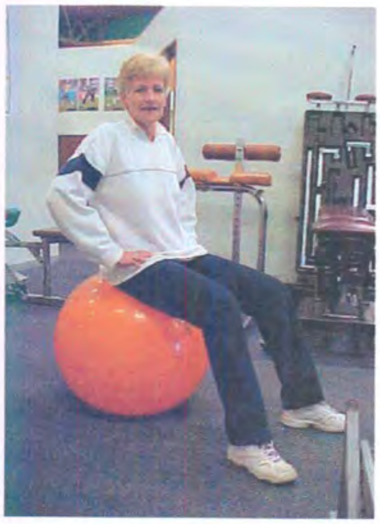

Figure 66 : Pelvic Tilt on Swiss Ball

Pelvic Tilt on the Swiss Ball: Patient was required to sit upright on a Swiss ball (size of the ball was determined by the height of the patient). Patient tilted the pelvis forward by means of contracting the abdominal muscles. This position was held for approximately 2 seconds, thereafter the starting position was resumed.

Figure 67 : **Crunches**

Crunches: Patient lay in a supine position on a mat. Knees were bent with arms placed behind the head. The patient had to lift his/her shoulder off the ground and then return to the starting position. Emphasis was placed on keeping the elbows open with hands placed behind the head to support the neck.

- UPPER BODY STRENGTHENING EXERCISES

Figure 68: **Shoulder Rolls Backwards**

Shoulder Rolls Backwards: The patient was instructed to stand in front of the mirror, feet, hip width apart, arms at the side. (Dumbells could be held in either hand, if hands allowed for this and no strain was placed on the hands and wrists). Shoulders were then moved in a circular motion, backwards.

Figure 69 : **Narrow-Grip Incline Pull-Down**

Narrow-Grip Incline Pull-down: The patient was instructed to sit on a gymnasium bench, placed at approximately 45°. While keeping the back supported against the bench, the narrow-grip pulled towards the patient's chest in a controlled manner. (Correct wrist and finger positioning was stressed). Patient then returned to the starting position in an equally controlled manner.

Figure 70 : Lateral Raises

Lateral Raises: The patient was instructed to stand in front of the mirror, feet, hip width apart, arms at the side. (Dumbells could be held in either hand, if hands allowed for this). While remaining in a perfect upright posture, patient lifted the arm upwards and outwards, (shoulder abduction), until arms where parallel to the ground. The starting position was then resumed.

- **CARDIORESPIRATORY ENDURANCE EXERCISES**

Figure 71 : Treadmill (Walking)

Treadmill (walking): Walking was only included in the patients programme if the RA involvement in the joints of the lower-limbs allowed a normal gait with no pain. If walking was not possible, an alternative aerobic activity was selected such as the bicycle or health-walker. Duration and speed of the walking varied according to the patients ability and was gradually increased as the patient progressed. A minimum of 20 minutes was aimed for. Emphasis was placed on the importance of maintaining good posture while walking.

Figure 72 : Health-Walker

Health-walker: Certain patients used the Gym-trim health-walker, for the aerobic section of their programme due to the limited impact on the joints. Average length strides were used and as the patients fitness improved, duration was lengthened.

Figure 73 : Cycling

Knees had to remain 'soft' at all times and 20 minutes were aimed for.

Cycling: The recumbant or upright bicycle was also an option for the aerobic conditioning of the patient.

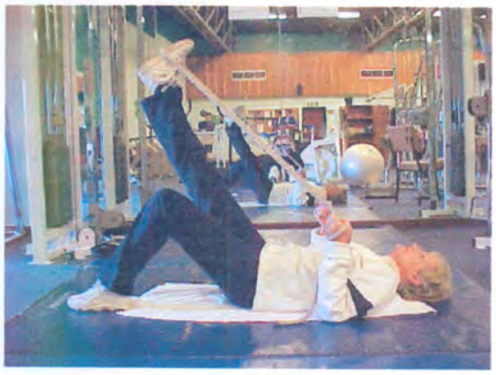

Figure 74 : Hamstring Stretch

Figure 75 : Knee-to-Chest Stretch

STRETCHING & RANGE-OF-MOTION EXERCISES : (Each stretch was held for 20 – 30 seconds and repeated twice)

Hamstring Stretch with rope: The patient lay in a supine position, a rope was placed over the right foot. The left leg remained bent on the floor while the right leg remained straight, the leg was lifted to where slight tension was felt in the hamstring and calf muscle. The stretch was held for 20 – 30 seconds and then performed on the left side.

Knee-to-chest stretch: The patient lay in a supine position with both knees flexed. The right knee was then brought to the chest and held in that position for 20 to 30 seconds. The stretch was then performed on the left side. Patients were instructed to bend the knee to a position of comfort.

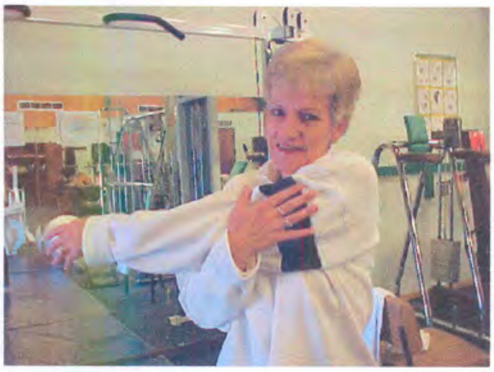

Figure 76 : Shoulder Stretch

Shoulder Stretch: Standing in an upright position, the patient placed the right arm across the chest. Using the left hand slight pressure was placed on the right elbow with slight tension being felt across the upper-back and shoulder. The stretch was held for 20 – 30 seconds and then repeated on the other side.

- **COOL-DOWN AND GENTLE HAND EXERCISES**

Figure 77 : Cycling with gentle hand exercises

Cycling: A cool-down consisted of cycling on the recumbant, or upright bicycle, at a low resistance and slow speed. Patient simultaneously performed gentle finger and wrist range-of-motion exercises. The duration of the cool-down was approximately 3 – 5 minutes

3.3.2 PROGRAMME II : WATER-BASED EXERCISE PROGRAMME

The exercise regimen in the pool also consisted of 4 phases, warm-up exercises, strengthening exercises, aerobic exercises and cool-down exercises with stretches. As with the land-based exercise programme, initially the warm-up and strengthening phases were longer in order to build muscle strength. Gradually, the aerobic minutes were increased.

A basic programme was followed, however, the programme was varied slightly throughout the 12 weeks and individual needs and abilities were taken into consideration.

BASIC PROGRAMME

Figure 78 : Cycling Supported by Noodle

Figure 79 : Standing Hip Abduction/Adduction

Figure 80 : Standing Knee Extension/Flexion

- WARM -UP EXERCISES

Cycling (supported by noodle): The patient placed a noodle along the upper back, arms resting on top of the noodle. The patient then performed a cycling motion with the legs. Patients were instructed to maintain a moderate pace for 3 to 5 minutes.

- STRENGTHENING EXERCISES

- LOWER BODY STRENGTHENING EXERCISES: (Holding on to bar/hand rail for support)

Standing hip abduction/adduction: The patient held lightly onto the rail with the left hand, keeping an upright posture, the patient moved the right leg upward and outwards (hip abduction). The patient was instructed to only move the leg to a height where good posture could be maintained. The right leg was then brought back to the starting position. After completing 20 – 30 repetitions, the same exercise was performed on the left leg.

Standing knee extension/flexion: The patient held lightly onto the rail with the left hand. Right leg was elevated so that the upper leg was approximately parallel to the ground. Keeping the knee motionless, the patient flexed and extended the right leg. After completing 20 – 30 repetitions, the same exercise was performed on the left leg.

Figure 81: Standing Calf Raises

Standing Calf-raises: The patient faced the rail, lightly supporting himself/herself with both hands on the rail. Feet were placed, hip width apart, extending the body to maximum height on the toes and then returning to starting position. 40 – 50 repetitions were performed.

- ABDOMINAL STRENGTHENING EXERCISES:
Standing pelvic tilt: The patient stood facing the rail, lightly supporting himself/herself with both hands on the rail. Feet were placed, hip width apart, knees slightly bent. The patient then performed a forward pelvic tilt by contracting the abdominals. The tilt was held for a few seconds and then released. Breathing during the tilt was emphasised. 20 – 30 repetitions were performed.

Figure 82 : Standing Pelvic Tilt

Reverse crunches (hip flexion with bent knees): The noodle was placed across the upper-back, arms resting on the noodle. The patient lay in a supine position supported by the noodle. Knees were then brought towards the chest and then returned to the starting position. 20 – 30 repetitions were performed.

Figure 83 : Reverse Crunches

- UPPER BODY STRENGTHENING EXERCISES:

Alternative shoulder extension/flexion (standing): The patient stood with one leg in front of the other. Keeping the upper body motionless, the patient extended the right shoulder while simultaneously flexing the left shoulder and vice-versa until approximately 30 – 40 repetitions had been performed on the right and left side.

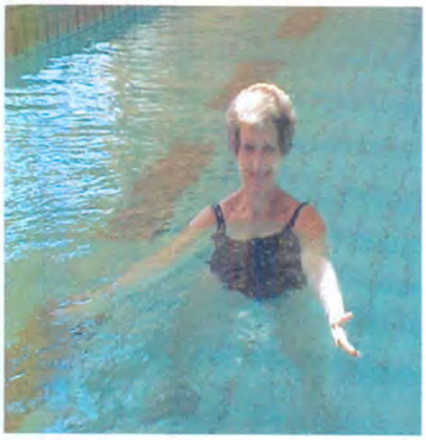

Figure 85 : Shoulder Abduction/Adduction

Shoulder abduction/adduction: The patient stood with feet, shoulder width part, knees bent. The patients right and left arm was held horizontal to the ground, just below the surface of the water. Keeping the arms straight and fingers together, the right and left shoulder was simultaneously adducted and then abducted back to the starting position. 30 – 40 repetitions were performed.

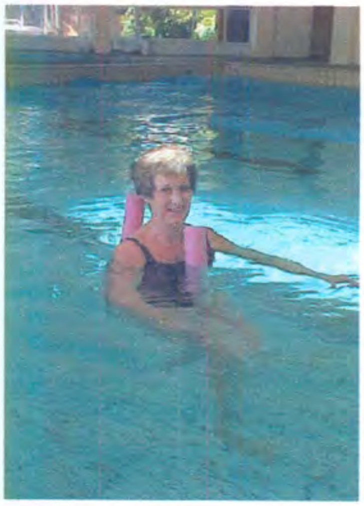

Figure 86 : Cycling, Seated on Noodle

- **CARDIORESPIRATORY ENDURANCE EXERCISES**

Various aerobic exercises were performed. Type and duration of exercise were determined by patients abilities and stage in the programme. 20 minutes were aimed for. Examples : walking variations: walking on toes; walking on heels;

sideways walking; walking forward (lunges), cycling seated on noodle.

