The Value of Hydrotherapy in the Rehabilitation of Low Back Pain with Radicular Involvement in the Lower Limbs.

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To Nannu Joey,
Respected, loved and missed.

The Value of Hydrotherapy in the Rehabilitation of Low Back Pain with Radicular Involvement in the Lower Limbs.

Owen Sant' Angelo

Dissertation submitted in part-fulfillment of the requirements for the degree of Bachelor of Science (Honours) Physiotherapy Studies, University of Malta.

2nd May 2000

Statement of Authenticity

This is to certify that the research study entitled “The Value of Hydrotherapy in the rehabilitation of Low Back Pain with Radicular Involvement in the Lower Limbs” which is being submitted to University of Malta, in partial fulfillment of the requirements for the degree of Bachelor of Science (Hons) Physiotherapy Studies, is solely the work of the student Mr. Owen Sant’ Angelo as supervised by Mr. Robert Camilleri.

____

Owen Sant’ Angelo

Physiotherapy Student

____

Robert Camilleri

Dissertation Supervisor

Acknowledgements

My very special thanks go to Mr. Robert Camilleri, my dissertation supervisor for his invaluable assistance, time and impressive patience.

I also sincerely thank:

My Tutors and the dissertation board for accepting my proposal for this study;

My parents, for their unfailing curiosity, encouragement and support;

Alison, for guiding, helping and supporting me throughout;

Mari, for her precious help.

“To go into water is a unique experience affording everyone opportunities of widening their knowledge and skills physically, mentally and psychologically.”

(Reid Campion1997: 3)

Abstract

The predominance of low back pain has led to a massive amount of research examining this multi-faceted condition. A number of researchers have attempted to compare treatments with the aim to validate the best one. That only few studies have taken the treatment environment into account seems an omission, considering the mechanics and nature of back injuries and the anecdotal benefits of warm water in such cases.

This study was designed to examine the value of hydrotherapy in the rehabilitation of low back pain with radicular components. Treatment on land was compared to treatment via a similar regime of exercises in the hydrotherapy pool. 6 subjects were included in the study, each treated individually and none differing from the other significantly. All had been suffering from an average of 2 years before attending for treatment.

Before and after the treatment sessions, subjects were measured for the various components low back pain rehabilitation, namely pain, functionality, lumbar mobility. All subjects attended 8 sessions of 30-45 minutes each, twice weekly over a month. Treatment was progressed according to individual requirements, but was considered to have reached a uniform level throughout both groups by the end of the 4th week.

The experimental hydrotherapy group appeared to have benefited more than the control land group in terms of functionality, forward lumbar flexion and neurologically. The opposite was true of lumbar extension and straight leg raises. Pain was considerably alleviated in both treatment environments. Statistically, no significant difference was found when comparison was made between either group. Significant changes were, however, found when correlating the improvements of both groups with time.

This study suggests that the exercise regime adopted was well suited to its purpose of rehabilitating the condition being investigated. It is also suggested that hydrotherapy may play a more significant role with regards to the previously mostly land-oriented treatment of low back pain with radicular involvement in the lower limbs.

Key Words: hydrotherapy, low back pain, radicular involvement

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Abstract

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Appendix L2

Mean with Standard Deviation values of Outcome Measures per Treatment Group

Pain, Functionality and Lumbar Mobility Changes:

	Patient	ODQ	VAS	FI	Ext	right SLR	left SLR
Before	LTG	36 ± 10	8 ± 2	37 ± 11	17 ± 4	58 ± 20	53 ± 2
	HTG	37 ± 10	8 ± 1	32 ± 2	21 ± 14	77 ± 19	59 ± 3
After	LTG	12 ± 11	2 ± 1	37 ± 11	22 ± 6	94 ± 1	94 ± 1
	HTG	6 ± 3	1 ± 1	41 ± 5	23 ± 14	101 ± 2	92 ± 12

Neurological Changes:

	MP		Reflexes		LTS	
	HTG	LTG	HTG	LTG	HTG	LTG
Improved Condition	2	1	1	1	3	0
Deteriorated Condition	0	1	0	0	0	0
Remained Same	1	1	2	2	0	3

Appendix L1

Subject Mean with Standard Deviation Values for Characteristics per Treatment Group

Group	Number	Sex		Age	Height	Weight	Duration
		M	F	(years)	(cms)	(kgs)	(months)
Water	3	3	0	39 ± 4.08	168 ± 3.74	86.9 ± 0.7	20.3 ± 21.01
Land	3	1	2	47 ± 9.2	159.7 ± 5.91	82.67 ± 10.62	20.3 ± 17.75

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Appendix J1

Exercise Regimes

Exercise Program for Subjects in both Groups.