- **STRETCHING AND RANGE-OF-MOTION EXERCISES** : (Each stretch was held for 20 – 30 seconds – repeated twice)

Figure 87 : Jog with Wrist and Finger Exercises

Light jog with wrist and finger exercises: The patient performed a light jog while simultaneously performing wrist and finger range-of-motion exercises such as wrist circles, wrist flexion/extension and opening and closing the fingers. The duration was approximately 3 – 5 minutes.

Figure 88 : Hamstring Stretch against the wall

Hamstring stretch against the wall: The patient lightly held onto the rails with both hands while the right leg was placed on the wall, keeping the leg as straight as possible. The left leg remained on the ground, slightly bent. The right leg was placed at a height where slight tension was felt in the hamstring and calf muscle. After holding the stretch it was repeated on the left side.

Figure 89 : Knee-to-Chest Stretch

Knee-to-chest stretch: The patient held the rail with the left hand. Keeping an up-right posture, the right knee was flexed and brought as high as possible to the chest. After holding the stretch it was repeated on the left side.

Figure 90 : Shoulder stretch

Shoulder Stretch: Standing in an upright position, the patient placed the right arm across the chest. Using the left hand, slight pressure was placed on the right elbow so that slight tension was felt across the upper back and shoulder. After holding the stretch for 20 – 30 seconds it was repeated on the other side.

3.4 RESEARCH DESIGN

The important research areas that are common identified by sports and exercise investigators, which land themselves to the application of epidemiologic techniques, are as follows :

1. estimation of the burden of morbidity and/or mortality in populations of athletes;
2. identification of risk factors and high risk participants;
3. development of preventive interventions;
4. evaluation of diagnosis and therapy; and
5. physiological and biomechanical studies of exercise and sports (Walter & Hart, 1990)

In recent years there has been growing interest in applying epidemiologic methods to problems with greater clinical content. This translation of 'classical' epidemiologic techniques to the clinical arena leads to a more systematic evaluation of diagnostic strategies and therapeutic choices and also permits effective critical appraisal of the medical literature. Prominent among these developments has been the evaluation of the randomized controlled trials (RCT) as the preferred method for assessment of new methods of therapy. Randomization greatly reduces the chance of confounding and thereby provides a real advantage over otherwise comparable unrandomized designs, thus alleviating some of the problems of statistical analysis (Walter & Hart, 1990).

Thus, this study was a typical experimental epidemiological study where an intervention (3 month water and land exercise programme) was evaluated. As a result a true pre-test post-test randomized groups experimental design was adopted (Thomas & Nelson, 1990). The only difference was that a mid-test was included because of the possibility of a flare-up in any of the subjects.

R	O_1	T_1	O_2	T_2	O_3
R	O_4	T_3	O_5	T_4	O_6
R	O_7		O_8		O_9

R: Random assignment of subjects to groups;

O: Observation or test (subscripts refer to the order of testing; i.e. O_1 is the first time a test is given and O_2 the second;

T: This signifies that a treatment is applied (the terms T_1 and T_2 on different lines refer to different treatments; terms on the same line mean that the treatment is administrated more than once, a blank space means that the group is a control.

The major purpose of this type of design was to determine the amount of change produced by the treatment (in this case, the 3 month land or water based exercise programme). This design threatens the internal validity of testing, but the threat is controlled, as the comparison of O_7 to O_8 and O_9 in the control group includes the testing effect as well as the comparison of O_1 to O_2 and O_3 in the 1 experimental group and the comparison of O_4 to O_5 and O_6 in the other experimental group. Thus, although the testing effect could not be evaluated, it was controlled (Thomas & Nelson, 1990).

3.5 STATISTICAL ANALYSIS

In consultation with an independent statistician and in cognizance of the size of the groups, the Kruskal – Wallis test for three or more independent groups for the inter-group comparison was adopted as the appropriate statistical technique for the inferential analysis of the data. This test is a non-parametric equivalent to a one-way analysis of variance (ANOVA) (Howel, 1992).

Although this non-parametric statistical test is less powerful than the parametric t-test, it was applied because it does not rely on parametric estimation and/or specific distribution assumptions. The only assumption needed for the Kruskal-Wallis test is that the variances from the different groups must be similar (not necessarily known). Thus, the validity of the test was not affected by whether or not the distribution of the variables in the population was normal or any other specific distribution (Smit, 1999).

For the intra-group comparisons, the Friedman's rank test was adopted. This test is closely related to a standard repeated-measures analysis of variance applied to ranks instead of row scores. It is a test on the null hypothesis that the scores of each treatment were drawn from identical population, and it is especially sensitive to population differences in central tendency (Howell, 1992).

Computations to determine standard descriptive statistics (mean and standard deviation) and the non-parametric analysis (Kruskal-Wallis H test) were performed using the Statistical Package for Social Sciences (SPSS), Microsoft Windows release 9.0.

CHAPTER FOUR : RESULTS & DISCUSSION

The primary aim of the study was to compare the effects of a land based exercise programme with that of a water based exercise programme in RA patients.

The results of the study are displayed in tabular (tables XI to XIV) and graphic form (figures 91 to 114) and are reported in the following categories of dependent variables:

Disease Activity

- **Joints:** **Tender Joint Count (TJC)**
  Swollen Joint Count (SJC)

- **Haematology: Erythrocyte Sedimentation Rate (ESR)**
  Hemoglobin (Hb)

ADL and Psychological Status

- **Health Assessment Questionnaire (HAQ)**
- **Profile Of Mood States (POM)**

Physical Condition

- **Body Mass**
- **Blood pressure**
- **50 – ft walk test**
- **Grip Strength**
- **Aerobic capacity (VO_2max)**
- **Muscle Strength**
- **Joint mobility**

Henceforth each variable is discussed with respect to its response within and between the experimental groups and within the context of the relevant literature.

4.1 DISEASE ACTIVITY

4.1.1 JOINTS

The results indicating the response of the joints with regards to tenderness and swelling among the groups are reflected in table XI and figures 91 and 92.

a) TENDER JOINT COUNT (TJC)

The key signs of joint inflammation in RA are those of tenderness and swelling. The American College of Rheumatology (ACR) TJC is an assessment of 28 joints. The joint count is done by scoring several different aspects of tenderness, as assessed by pressure and joint manipulation on physical examination. The information on various types of tenderness are then collapsed into a tender – versus – no tender dichotomy (Harris, 1997; Kippel & Dieppe, 1994).

There was no significant difference between the three groups with regards to total TJC count at the beginning of the intervention ($p>0.05$). At the end of the exercise intervention, there was a reduction in the total TJC in both, group W and L. There was a significant decrease in total TJC in group W (53%) on the 10% level of significance ($p<0.10$). Although not statistically significant there was a 4.7% decrease in the total TJC in group L. The total TJC of group C remained globally unchanged.

It appears that both exercise interventions (land and water based) had a positive influence on the total TJC. Despite concerns that land exercises may have a negative effect on disease activity, this was not the case in the present study as far as the TJC was concerned. However, it is interesting to note the large decrease in the total TJC in Group W in comparison to group L. Thus, it appears that the water based exercise programme was more effective in reducing the TJC.

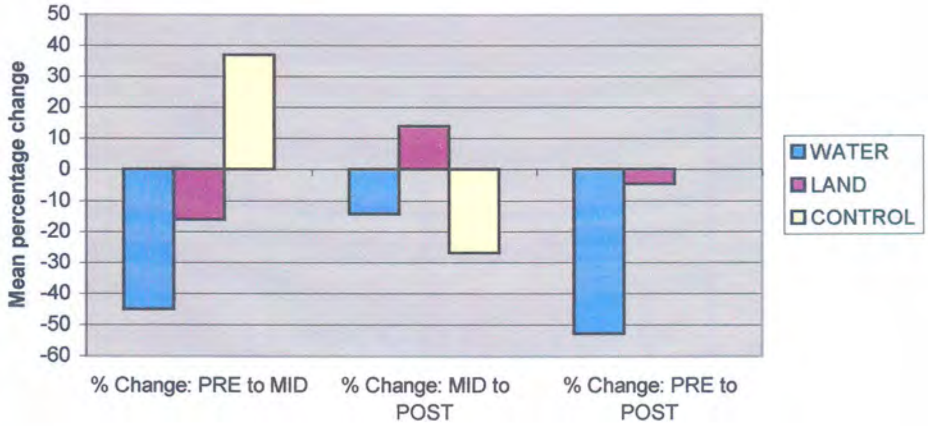

Figure 91: Total Tender Joint Count

b) SWOLLEN JOINT COUNT

A joint is considered 'active' if it is tender on pressure or painful on passive movement with stress and/or swelling other than bony proliferation. Joint swelling may be peri-articular or intra-articular. The ACR SJC is an assessment of 28 or more joints. Joints are either swollen or not swollen (Harris, 1997; Kippel & Dieppe, 1994).

A similar trend was observed in the total SJC. Pre- and post-test results indicate a decrease in the total SJC in both experimental groups but not the control group. There was a 31% decrease in the total SJC in Group W and a decrease of 8,5% in Group L. However, reductions were not statistically significant (p>0.05). No change was observed in group C's total TJC.

Once again both the land and water exercises had a positive effect on the SJC. The land exercises did not increase the SJC even although the decrease in the total SJC was somewhat greater in the water based exercise group.