Warm-up and Cool-down (McIlveen and Robertson, 1998).
Maintained equal throughout, both groups.
Walk in water (not holding on). Do 10 widths (50 metres) in each direction.

- Forwards – place the opposite arm and leg forward at the same time.
- Backwards –stretch the hip back behind the body.
- Sideways – stretch the legs apart gently. Move arms up at the sides as the legs come part. Do not cross the legs.

Land Flexion exercises
Lying
Progressed by range of movement and repetitions to 10 and then to standing.

- Lie down face up without a pillow.
- Bend both knees.
- Raise first one leg towards you and hold with one hand behind the knee, and then the other and hold that behind with the other hand.
- Use your arms to pull both legs down towards your chest, as far as you can.
- Repeat X times
- Let go of one leg, lower it whilst keeping it bent until the foot rests on the couch.
- Let go of the other leg and lower it too.

Standing
Progressed by range of movement and repetitions to 10 and then maintained.

- Stand with legs slightly apart (approx. 20cms)
- Slowly and gently reach down as though to touch the floor, bending from your neck downwards as though curling, as far as you can go.
- Straighten back up slowly from the bottom of your back upwards, as though uncurling, until you are straight.

Land Extension exercises
Lying
Progressed by time to 5 minutes, then to press-ups.

- Face down lying with head rotated to side and arms by side.

Progressed by range of movement and repetitions to 10 and then to standing.

- Press-up exercise – Lie face down, and push up with your hands placed in front of you at shoulder level and slightly more apart than your shoulders, until your back bends backwards as far as possible. Then allow the lower back to sag downwards and return to lying.

Standing
Progressed by range of movement and repetitions to 10 and then maintained.

- Stand with legs slightly apart (approx. 20cms)
- Place your hands on the back of your hips over the prominent bony crests.
- Slowly and gently bend backwards from you neck downwards, as though curling, until you feel your hips start turning backwards too.
- Straighten back up slowly from the bottom of your back upwards, as though uncurling, until you are straight.

Appendix J2

Exercise Regimes – page 2

Hydrotherapy Flexion and Extension exercise
Progressed by range of movement and repetitions to 10 and then maintained.

- Lie on your stomach with a shoulder float (tyre) facing forward towards the rails, holding them with arms stretched outwards.
- Allow your legs to float upwards behind you.
- Whilst keeping the knees and feet together, bend your legs and bring them beneath you.
- Allow your bent legs to rise in front of you, until they reach the tyre in front of your chest.
- Keep the knees and feet together and slowly bring your bent legs downwards, beneath you and allow them to rise behind you as before.

Land Abdominal stabilization exercises
Progress by time to 10 seconds and repetitions to 10 and then maintain.

- Lie face upwards and bend your knees to 45degrees.
- Draw your navel upwards to your head and in to your back, so as to hollow your stomach and keep so for 10 seconds.
- Remember not to bend your head or chest forward, push on your feet or bend your hip forward. Keep breathing normally.

Hydrotherapy Abdominal stabilization exercises
Progress by time to 10 seconds and repetitions to 10 and then maintain.

- Stand at the side of the pool, facing the rail and hold on to it.
- Bend at the knees and lower yourself into the water until your neck is immersed.
- Draw your navel upwards to your head and in to your back, so as to hollow your stomach and keep so for 10 seconds.
- Remember not to bend your head or chest forward, push on your feet or bend your hip forward. Keep breathing normally.

Land Bicycling
Progressed by resistance till medium resistance (setting 5/10 on machine), and time to 5 minutes and then maintained.

- Performed on a Tunturi™ exercise bicycle at medium resistance.

Hydrotherapy Bicycling (McIlveen and Robertson, 1998).
Progressed by resistance to float per ankle, by time to 5 minutes and then maintained.

- Lie on the back at the rail with a hip float on (and collar if needed comfort)
- Bicycle the legs vigorously for 5 minutes.

<u>Appendix H</u>
Specimen
Consent Letter

Owen Sant' Angelo
"Roslow", Iris Street
Santa Lucia PLA 10
Malta
3rd January, 2000.

Mr. Mark Sacco
Co-Ordinator of Physiotherapy Courses, IHC

Dear Mr. Sacco,

I am a fourth year B.Sc. (Hons) Physiotherapy student. A research project has to be submitted in part fulfillment of the B.Sc. (Hons) course requirements. In this regard, I plan to carry out my research at St Luke's Hospital. What follows is a brief outline:

My research will involve six subjects who suffer from low back pain of varying intensity with an added radicular component. The aim of the study is to, essentially, evaluate and compare treatment using hydrotherapy as a 'modality' versus a land-based approach. The patients will be chosen according to set criteria.