Therefore it seems that both the land and water exercise interventions had a positive effect on disease activity as far as the TJC and SJC was concerned. However, the water exercises appear to have had a greater positive effect on the joint counts

Table IX: Total Tender & Swollen Joint Counts (* = p < 0.05)

Groups		Control					Water Group					Land Group					Significance		
VARIABLES	UNITS	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	C	W	L
Tender joint count	no.	13.5	7.8	13.5	7.8	0	12.8	7.8	6	2	**53**	10.8	1.7	10.3	3.7	**-4.7**		*	
Swollen joint count	no.	13	4.2	13	4.2	0	8.8	5.0	6	2	**-31**	11.2	2	10.3	2.2	**-8.5**			

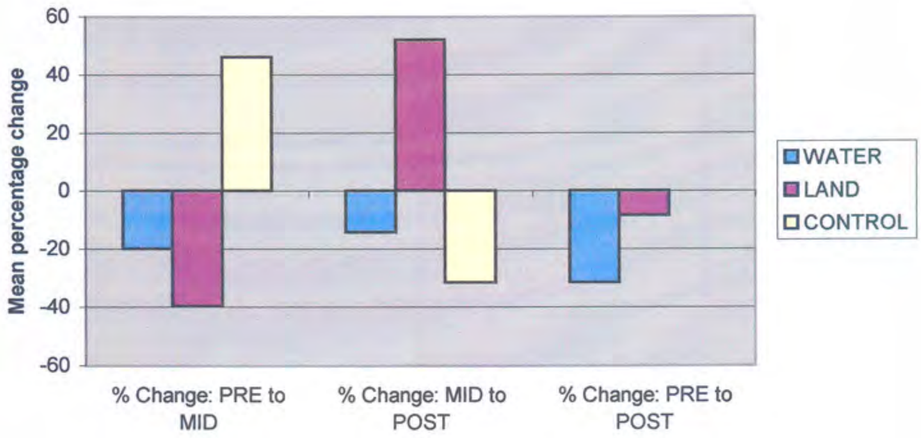

Figure 92: Total Swollen Joint Count

4.2 HAEMATOLOGY

The results indicating the response of blood values with regards to ESR and Hb among the groups are reflected in table X and figure 93 and 94.

a) ERYTHROCYTE SEDIMENTATION RATE (ESR)

The ESR is a convienient index of inflammatory activity in RA and is an indispensable investigation. It is nevertheless an entirely non-specific investigation, elevation depending on acute phase reactants, raised immunoglobulin levels and anaemia (Currey, 1980). The ESR commonly is markedly elevated in RA patients and tends to be parallel with disease activity; exacerbations usually are accompanied by an increase and remissions by a decrease in sedimentation rate (Resnick, 1995). According to the Institute of Pathology (University of Pretoria), the normal physiological range of ESR values is between zero and twenty.

ESR did not significantly change in any of the groups ($p>0.05$). ESR decreased by 29% in group W and increased by 11,9% in group L. Even although there was a slight increase in the ESR of the land based exercise intervention group, values still remained within the normal range and thus the increase is not a concern. In addition, although there were no significant differences (p >0.05) between the 3 groups before the intervention with regards to ESR values, only group W and group C's mean ESR values were above the normal range and thus improvements were possible. There was a 33% decrease in the ESR of group C.

Taking the above points into consideration, it appears that the water based exercise groups ESR values were improved possibly because their initial values were above the normal range. While the land based exercise groups ESR values were not negatively affected because their ESR values remained within the normal range.

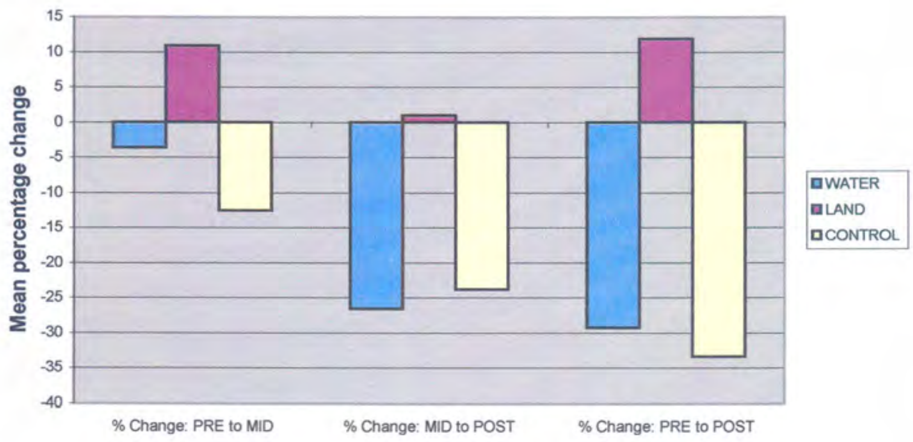

Figure 93: Erythrocyte Sedimentation Rate (ESR)

b) HEMOGLOBIN (Hb)

Some degree of anemia almost invariably accompanies RA of any severity. The causes are multiple (Currey, 1980). The degree of anemia in RA correlates with the activity of the underlying disease, particularly the degree of articular inflammation (Kippel & Dieppe, 1994). The Hb is usually less than 10 gm/dL but may rarely be as low as 8 gm/dL. Normal Hb values range from 13 – 18 gm/dL in men and 12 – 16 gm/dL in women (Berkow et al., 1992).

Table X: Haematology (* = p < 0.05)

Groups		Control					Water Group					Land Group					Significance		
VARIABLES	UNITS	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	C	W	L
ESR	mm/h	24	8.4	16	2.8	**-33**	20.5	21	14.5	10.6	**-29**	14.8	10.5	16.5	17.1	**11.9**			
Haemoglobin	gm/dl	13.9	1.3	14.3	1.0	**2.9**	14.6	0.9	14.3	0.8	**-1.9**	14.1	1.8	13.8	2.06	**-1.7**			

Hb levels remained globally unchanged for all groups. No significant changes were observed ($p > 0.05$). All three groups pre-intervention Hb values were within the normal physiological range, thus no dramatic changes were desired.

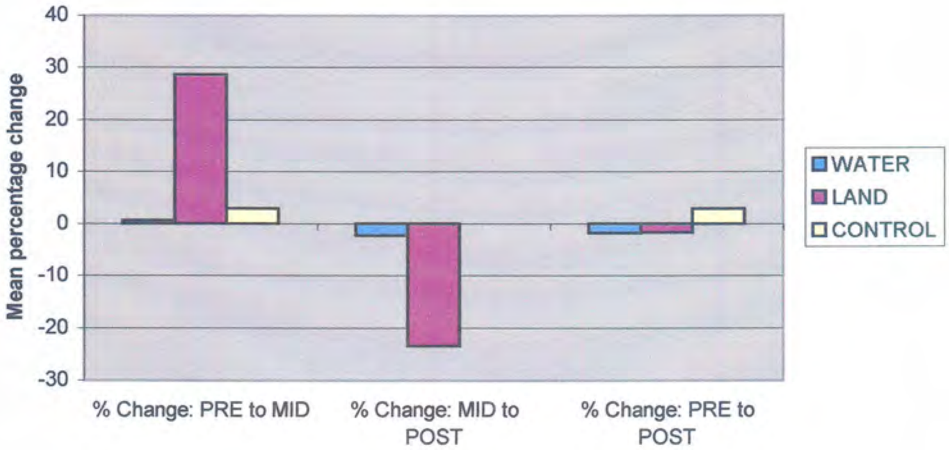

Figure 94: Hemoglobin (Hb)

4.3 ACTIVITIES OF DAILY LIVING (ADL) AND PSYCHOLOGICAL STATUS

The results indicating the change in functional ability and psychological status with regards to the total HAQ and POMS scores among the groups are reflected in table XI and figures 95 and 96.

4.3.1 PATIENTS SELF-ASSESSED DISABILITY (HEALTH ASSESSMENT QUESTIONNAIRE) (HAQ)

In assessing prognosis a number of health status self-report questionnaires have been developed and found valuable for routine and research use. These provide clinically useful information not available by conventional means. They can be used to document the patient's functional status with results similar to many traditional measures of RA activity (Kippel & Dieppe, 1994).

In RA the most frequently employed measure to evaluate the effect of treatment on functional ability is the HAQ. The HAQ has proven to be a useful outcome measure of functional ability in clinical trials (van den Ende et al., 1997).

Despite the fact that a number of clinical trials exploring the effects of exercise therapy did not result in an improvement in the HAQ score, in the current study this was not the case. Both group W and L showed improvements with regards to HAQ scores. Although not statistically significant ($p>0.05$), group W improved by 15% and group L improved by 18%. There was however deterioration in the control groups score (13%).

Thus, it appears that both exercise interventions were successful in improving the RA patient's functional ability, and more importantly, was effective in preventing any further deterioration. This is an important finding because rheumatic diseases are chronic, relapsing and remitting and impose a major impact on function. Thus, the primary aim of rehabilitation is preventing, maintaining or restoring function (Gerber, 1988).

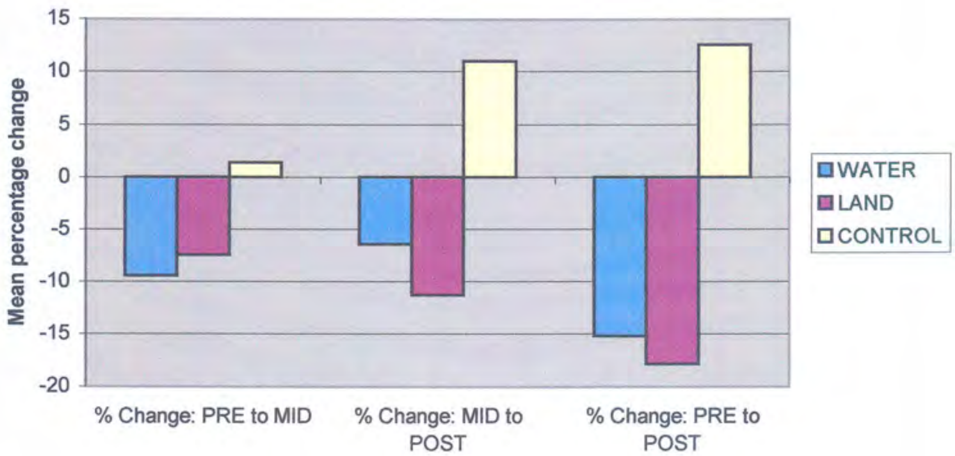

Figure 95 : Health Assessment Questionnaire (HAQ)

4.3.2 PROFILE OF MOOD STATES (POMS)

Although most attention is usually paid to the physical damage of RA, the profound effect of this chronic disabling condition on the psyche must never be forgotten (Clarke, 1987). Thus RA is not only a source of physical stress to the joints and the body, but also emotional stress (Hewlett, 1999).

One of the many desirable benefits derived from exercise or physical activity is improved psychological status or mood profile. The POMS, which measures six identifiable mood or affective states, has been proven to be a sensitive measure of the effects of various experimental manipulations (Norceau et al., 1995).

Exercise elevates the release of neurohormones that have an affect resembling opiates and play an important role in general physiologic stress reactions. They seem to reduce pain and enhance the general feeling of well-being (Kippel & Dieppe, 1994).

Pre- and post-intervention comparisons indicate that there was a significant improvement ($p<0.05$) in group W and group L's total POMS scores. Most of the sub-levels significantly improved after exercise training. These results suggest that the majority of the patients in both exercise groups perceived a decrease in the symptoms of depression, anxiety, and fatigue as well as a higher level of vigor after the three-month exercise intervention.