The first session will be devoted to assessment – thereafter, the study will span a 4-week period. It is my intention to give a **comparable** exercise regime to both the land-based and hydrotherapy groups. In addition, both groups will be given the **same** home exercises and specific advice. Indeed both groups will be reassessed on a regular basis to ensure the best adaptation of treatment.

In view of the above I ask for your permission to initiate this study.

Thanking you in advance,

Yours sincerely,

____

Owen Sant' Angelo

____
Mr. Mark Sacco
Co-Ordinator of Physiotherapy Courses, IHC

____
Mr. Robert Camilleri
B.Sc. (Hons) Physiotherapy S.R.P. i/c Pool

APPENDIX G1
Specimen
Patient Consent Form - English

PATIENT CONSENT FORM

In signing this paper, I ___________________ (name of participant in block letters) am giving my consent to be assessed and treated by Owen Sant' Angelo who is doing his Research Project.

I understand that I will be part of a research study that will help compare the effects of exercise in water as opposed to exercise on land with patients who suffer from low back pain and associated nerve involvement.

Date ___________________________

Participant's Signature___________________________

Owen Sant' Angelo ___________________________

Owen Sant' Angelo
"Roslow"
Iris Street
Santa Lucia PLA10
Malta.
Tel: 801499

APPENDIX G2
Specimen
Patient Consent Form - Maltese

KARTA TAL- KUNSENS TAL- PAZJENT

Jiena,______________________________ (isem b'ittri kbar), hawn ta]t iffirmat/ a qed nag]ti l-permess lil Owen Sant' Angelo biex jinkludini fl-istudju tieg]u.

Jiena nifhem li se nkun parti minn studju li se jqabbel trattament fl' ilma ma trattament fuq l-art ta' pazjenti li jbatu minn ugieg] fid-dahar w u[ieg] li jinfirex fin-nervituri li jin\lu fis-sieq.

Data ________________________

Firma tal-parti`ipant ________________________

Owen Sant' Angelo ________________________

Owen Sant' Angelo
"Roslow"
Iris Street
Santa Lucia PLA10
Malta
Tel: 801499

Owen Sant' Angelo
"Roslow"
Iris Street
Santa Lucia PLA10
Malta
Tel: 801499.

<u>Appendix F1</u>
Specimen
Patient Introductory Letter - English

Dear Mr/ s ______________________,

My name is Owen Sant' Angelo and I am currently completing my final year as a B.Sc. (Hons) Physiotherapy student. A research project has to be submitted as part of the usual course requirements.

I will be comparing the effects of exercise in water as opposed to exercise on land with patients who suffer from low back pain and associated nerve involvement.

In order to complete the study, I will need your full co-operation. This will involve attending for set treatment sessions and following a designated, home exercise program along with the advice given. Regular assessment procedures will also form part of the study.

However, your participation is entirely voluntary at all stages of the study – you may decide not to participate and thereby be excluded from the study. In addition, every effort will be made to keep personal records strictly confidential.

The study is set to span 4weeks with a final assessment to complete and organize all the relevant data. I will appreciate any questions or comments. Please feel free to contact me at any time on this telephone number: 801499.

Thank You.

Sincerely,

____
Owen Sant' Angelo

Owen Sant’ Angelo
“Roslow”
Triq l- Iris
Santa Lucia PLA10
Malta.
Tel: 801499.

Appendix F2
Specimen
Patient Introductory Letter - Maltese

G]a\i\/ a Sinjur/ a ___________________,

Jiena, Owen Sant’ Angelo ninsab fl-a]]ar sena tal-kors tal-Fi\joterapija. B]ala parti mill-kors se nag]mel studju biex inqabbel trattament fl’ ilma ma trattament fuq l-art ta’ pazjenti li jbatu minn ugieg] fid-dahar w u[ieg] li jinfirex fin-nervituri li jin\lu fis-sieq.

Biex inkun nista’ nag]mel dan l-istudju, se jkolli b\onn il-kunsens tieg]ek. G]aldaqstant, la darba tidde`iedi tie]u sehem, ikollok b\onn ti[i regolarment g]at-trattamenti li se nofrilek. Tkun trid tag]mel xi e\ercizzji d-dar, u toqg]od attent/a g]at- twissijiet li sejjer nag]tik. Barra minn hekk, l-istudju jitlob e\aminar fid-dettal li jibqa g]addej tul l-istudju kollu, li hu ppjanat li jie]u erba’ [img]at. Id-dettalji tieg]ek jibqg]u kunfidenzjali.

Madankollu, il- parti`ipazjoni tieg]ek hija dejjem volontarja – tista tag]\el li ma tie]ux sehem u, g]aldaqstant, tinqata mill-lista.

F’ ka\ ta’ diffikulta tista’ ``empel fuq dan in-numru tat-telefon: 801499.

Grazzi.

____

Owen Sant’ Angelo

Appendix E

Exclusion Criteria

One or more of the following:

Pain Duration
[] Back Pain more than 3 months (since____________)
[] Leg Pain more than 3 months (since____________)

Fitness
[] Uncontrolled Hypertension
[] Severe Postural Hypotension
[] Left Heart Failure
[] Exercise Induced Angina
[] Lung Vital Capacity less than 1.5 litres
[] Faecal or Urinary Incontinence
[] Allergy to Chlorine
[] Tendency to antisocial behaviour such as can occur following a head injury
[] Severe limiting airways disease
[] Women in the first trimester of pregnancy

Hydrotherapy Screening
[] Systemic Ilnness/pyrexia
[] Recent Deep Vein Thrombosis
[] Skin or wound infection
[] Recent Pulmonary Embolus
[] Fear of water

Additional Criteria
[] Spondylolisthesis
[] Underwent lower limb joint replacement surgery
[] Previous spinal surgery
[] True Leg Length Discrepancy > 0.5 inch (Frymoyer and Cats-Baril, 1991).
[] Receiving work/ traffic injury-related compensation
[] Requires alternative medicine/ therapy
[] Attends private physiotherapy

Appendix D1

Specimen

Oswestry Disability Questionnaire in English - page 1

Date:___/___/______

Name:______________________________ **ID No:**_________(__) **Age:**____ years
Address:____ **Tel. No.:**_____________
Occupation:___________________________
Consultant:_____________________________

Date your back pain started: ___/___/______
Date any leg pain started: ___/___/______

This questionnaire is designed to collect information on how your low back and leg pain has affected your ability to manage in everyday life. Answer all sections. For the ten sections below mark **one box** next to a phrase. Select the phrase which **MOST CLOSELY** describes your problem right **NOW**.

Pain

[] I can tolerate the pain without having to use medication
[] The pain is bad but I can manage without pain killers
[] Painkillers give complete relief from pain
[] Painkillers give moderate relief from pain
[] Painkillers give very little relief from pain
[] Painkillers have no effect on the pain and I do not use them

Personal

[] I can look after myself normally without causing extra pain
[] I can look after myself normally but it causes extra pain
[] It is painful to look after myself and I am slow and careful
[] I need some help but manage most of my personal care
[] I need help every day in most aspects of self care
[] I do not get dressed. I wash with difficulty and stay in bed

Lifting

[] I can lift heavy objects without extra pain
[] I can lift heavy objects but it gives extra pain
[] I can't lift heavy objects from off the floor but off a table is OK
[] I can't lift heavy objects but but light to medium ones are OK
[] I can only lift very light weights
[] I cannot lift of carry anything at all

Walking

[] Pain does not prevent me from walking any distance
[] Pain prevents me from walking more than about two kilometres (one mile)
[] Pain prevents me from walking more than one kilometre (one-half mile)
[] Pain prevents me from walking more than half a kilometre (quarter mile)
[] I can only walk using a stick or crutches
[] I am in bed most of the time and have to crawl to the toilet

Appendix D1
Specimen
Oswestry Disability Questionnaire in English – page 2

Sitting
[] I can sit in any chair as long as I like
[] I can sit in my favourite chair as long as I like
[] Pain prevents me from sitting more than one hour
[] Pain prevents me from sitting more than 30 minutes
[] Pain prevents me from sitting more than 10 minutes
[] Pain prevents me from sitting at all

Standing
[] I can stand as long as I want without extra pain
[] I can stand as long as I want but it gives extra pain
[] Pain prevents me from standing for more than 1 hour
[] Pain prevents me from standing for more than 30 minutes
[] Pain prevents me from standing for more than 10 minutes
[] Pain prevents me from standing at all

Sleeping
[] Pain does not prevent me from sleeping well
[] I can sleep well only by using tablets
[] Even when I take tablets I have less than six hours of sleep
[] Even when I take tablets I have less than four hours of sleep
[] Even when I take tablets I have less than two hours of sleep
[] Pain prevents me from sleeping at all

Sex life
[] My sex life is normal and causes no extra pain
[] My sex life is normal but causes some extra pain
[] My sex life is nearly normal but is very painful
[] My sex life is severely restricted because of pain
[] My sex life is nearly absent because of pain
[] Pain prevents any sex life at all

Social
[] My social life is normal and gives me no extra pain
[] My social life is normal but increases the degree of pain
[] I can't participate in more energetic activities like tennis
[] Pain restricts my social life and I don't go out as often
[] Pain restricts my social life to my home
[] I have no social life because of pain