There was no significant ($p>0.05$) change in the control groups total POMS score. In addition, for some reason, the group doing the land based exercises improvements with regards to affective states, was greater. There was a 163% improvement in group L and a 99% improvement in group W.

These improvements with regards to psychological status are important for RA patients. Due to the fact that the chronicity of RA and its capriciousness, variable disability and potential to disfigure affect all aspects of a person's life. Depression is common in chronic disease. It is characterized by feelings of sadness, helplessness, isolation, loss of self-worth, and loss of interest in others. It may be manifested in loss of appetite or poor sleep habits and is often over-looked as part of the physical symptoms of the disease.

Table XI : **Total HAQ and POMS Scores** (* = $p < 0.05$)

Groups		Control					Water Group					Land Group					Significance		
VARIABLES	UNITS	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	C	W	L
POMS	scale	5	35.3	3.5	37.5	**-30**	28.3	55	0.3	35.7	**-99**	20.8	34.2	-13	11	**-163**		*	*
HAQ	scale	36	26.9	40.5	20.5	**13**	34.5	9.7	29.3	7.7	**-15**	33.5	7.0	27.5	6.0	**-18**			

(Liang & Logigian, 1992; Partridge, 1988). In addition, depression seems to be an important predicter of pain and functional decline (Stenström et al., 1991).

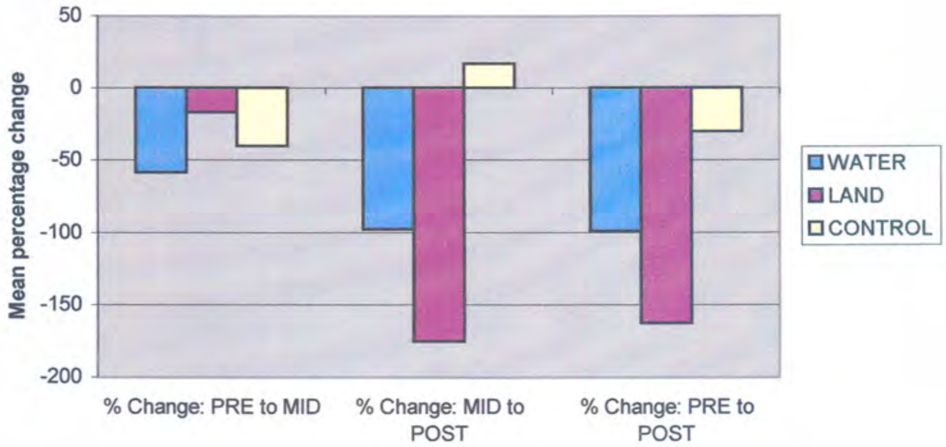

Figure 96: Profile of Mood States (POMS)

4.4 PHYSICAL CONDITION

4.4.1 BODY MASS

The results indicating the response of body mass are reflected in figure 97.

As mentioned earlier, the maintenance of ideal body mass is advantageous for RA patients. Extra body mass puts undue stress on the joints, particularly the weight bearing joints. In addition, RA patients who are on corticicosteriod therapy, are warned about increased appetite, fluid retention and unavoidable weight-gain, as side effects of therapy. Therefore exercise assists in the management of maintaining ideal body weight or in aiding weight loss, if necessary (internet) (Kippel & Dieppe, 1994; Eustice, 2000).

There was no significant change in body mass in all three groups ($p>0.05$). A 9,2% reduction in body mass was observed in group W at the end of the study. There was no change in group L's mean body mass values. In addition, group C's body mass increased by 2%.

The small change in body mass may be due to the fact that exercise tends to increase lean body mass. Thus, it is possible that the subjects lean body mass increased while their fat percentage decreased and their weight remained more or less constant.

It is also possible that the land based exercise groups body mass decrease was less because the land exercises were more effective in increasing lean body mass.

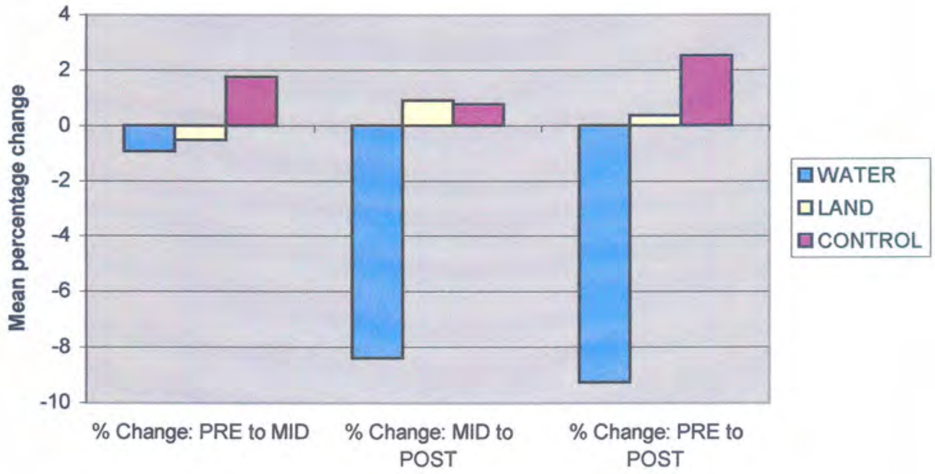

Figure 97: Body Mass

4.4.2 BLOOD PRESSURE

Blood pressure response is indicated in table XII and figure 98.

In essence, arterial blood pressure is a function of the arterial blood flow per minute and the vascular or peripheral resistance to that flow. Systolic and diastolic blood pressure can be lowered by approximately 6 to 10 mm Hg with regular aerobic exercise (McArdle et al., 1991).

There were no statistically significant ($p>0.05$) differences in mean blood pressure values in the 3 groups with regards to both pre- and post-exercise intervention values. No dramatic changes were expected because all the groups mean systolic and diastolic blood pressure values fell within the normal physiological range. In addition, blood pressure is not a primary concern in rheumatic diseases.

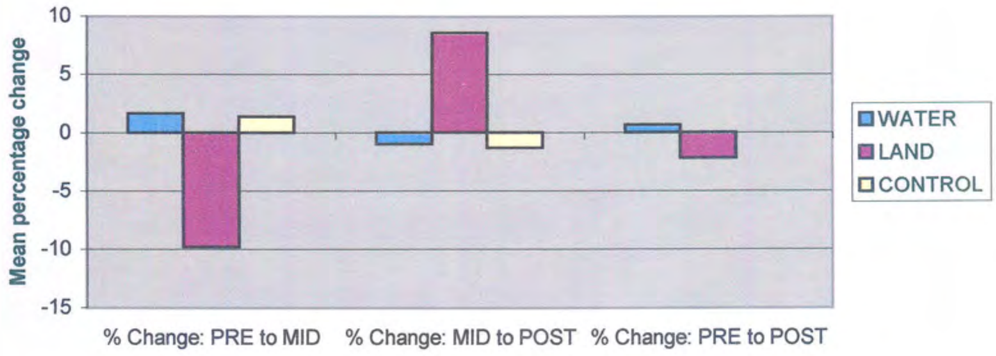

Figure 98: Diastolic Blood Pressure

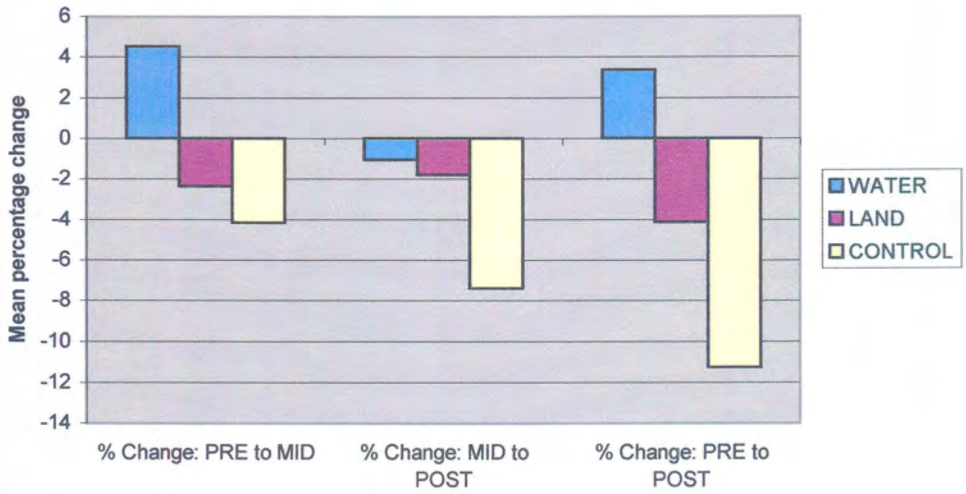

Figure 99: Systolic Blood Pressure

4.4.3 50-FT WALK TEST

Changes in the 50-ft walk test is reflected in table XII and figure 100.

Walking time is one of the traditional measures to document functional status in RA patients (Kippel & Dieppe, 1994).

Group W's 50-ft walk-time was significantly ($p>0.05$) greater than the other 2 groups throughout the study. Both group W and L significantly ($p<0.05$) improved their walk-time. Walk time improved by 18% in group W and by 15% in group L. No change was observed in group C. Thus, the pre- and post-test comparisons indicate that the water- and land-based exercises had approximately an equal in influence on walk-time.

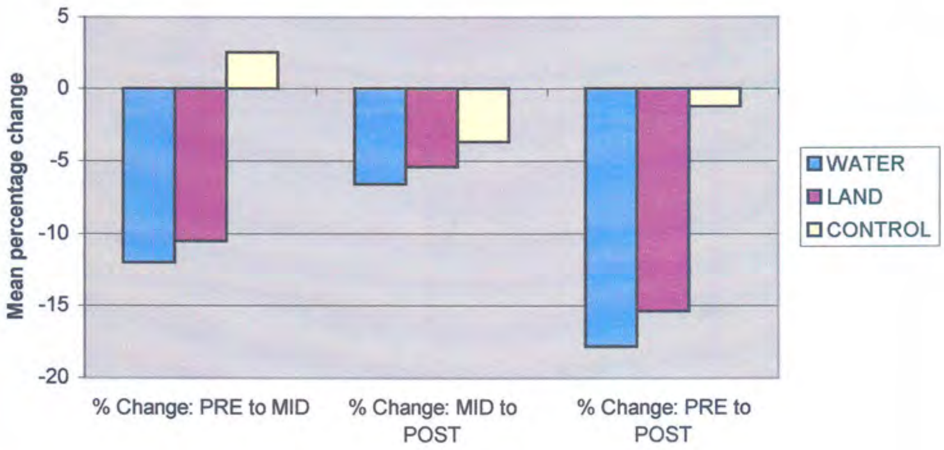

Figure 100 : 50-Ft Walk Test

4.4.4 GRIP STRENGTH

Right and left grip strength response is indicated in table XII and figures 101 and 102. As already mentioned, the joints of the finger and wrist are commonly affected in RA patients. "Thus, RA can have an effect on the various types of grip. Grip strength is an important measurement of RA patients functional status. Poor grip strength can affect ADL such as the ability to open and close small buttons, to write and perform any function related to work or housework (Clark, 1987; Minor & Hewett, 1995).

There was no statistically significant ($p>0.05$) difference between pre- and post-test scores in all 3 groups, as far as right grip strength was concerned. Group C's right grip strengths mean score remained the same. Right grip strength increased by 18% in group W and 4,8% in group L.

As far as left grip strength is concerned, there were significant changes ($p<0.05$) in group W. There was also an increase in group L's left grip strength (16,1%) but it was not significant ($p>0.05$). Group W left grip strength increased by 35%. Group C's left grip strength decreased by 16% ($P>0.05$).

It is important to note that both exercise interventions were able to improve grip strength, in addition, the control group experienced a decrease in grip strength (left), thus having important functional implications.

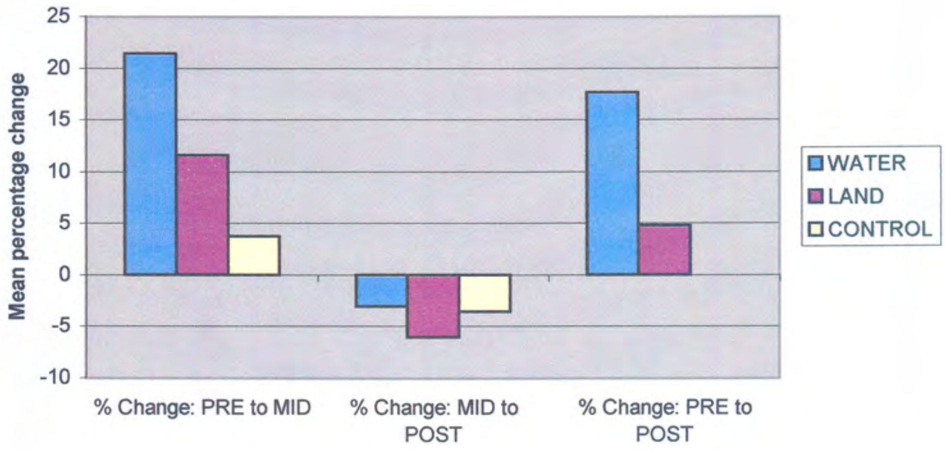

Figure 101 : Right Grip Strength

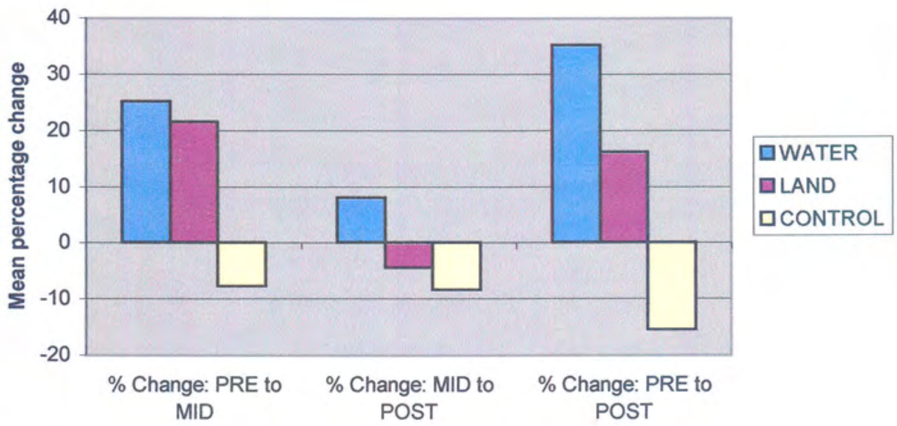

Figure 102 : Left Grip Strength

4.4.5 AEROBIC CAPACITY

Changes in aerobic capacity are reflected in table XII and figures 103 and 104.

Patients with RA show lower cardiorespiratory fitness than normal subjects (Ekdahl & Broman, 1992). In addition, RA patients die ten to 15 years earlier than non-afflicted persons. The cause of death may often be cardiovascular disease (Lyngberg et al., 1994). Therefore, aerobic exercises are important for RA patients. RA patients are able to increase their aerobic capacity substantially in endurance training programmes without precipitating acute joint flares. Furthermore, functional level and ability to improve ADL have been reported for RA patients on an aerobic programme (Hicks, 1990).

Astrand's method was used to calculate the maximum oxygen intake (VO_2max) during a submaximal load provided by a bicycle ergometer in the subjects (Ekdahl & Broman, 1992). VO_2max is regarded as an acceptable measurement of cariorespiratory endurance (McDougal et al., 1991).

There were statistically significant ($p<0.05$) increases in both absolute and relative VO_2 max values in both experimental groups. There were no significant changes ($p>0,05$) in the control groups VO_2max values, however, there was a decrease of 11% in mean relative VO_2max values and a 6.7% decrease in absolute VO_2max values. Thus, these results prove that the RA patients can improve their health status and fitness with exercise.

The increase in relative VO_2max for group W and L was 30% and 16.6% respectively. The increase in absolute VO_2max for group W and L was 28% and 31% respectively. The conflicting results with regards to improvements in relative and absolute VO_2max results may be attributed to the fact that there was a greater decrease in group W's weight and thus their relative VO_2max values improved more than their absolute values.

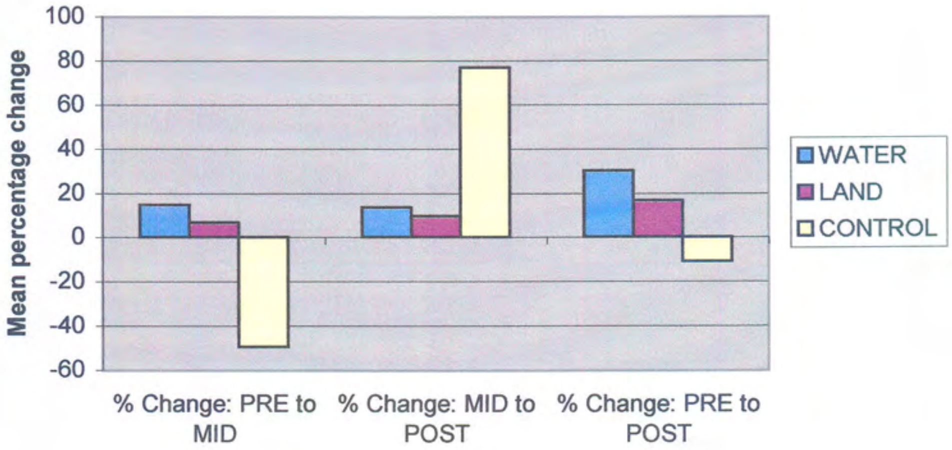

Figure 103 : Relative VO_2max

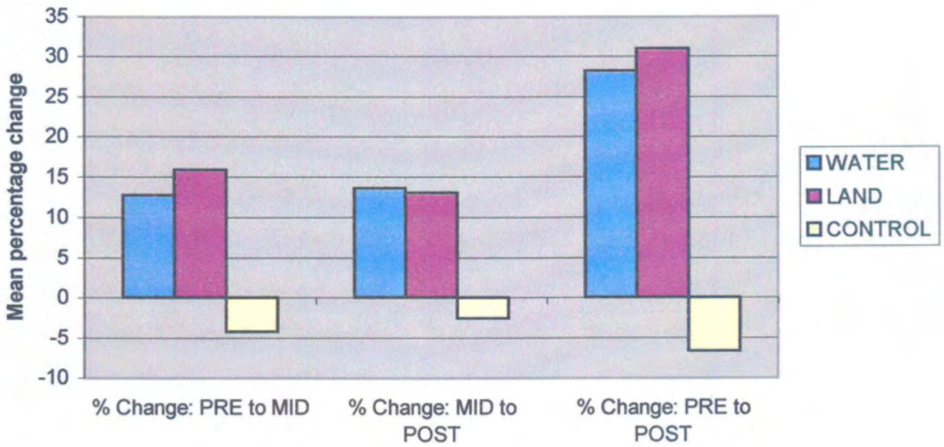

Figure 104 : Absolute VO_2max

Table XII : Physical Status (* = $p < 0.05$)

Groups		Control					Water Group					Land Group					Significance		
VARIABLES	UNITS	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	C	W	L
Blood Pressure (Sys)	mm Hg	120	0	106.5	2.0	**-11**	111.3	10.3	115	10.8	**3.4**	126.8	29.8	121.5	16.2	**-4.1**			
Blood Pressure (Dias)	mm Hg	75	0	75	7.0	**0**	76.3	9.5	76.8	10.4	**0.7**	81.3	13.1	79.5	7.6	**-2.2**			
50ft Walk test	sec.	8.5	1.3	8.4	1.6	**-1.2**	10.8	0.8	8.7	1.0	**-18**	8.4	0.5	7.1	0.5	**-15**		*	*
Grip strength - R	mm Hg	40.5	0.7	40.5	3.5	**0**	121.8	28.1	143.3	32.0	**18**	126.0	94.0	132.0	71.0	**4.8**			
Grip strength - L	mm Hg	51.5	10.6	43.5	2.1	**-16**	106.5	24.1	144	28.5	**35**	124.3	94.7	144.3	104	**16.1**		*	
Absolute V02	L/min	2.0	0.1	1.9	0.1	**-6.7**	1.7	0.6	2.2	0.4	**28**	1.9	0.7	2.4	0.4	**31**		*	*
Relative V02	ml/kg/min	35.1	4.3	31.4	1.1	**-11**	22.7	10.3	29.5	9.1	**30**	29	14.8	33.8	13.2	**16.6**		*	*

4.4.6 MUSCLE STRENGTH

Knee extensor and flexor strength changes are reflected in table XIII and figures 105, 106, 107 and 108.

Impaired muscle function is a common consequence in patients with RA (Ekdahl & Broman, 1992). It is important to maintain normal muscle strength, not only in order to maintain physical function, but also to stabilize the joints and prevent joint angulation and later osteoarthrosis (Lyngberg et al., 1994).