Travel
[] I can travel anywhere without pain
[] I can travel anywhere but it gives me extra pain
[] Pain is bad but I manage journeys over two hours
[] Pain restricts me to journeys of less than one hour
[] Pain restricts me to short necessary journeys of less than 30 minutes
[] Pain prevents me from traveling (except to my health practitioner)

Appendix D2
Specimen
Oswestry Disability Questionnaire in Maltese – page 1

Data:___/___/______
Isem:_______________________________ **ID No:_________(__)** **Snin:____**
Indirizz:____ **Tel. No.:_____________**
Xog]ol:___________________________
Consulent:___________________________
Kemm ilek issofri bl-u[ieg] f'saqajk? ___________________
Kemm ilek issofri bl-u[ieg] f'dahrek? ___________________

Dawn il-mistoqsijiet huma mportanti biex jag]tu informazzjoni dwar kif l-u[ieg] f'dahrek u fin-nervituri ta' saqajk seta b'xi mod affetwa l-]ajja tieg]ek ta' kuljum. Jekk jog] [bok irrispondi g]all-mistoqsija wa]da biss minn kull sezzjoni. Immarka l-kaxxa li t]oss li l-aktar tixba] il-problema tieg]ek **b]alissa.**

Qawwa ta l-u[ieg]

[] Nista' nissaporti l-u[ieg] tieg]i ming]ajr ma nie]u pilloli.
[] L-u[ieg] huwa qawwi i\da m'hemmx g]alfejn nie]u pilloli.
[] Bil-pilloli jg]addili l-u[ieg] kollu.
[] Il-pilloli jtaffuli xi ftit mill-u[ieg].
[] Il-pilloli ftit li xejn itaffuli mill-u[ieg].
[] Il-pilloli ma jkollhomx effett u l-anqas nu\hom.

Kura Personali

[] Nista nie]u]sieb tieg]i nnifsi ming]ajr ma nwe[[a'.
[] Nista nie]u]sieb tieg]i nnifsi i\da nwe[[a'.
[] Meta nie]u]sieb tieg]i nnifsi, nwe[[a' u jkolli noqg]od attent /a.
[] G]andi b\onn ftit g]ajnuna i\da nista' nag]mel hafna mill-affarijiet.
[] G]andi b\onn l-g]ajnuna kuljum g]al-]afna b\onnijiet personali.
[] Ma nistax nilbes, nin]asel b'diffikulta' u noqg]od fis-sodda.

Tqandil

[] Nista' nerfa affarijiet tqal ming]ajr ma nwe[[a'.
[] Nista' nerfa affarijiet tqal i\da nwe[[a'.
[] Ma nistax nerfa affarijiet tqal mill-art, i\da nista nerfag]hom minn fuq mejda.
[] Nista' nerfa affarijiet mhux daqshekk tqal, jew]fief.
[] Nista' nerfa affarijiet]fief biss.
[] Ma nista' nerfa jew in[orr xejn.

Mixi

[] Nista' nimxi fit-tul ming]ajr ma nwe[[a.
[] Min]abba l-u[ieg] ma nistax nimxi aktar minn zewg kilometri (mil).
[] Min]abba l-u[ieg] ma nistax nimxi aktar minn kilometru (nofs mil).
[] Min]abba l-u[ieg] ma nistax nimxi aktar minn nofs kilometru (kwart ta' mil).
[] Meta nimxi, jkolli nu\a l-bastun jew il-krozzi.
[] Inkun fis-sodda]afna u jkolli nitkaxkar sal-kamra tal-banju.

Appendix D2
Specimen
Oswestry Disability Questionnaire in Maltese – page 2

Meta Npo[[i

[] Nista’ npo**[[**i fuq liema si**[[**u li rrid u g**]**al kemm **]**in irrid.
[] Nista’ noqg**]**od biss fis-si**[[**u favorit tieg**]**i g**]**al kemm **]**in irrid.
[] Min**]**abba l-u**[**ieg**]** ma nistax indum bil-qeg**]**da aktar minn sieg**]**a.
[] Min**]**abba l-u**[**ieg**]** ma nistax indum bil-qeg**]**da aktar minn nofs sieg**]**a.
[] Min**]**abba l-u**[**ieg**]** ma nistax indum bil-qeg**]**da aktar minn aktar g**]**axar minuti.
[] Min**]**abba l-u**[**ieg**]** ma nistax inpo**[[**i.

Meta Noqg]od bil-Wieqfa

[] Nista’ noqg**]**od bil-wieqfa kemm irrid ming**]**ajr ma n**]**oss u**[**ieg**].**
[] Nista’ noqghod bil-wieqfa kemm irrid i\da n**]**oss l-u**[**ieg**].**
[] Min**]**abba l-u**[**ieg**]** ma nistax indum bil-wieqfa aktar minn sieg**]**a.
[] Min**]**abba l-u**[**ieg**]** ma nistax indum bil-wieqfa aktar minn nofs sieg**]**a.
[] Min**]**abba l-u**[**ieg**]** ma nistax indum bil-wieqfa aktar minn g**]**axar minuti.
[] Min**]**abba l-u**[**ieg**]** ma nistax noqg**]**od bil-wieqfa.

L-Irqad

[] Norqod tajjeb tul il-lejl kollu.
[] Norqod tajjeb biss jekk nie**]**u xi pilloli.
[] Norqod inqas minn sitt sieg**]**at anki jekk nie**]**u l-pilloli.
[] Norqod inqas minn erba’ sieg**]**at anki jekk nie**]**u l-pilloli.
[] Norqod inqas minn sag**]**tejn anki jekk nie**]**u l-pilloli.
[] Min**]**abba l-u**[**ieg**]** ma norqod xejn.

Hajja Sesswali

[] Il-**]**ajja sesswali tieg**]**i hija normali ming**]**ajr ma n**]**oss u**[**ieg**]**.
[] Il-**]**ajja sesswali tieg**]**i hija normali i\da nhoss xi u**[**ieg**]**.
[] Il-**]**ajja sesswali tieg**]**i hija kwa\i normali i\da nwe**[[**a’ **]**afna.
[] Il-**]**ajja sesswali tieg**]**i hija ristretta **]**afna min**]**abba l-u**[**ieg**]**.
[] Il-**]**ajja sesswali tieg**]**i kwa\i ma te\istix min**]**abba l-u**[**ieg**]**.
[] Il-**]**ajja sesswali tieg**]**i hija nieqsa g**]**al kollox min**]**abba l-u**[**ieg**]**.

}ajja So`jali

[] Il-**]**ajja so`jali tieg**]**i hija normali u ma tikka**[**unax u**[**ieg**]**.
[] Il-**]**ajja so`jali tieg**]**i hija normali i\da n**]**oss xi w**[**ieg**]**.
[] Ma nistax nie**]**u sehem f’affarijiet li jitolbu aktar ener**[**ija e.\. sport.
[] Ma tantx no**]**ro**[** min**]**abba l-u**[**ieg**]**.
[] Inqatta l-**]**in tieg**]**i d-dar min**]**abba l-u**[**ieg**]**.
[] Il-**]**ajja so`jali tieg**]**i hija nieqsa g**]**al kollox min**]**abba l-u**[**ieg**]**.

Vja[[ar

[] Nista’ nivja**[[**a kullimkien ming**]**ajr ma n**]**oss u**[**ieg**]**.
[] Nista’ nivja**[[**a kullimkien i\da n**]**oss xi u**[**ieg**]**.
[] Kapaci nivja**[[**a g**]**al aktar minn sag**]**tejn i\da nwe**[[**a **]**afna.
[] Min**]**abba l-u**[**ieg**]**, ma nistax nivja**[[**a aktar minn sieg**]**a.
[] Min**]**abba l-u**[**ieg**]**, ma nistax nivja**[[**a aktar minn nofs sieg**]**a.
[] Ma nistax nivja**[[**a min**]**abba l-u**[**ieg**]**, **]**lief g**]**al g**]**and it-tabib.

Appendix C

Visual Analogue Pain Scale (VAS)

Name of Patient: ______________________ **Date**: __/__/____

Session Number: ______________________

Appendix B

Normal Lumbar and associated Pelvic Kinematics

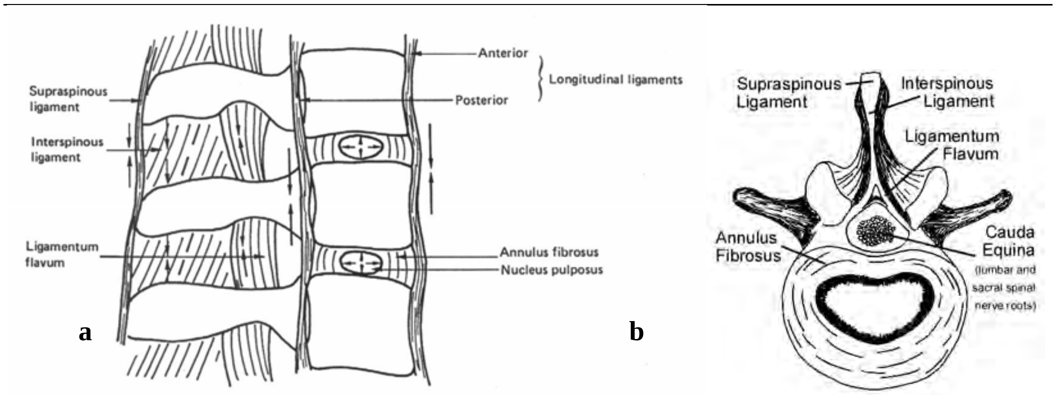


Fig B1. *Ligaments of the Spine: a) Sagittal View (from Palastanga 1998: 661)*
b) Caudal View (from http://www.mckenziemdt.org)