Earlier studies have reported that patients with RA, as compared with healthy subjects, have reduced isometric and isokinetic muscle strength (Tiselius, 1969; Ekblom et al., 1974; Nordesjö et al., 1983, Beals et al., 1985; Danneskiold-Samsoe & Grimby,1986; Hsieh et al., 1987;

Knee extensor muscle strength is usually reduced in RA patients, this effects everyday functions such as walking (Lyngberg et al., 1994). Isokinetic muscle strength of the extensors and flexors was measured with a Cybex II isokinetic dynamometer.

a) KNEE FLEXION

Pre- and post-test comparisons show that right knee flexor strength increased significantly ($p<0.05$) in group W. The increase in right knee flexor strength was 43%. The right knee flexor strength of group L increased by 22.1%, however, the increase was not significant ($p>0.05$). Group C's right knee-flexor strength decreased by 1,8%. There was an equal increase in left knee flexor strength in group W and L (24%). The increase was not statistically significant ($p>0.05$). Group C showed a decrease in left knee flexor strength (12%) although the decrease was not considered significant ($p>0.05$).

No fewer than 12 muscles cross the knee joint, contributing to both its stability and function. Knee flexion is produced by the hamstring muscle group, which consists of the biceps femoris, semitendinosous and semimembranous muscles. The gastrocnemius muscle assists the hamstring muscle group in producing flexion of the knee (Perrin, 1993).

Increase in knee flexor strength was more or less equal in both experimental groups, however, the increase in right flexor strength was slightly higher in the water intervention group. Decline in the right and left knee flexor strength in the control group prove once again the detrimental consequences of a sedentary lifestyle in RA patients.

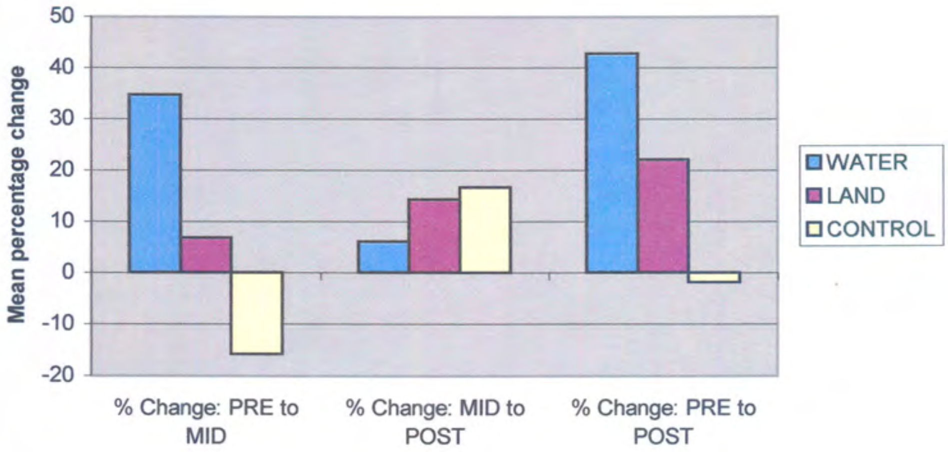

Figure 105 : Right Flexor Strength

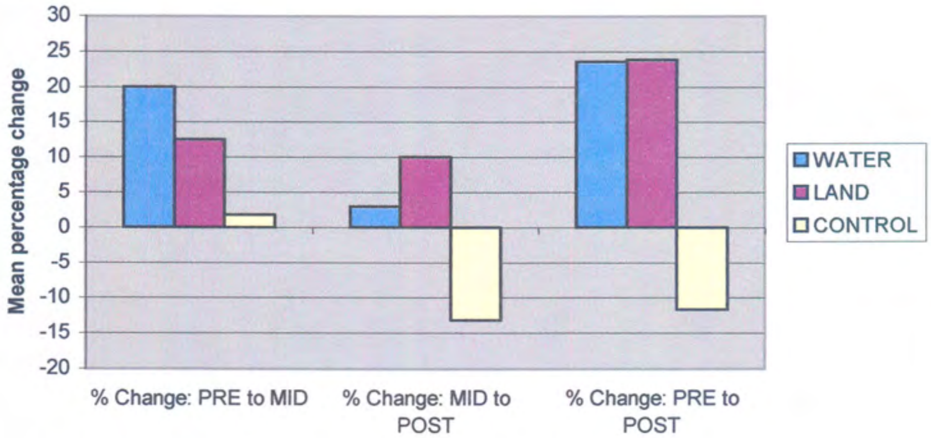

Figure 106 : Left Flexor Strength

b) KNEE EXTENSION

A similar trend was observed in the changes in knee extensor strength after the exercise interventions. Group W and L's right knee extensor strength improved by 32% and 9% respectively. Group C's right knee extensor strength showed a decline of 9,7%. All changes were non-significant (p>0.05).

There was a 34% increase in group W and a 2,4% increase in Group L, concerning left knee extensor strength. There was no change in group C's left extensor strength. Changes were not statistically significant (p>0.05).

Knee extension is accomplished primarily by contraction of the quadriceps femoris muscles, which consist of the rectus femoris and vastismedialis, intermedius and lateralis muscles (Perrin, 1993).

Both the land and water exercise interventions were successful in improving left and right knee extensor strength. This is an important consequence of the exercise therapy because as already mentioned, knee extensor muscle strength is usually reduced in patients with RA, even those with mild knee involvement (Lyngberg et al., 1994). Increases in knee extensor strength were greater in those following the water exercise programme. This may be due to the fact that the water exercise groups mean knee extensor strength values were lower than those following the land exercise programme prior to the study. However, the difference was not considered significant (p>0.05). The control groups right knee extensor strength decreased. Even although the decrease was not significant (p>0.05), if one considers that the decease took place over a relatively short period of time (three months) and that even a small decrease can affect function, the importance of exercise is emphasized.

c) HAMSTRING/QUADRICEPS RECIPROCAL MUSCLE GROUP RATIO

Important improvements were observed in the hamstring/quadriceps reciprocal muscle group ratio in the experimental groups. In general, the hamstring muscle group has been shown to produce about 60% of the torque values generated by the quadriceps muscles at slow isokinetic test velocities (Perrin, 1993).

Group W's mean ratio improved from 39,8% to 44,9% on the right leg. Group L's mean ratio improved from 50,4% to 55,5% on the right leg. There was a small change in group C's right leg mean ratio from 44% to 47%.

On the left leg group L's ratio was already within the correct range before the intervention and remained within the range after the intervention. Mean score for group L changed from 62% to 56.8%. Group W's left leg ratio was not within the optimal range after the exercise intervention, but it did improve from 45,9% to 47,3%. Group C's ratio deteriorated, the mean score decreased from 47,8% to 41,4%.

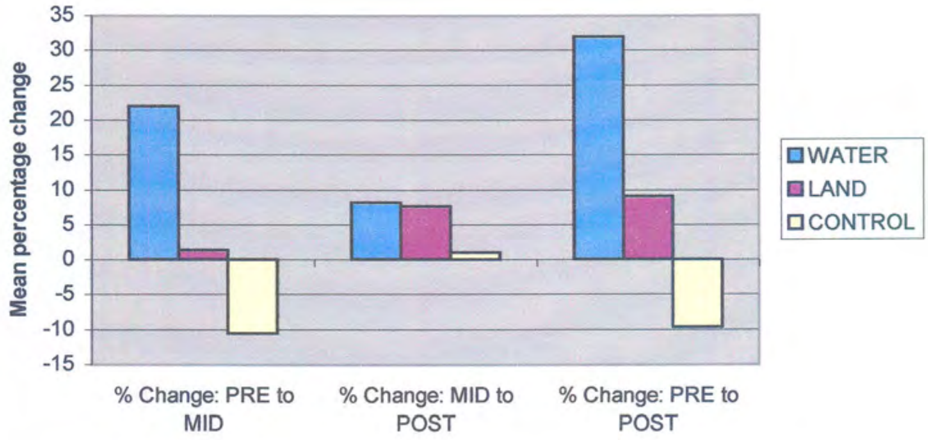

Figure 107 : Right Extensor Strength

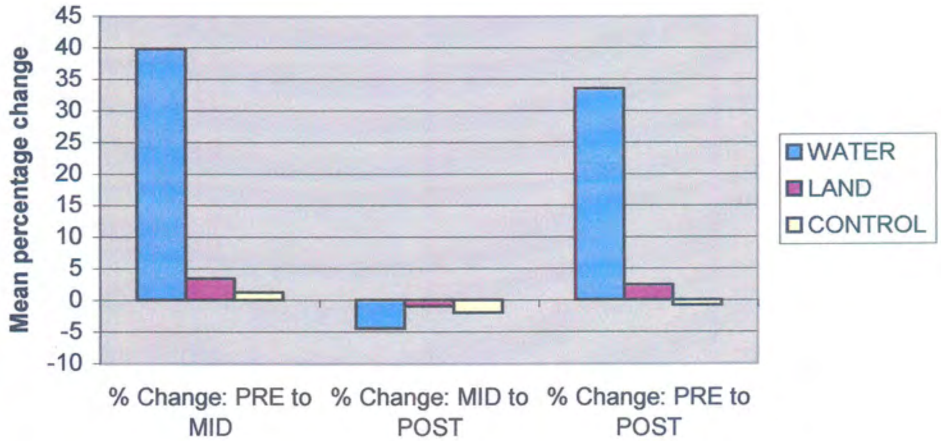

Figure 108 : Left Extensor Strength

Table XIII : Physical Status (* = p < 0.05)

Groups		Control					Water Group					Land Group					Significance		
VARIABLES	UNITS	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	C	W	L
Hamstring – R	Nm/kg	75.1	14.3	73.8	22.3	**-1.8**	34.3	24.7	48.9	17	**43**	74.1	21.9	90.5	33.5	**22.1**		*	
Hamstring – L	Nm/kg	73.8	26.6	65.2	14.4	**-12**	38.1	24.7	47.1	15.1	**24**	70.9	17.3	87.8	31.8	**23.8**			
Quadriceps - R	Nm/kg	170.3	26.3	153.8	8.2	**-9.7**	80.1	41.1	105.7	15.5	**32**	152.3	62	166.1	59.4	**9.0**			
Quadriceps - L	Nm/kg	152.1	33.7	150.9	32.3	**-0.8**	75.0	36.1	100.2	31.1	**34**	147.5	47.3	151	35.2	**2.4**			
Ratio – R		44	1.6	47	12.7	**6.8**	39.8	17.7	44.9	13.4	**13**	50.4	8.3	55.5	8.4	**10.1**			
Ratio – L		47.8	6.9	41.4	2.9	**-13**	45.9	21.9	47.3	5.8	**3.1**	62.0	25	56.8	8.5	**-8.3**			

4.3.7 JOINT MOBILITY

Changes in wrist and knee range of motion are reflected in table XIV and figures 109, 110, 111 and 112.

Limitation of ROM leads to functional impairment and therefore improvement of joint mobility is an important goal in the treatment of RA (Vleiland et al., 1993).

The maintenance of functional ROM is necessary for daily activity and efficiency of movement. Critical ranges for normal ambulation have been carefully worked-out (Gerber, 1988).

Wrist and knee active ROM in flexion and extension was evaluated using a standard goniometer. These two joints were selected on the basis of the exercises performed and relative ease and reliability of measurement.

- Wrist ROM

The normal ROM for wrist extension is 70° (Thrombly, 3rd ed). 5° - 10° wrist dorsiflexion is necessary for normal functioning (Liang, 1992). There was a significant ($p<0.05$) increase in group W's right wrist extension ROM. Right wrist extension ROM increased by 49%. Group L's right wrist extension ROM improved by 20.7%, although the increase was not statistically significant ($p>0.05$). There was a small decrease in Group C's right wrist extension ROM of 4.7% ($p>0.05$).

Once again, there was significant ($p<0.05$) increase in group W's left wrist extension (30,9%). There was a non-significant ($p>0.05$) increase of 15,7% and 6,7% in left wrist extension ROM in group L and group C respectively.

The normal ROM for the wrist flexion is 80° (Thrombly, 3rd ed). Both left and right wrist flexion ROM increased in group W, although the results were not significant ($p>0.05$). Right wrist flexion ROM increased by 12% and left wrist flexion ROM increased by 19%.

In group L, there was a statistically significant ($p<0.05$) improvement in right wrist flexion ROM but not in the left wrist flexion ROM ($p>0.05$). Left wrist ROM increased by 7,6% and right wrist flexion ROM decreased by 2.6%.

There was a decrease in right and left wrist flexion ROM in group C, although the decreases were not significant ($p>0.05$). Right wrist flexion ROM decreased by 1,3% and left wrist flexion ROM decreased by 21%.

In general, it appears that the water based exercise programme was more effective in improving wrist extension ROM and the land based exercise programme was more effective in improving wrist flexion ROM. It is possible that exercises in the water require more wrist extension movements and the exercises on land require more wrist flexion movements, thus explaining the improvements in wrist extension ROM for group W and improvements in wrist flexion ROM for group L.

Deterioration was noted again in the control group with regards to wrist ROM due to lack of exercise therapy.

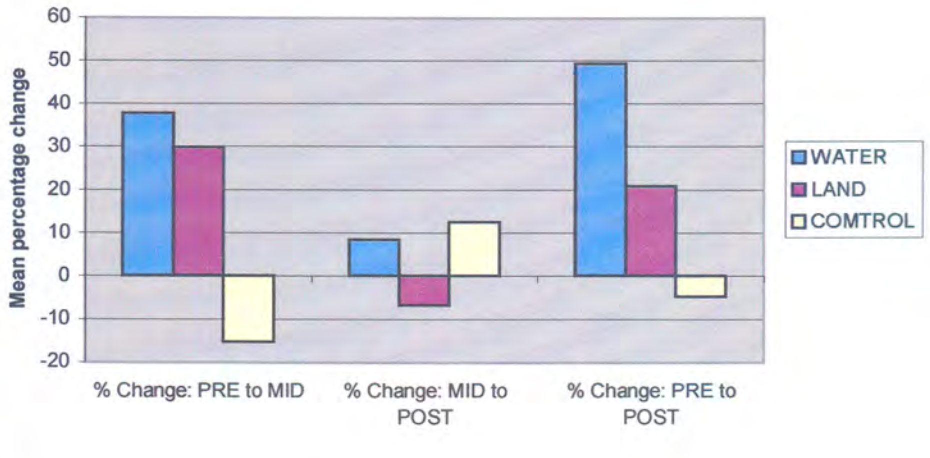

Figure 109 : Right Wrist Extension ROM

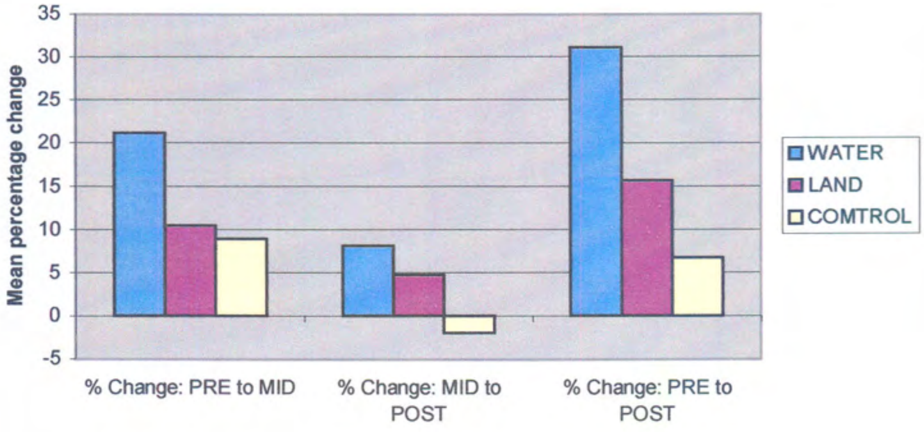

Figure 110 : **Left Wrist Extension ROM**

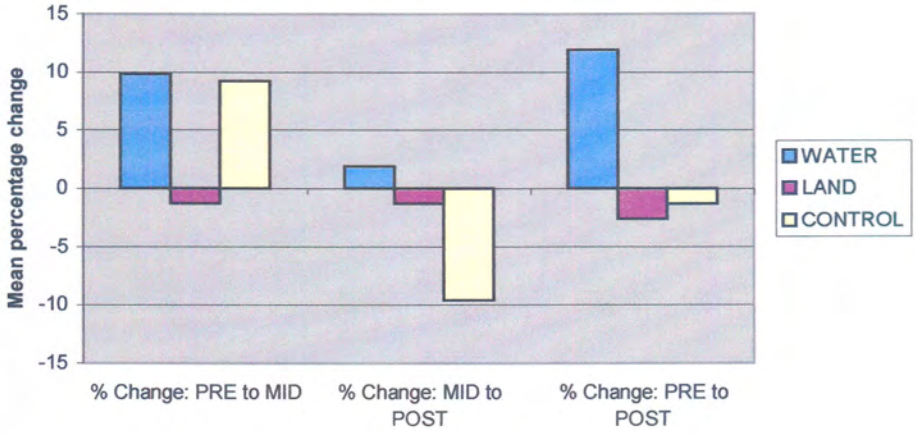

Figure 111 : **Right Wrist Flexion ROM**

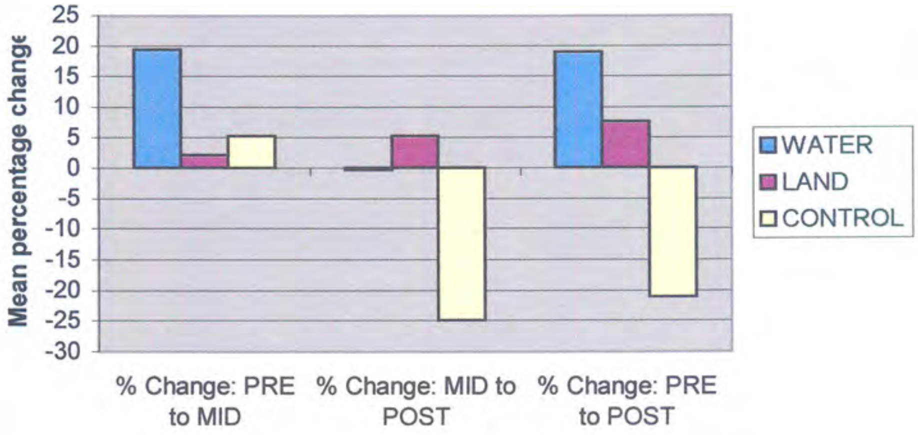

Figure 112 : Left Wrist Flexion ROM

- Knee ROM

The normal ROM for knee extension is 0° (Thrombly, 3rd ed). All subjects, except one, had normal knee extension ROM values, thus knee extension values were not used as a parameter.

The normal ROM for knee flexion is 135° (Thrombly, 3rd ed). Functional impairment exists at less than 60° knee flexion (Liang & Logigian, 1996).

Pre and post test comparisons showed a significant ($p<0.05$) increase in both left and right knee flexion ROM in group W. Right knee flexion ROM increased by 12% and left knee flexion ROM increased by 14%.

There was also a statistically significant ($p<0.05$) improvement in both left and right knee flexion ROM in group L. Right knee flexion ROM increased by 9,2% and left knee flexion ROM increased by 7,4%.

There was no significant ($p>0.05$) changes in group C's right and left knee flexion ROM. Right knee flexion ROM decreased by 1,2% and left knee flexion ROM increased by 1,2%.

Both exercise programmes significantly ($p<0.05$) improved knee flexion ROM. Percentage increases in flexion ROM was slightly higher in the water based exercise group than the land based exercise group. In addition, no significant ($p>0.05$) changes occurred in the control group as far as knee flexion ROM was concerned, however a slight deterioration (1,2%) occurred in the right knee flexion ROM.