Lumbar flexion is usually about 45^0. Further flexion incurs lumbar pelvic rhythm as the pelvis is tilted anteriorly to the extent permitted by soft tissues. In standing, it is aided by gravity but controlled by the erector spinae muscles working in eccentric fashion, thoracolumbar fascia, posterior part of the intervertebral disc, posterior longitudinal ligament, ligamenta flava and inter- and intraspinous ligaments (Palastanga 1998, Cailliet 1991). In sitting, it is brought about mainly by the rectus abdominis, external and internal oblique muscles and psoas major and minor (when present) working in concentric fashion (Palastanga 1998). If the rib cage is stabilized, contraction of the first three causes posterior pelvic tilt. This movement causes the vertebrae to tilt anteriorly, compressing the anterior portion of the intervertebral disc, and displacing the nucleus towards the posterior distracted portion to redistribute the load throughout the disc (Grieve 1994, Kisner and Colby 1990). The inferior facets glide upwards and forwards on the superior facets of the vertebra below. The vertebra above moves slightly forward over the one below, causing the intervertebral foramen to decrease in antero-posterior size but increase in supero-inferior distance (Palastanga 1998).

Lumbar extension occurs when extending the flexed spine to the normal erect posture. The muscles used vary according to the degree of flexion. Cailliet (1991) names the thoracolumbar fascia as the main structure extending the spine flexed at 90^0, with the erector spinae being activated by muscle spindles at 45^0.
Lumbar hyperextension is usually about 30^0. In standing, it is aided by gravity but limited mechanically by apposition of the facet joints and spinous process, the anterior longitudinal ligament, the anterior part of the intervertebral disc and voluntarily by eccentric contraction of the lumbar flexors. In prone it is brought about by bilateral concentric work of the quadratus lumborum, multifidus, semispinalis, erector spinae and interspinales muscles (Palastanga 1998), and the thoracolumbar fascia (Cailliet 1991). This movement compresses the posterior portion of the disc, displacing the nucleus anteriorly. The inferior articular process glides down on the superior below so that the vertebra above moves slightly posteriorly (Adams 1994).

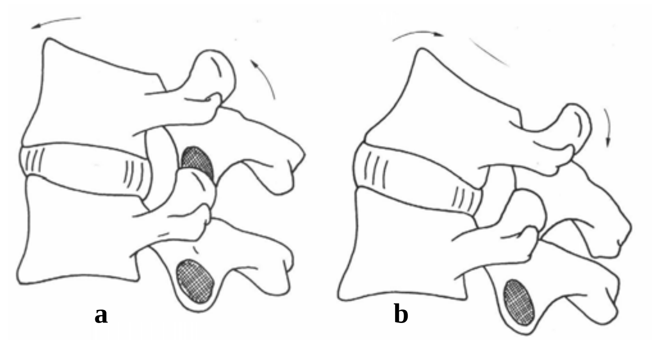


Fig B2. *Interaction between adjacent lumbar vertebra in a) flexion; b) extension (from Palastanga, 1998: 667)*

For both lumbar flexion and extension, there is least movement in the thoracolumbar joint and most in the lumbosacral joint. In the latter, flexion results in the inferior facet gliding supero-anteriorly upon the sacral facets, limited by the strong iliolumbar, inter- and supraspinous ligaments, vertebral muscles and thoracolumbar fascia, whilst extension results in a poster-inferior glide, limited mainly by apposition of the spinous process of L5 and S1 (Palastanga 1998). Any rotation of the pelvis upon the femoral heads occurs in the sagittal plain and will result upon change of the lumbar lordosis and lumbosacral angle. Posterior pelvic tilt, results in a decrease in lumbar lordosis, simulating flexion, whilst anterior pelvic tilt, limited by hamstrings, similarly simulates lumbar extension.