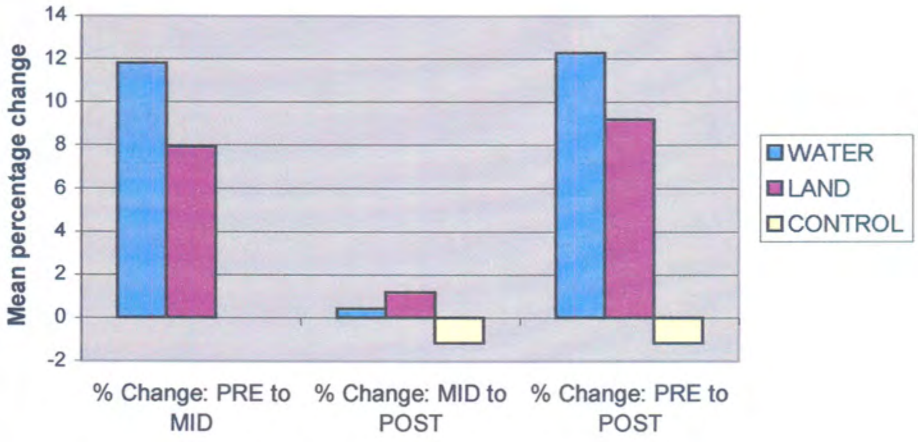

Figure 113 : **Right Knee Flexion ROM**

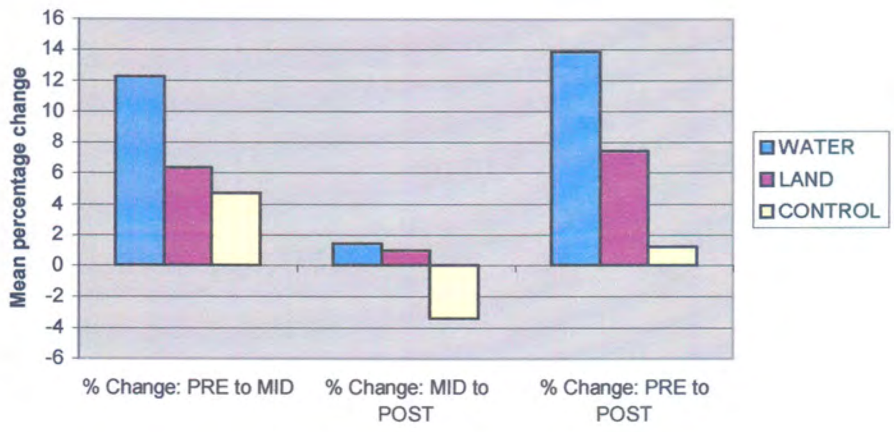

Figure 114 : **Left Knee Flexion ROM**

Table XIV : Physical Status (* = $p < 0.05$)

Groups		Control					Water Group					Land Group					Significance		
VARIABLES	UNITS	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	PRE (Mean)	Std. Dev.	POST (Mean)	Std. Dev.	%	C	W	L
Wrist extension - R	degrees	42.5	2.1	40.5	9.2	**-4.7**	54.3	10.6	81	22.4	**49**	55.5	17.7	67	16.4	**20.7**			
Wrist extension - L	degrees	45	5.7	48	12.7	**6.7**	63.8	6.4	83.5	12.3	**31**	62.3	18.4	72	16.7	**15.7**		*	
Wrist flexion - R	degrees	38	39.6	37.5	24.7	**-1.3**	71.8	17	80.3	12.2	**12**	75.8	29.4	73.8	30	**-2.6**			
Wrist flexion - L	degrees	19	12.7	15	9.9	**-21**	67.3	17.1	80	17.3	**19**	69.5	22.6	74.8	21.3	**7.6**			*
Knee extension - R	degrees	0	0	0	0	**0**	0	0	0	0	**0**	3.5	7	2.3	4.5	**-36**			
Knee extension - L	degrees	0	0	0	0	**0**	0	0	0	0	**0**	4.8	9.5	2.8	5.5	**-42**			
Knee flexion - R	degrees	127.5	3.5	126	8.5	**-1.2**	110	21	123.5	5.1	**12**	119.8	5.5	130.8	3.0	**9.2**		*	*
Knee flexion - L	degrees	126.5	6.4	128	7.1	**1.2**	110	20	125.3	9.2	**14**	121.8	7.7	130.8	7.8	**7.4**		*	*

SUMMARY, CONCLUSION & RECOMMENDATIONS

The primary aim of the study was to compare the effects of a three-month land- and water-based exercise programme among ten RA sufferers (Steinbrocker Functional Class I and II). In order to achieve this goal a pre- and post-test experimental groups design, with three levels of the independent variable, was adopted for the study (see Research Design Chapter Three).

Subjects were randomly assigned to one of the following three groups :

- Group W (n = 4) : A water-based exercise programme was followed
- Group L (n = 4) : A land-based exercise programme was followed
- Group C (n = 2) : Subjects were instructed to continue with current sedentary lifestyle. No exercise intervention was followed.

The following dependent variables were measured :

- Disease Activity
  - Joints: Tender joint count (TJC); Swollen joint count (SJC)
  - Haematology: erythrocyte sedimentation rate (ESR); hemoglobin (Hb)
- Activities of daily living (ADL) and psychological status
  - Patients self-assessed disability (health assessment questionnaire) (HAQ); Profile of Mood States (POMS);

- Physical condition

  - Body mass; blood pressure; 50-ft walk test; grip strength; aerobic capacity (VO_2max); muscle strength (knee flexors and extensors); joint mobility (knee and wrist ROM)

The specific tests carried out under each of these evaluations are discussed under Measurement in Chapter 3.

There is a growing interest among health professionals in improving the care of patients afflicted with chronic disabling diseases such as RA and the effects of exercise training programmes on the outcome., i.e., improvement in joint function, mobility, strength, endurance and cardiovascular fitness (Komatireddy et al., 1997).

One of the aims of this study was to determine whether exercise therapy is beneficial for RA patients. The positive changes produced by the water and land based exercise programmes compared to the control group, was significant ($p<0.05$) in many of the parameters tested.

It appears that the exercise therapies aided in the control of the disease activity as far as the tender and swollen joint counts are concerned. Both the tender and swollen joint counts were reduced in the experimental groups, but not in the control group.

In addition to improving disease activity, the exercise interventions were effective in improving the functional and psychological status of the subjects. The total POMS and total HAQ scores were much improved in the experimental groups, in comparison to the control group.

Other important parameters positively effected by the exercise therapies were the 50-ft walk time, grip strength, aerobic capacity, muscle strength (knee flexors and extensors) and joint mobility (knee and wrist ROM).

Thus, it appears that exercise therapy does indeed play an important role in the treatment of rheumatic disease and in the fight against rheumatic invalidism (Simon & Blotman, 1981). However, the primary purpose of the study was to determine which exercise mode, water-based exercise therapy or land-based exercise therapy, would be more effective in the treatment of RA. Hydrotherapy, has been considered the treatment of choice for rheumatic diseases for a long time, as the buoyancy provided by the water places less stress on the joints (Klepper, 1999). Physicians may be reluctant to prescribe land-based exercises for fear of joint damage and deterioration of disease activity. However, hydrotherapy is an expensive procedure and, on economic grounds alone, demands serious evaluation (Hall et al., 1996). Maintenance of heated pools designed for therapy is also time consuming. In addition, land-based exercises have many benefits that water based exercises do not have. Specifically, weight-bearing exercises strengthen the connective tissue surrounding the joint and stimulate bone formation. The above qualities are desirable for patients with RA (Kirsteins et al., 1991). The prescription of home programmes are also popular, the majority of which are land-based exercises.

It appears that the land-based exercise programme in the present study was just as effective in positively influencing the parameters tested as the water-based exercise programme. Disease activity was not exacerbated by the land-exercises. Total tender and swollen joint counts were reduced in both experimental groups. However, the decrease in the total tender and swollen joint count was only significant ($p<0.10$), in the water-based exercise group. The greater reduction in joint swelling and tenderness in the water-based exercise group may be attributed to the reduction of joint loading occasioned by the buoyancy. In addition, the hydrostatic pressure of water immersion is considered to reduce edema (Hall et al., 1996). Furthermore, even although there was a small non-significant ($p>0.05$) increase in the land-based exercise group's mean ESR values, they still fell within the normal ranges. The decrease in the mean ESR values of the water-based exercise group was not significant ($p>0.05$). Hb values remained globally unchanged in both groups.

Functional status according to total HAQ scores was also improved in both groups. There was a 15,2% improvement in the water-based exercise group and a 17,9% improvement in the land-based exercise group. Changes in the total HAQ scores were not significant ($p>0.05$). It is important to note that significant functional changes, as well as changes in other parameters measured, may be undetectable at the extremes of a scale because of a "ceiling" or "floor" Artifact (van den Ende et al., 1998). Furthermore, even small changes in functional status are noteworthy due to the fact that one of the primary objectives of exercise therapy for patients with RA is to improve functional ability (McMeeken et al., 1999).

Statistically significant ($p<0.05$) improvements were noted in total POMS scores for both experimental groups. Thus, both groups were equally effective in decreasing the symptoms of depression, anxiety, fatigue and tension, as well as improving vigour.

As far as physical status is concerned, the following results were obtained. Both exercise interventions significantly ($p<0.05$) improved 50-ft walk time. Right and left grip strength increased in the water and land-based exercise groups. Only the left grip strength increase in the water group was significant ($p<0.05$). In addition, right grip strength increase was greater (21,7%) in the water group than the land group (4,5%). There was a statistically significant ($p<0.05$) increase in absolute and relative VO_2max values in both groups. Right and left knee extensor and flexor strength increased in both groups. The only significant ($p<0.05$) increase was that of the water groups right hamstring strength. Lastly, joint mobility also improved in both groups. Both left and right knee flexion ROM improved significantly ($p<0.05$) in the water- and the land-based group. Right and left wrist extension ROM improved significantly ($p<0.05$) in those following the water-based exercises. There was improvement in the land-group concerning left and right wrist extension ROM, however improvement was not significant ($p<0.05$). The inverse was true for wrist flexion ROM. In those following the land-based exercises programme, left wrist flexion improved significantly ($p<0.05$). While right and left wrist flexion improved in the water-based groups, improvement was not significant ($p>0.05$).

Thus, the results indicate that benefits derived from both water- and land-based exercises, are very similar. It appears that the prescription of land-based exercises is feasible, especially when hydrotherapy is not possible or contraindicated. Furthermore, appropriate land-based exercises do not appear to enhance joint

destruction and disease activity. The importance of land-based exercises should not be forgotten.
This study confirms the view that exercise therapy is one of the cornerstones of the management of RA (Hazes et al., 1996). The separate benefits of both exercise interventions are obvious. Therefore, it is possible that the exercise of choice for RA patients should not be water-based exercises alone, as believed in the past, but an optimal combination of land-and water-based exercise. Ideally, the contribution of land- and water-based exercises to the overall programme of the RA patient should be manipulated according to the patient's needs and disease activity at that period of time.

It is important to stress the fact that the sample was small and any changes in disease symptoms must be viewed in light of the natural course of RA, where daily fluctuations in joint motion, swelling, pain and tenderness are not uncommon. However, all patients were on stable medication, thus eliminating the possibility of confounding results due to changes in medication. The following recommendations are made to expand on the knowledge and treatment of RA:

- further research, with a larger sample size, is required;
- research should focus on the benefits and disadvantages of dynamic land-exercises, specifically weight-bearing exercises, in the long- term;
- exciting research possibilities, concerning supplementation such as creatine and exercising arthritis patients, should be investigated