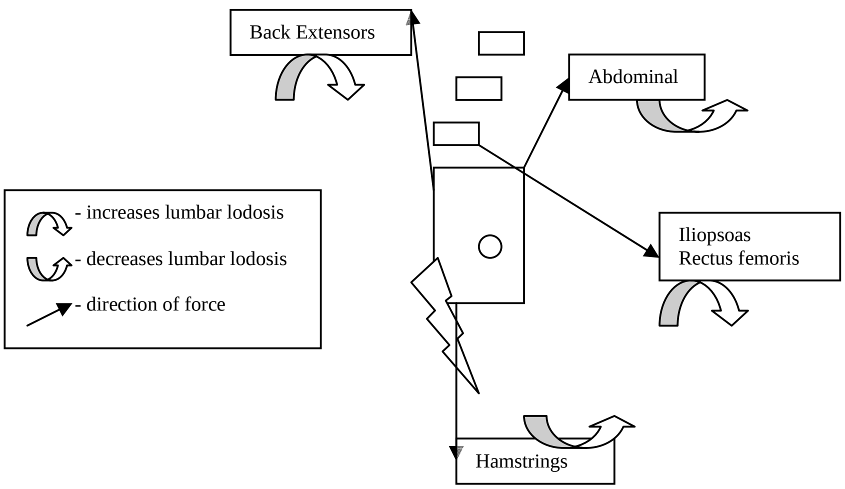
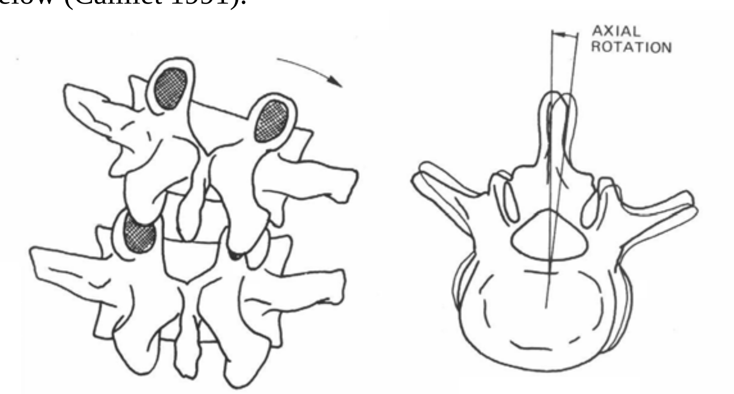


Fig B3. *Schematic representation of lumbar-pelvic association (adapted from Magee 1997)*

Lumbar Rotation is severely limited to 5^0 by the shape and orientation of the facet joints, that allow rotation only as far as the tiny gap between facets in standing are closed. Rotation is further limited in extension due to already closed gaps, but is slightly increased in flexion. It occurs more commonly with side-flexion. Rotation is brought about by unilateral contraction of multifidus, rotatores, semispinalis, internal and external oblique muscles (Palastanga 1998, Macintosh and Bogduk 1994). It is restricted by eccentric work of the their contra-lateral components, as well as by smaller ligaments and the above mechanisms. Cailliet (1991) states that 50-60% of the torque strength during rotation is sustained by the posterior articulations –the facet joints and capsules and the interspinous ligaments. The rest is provided by the annulus' fibres that run in the opposite direction to movement, thereby being

elongated, in addition to being increasingly put under stress by the compressed nucleus within (Palastanga 1998). Rotation causes the intervertebral foramina on the opposite side to decrease in size.
Lumbar side-flexion is only about 20-30^0 and much less in the lumbosacral joint. It is greatest in standing and least when the lumbar lordosis is lost. It is initially brought about by unilateral contraction of quadratus lumborum, intertransversarii, external and internal obliques, rectus abdominis, erector spinae and multifidus muscles (Macintosh and Bogduk 1994). Once 10^0 have been reached, the movement is controlled by eccentric contraction of the contra-lateral muscles (Palastanga 1998). Side-flexion is finally limited by annulus fibre elongation, facet joint approximation, and the intertransversus ligaments (Palastanga 1998). In pure side-flexion, approximation of the facet joints on the side concave to the movement occurs, whilst the convex facet joint space increases with a concurrent glide of the inferior process up on the superior one below it (Palastanga 1998, Adams 1994), finally resulting in increased intervertebral foramina diameter in the side convex to movement.
In side-flexion with rotation, the facets on the concave side of movement are approximated, providing a fulcrum around which the functional unit rotates and resulting in a lateral shear upon the disc as the vertebra above move slightly anteriorly on the one below (Cailliet 1991).



a **b**

Fig B4. *a) Interaction between adjacent lumbar vertebra in side-flexion; b) Range of axial rotation. (from Palastanga, 1998: 669)*

The pelvis affects the lumbar spine in the coronal plane when a leg length discrepancy of any kind occurs. Then, the sideways pelvic slant would deviate the lumbar spine away in the sagittal plane according to the degree of pelvic obliquity.

Palastanga (1998) notes that Interspinales, Multifidus, Rotatores and Intertransversarii muscles produce only weak assistance to movements. Their main function is therefore to act as eccentric ligaments thereby stabilizing vertebral units during trunk movements.

Cailliet's (1991) notes the importance of the pelvis with relation to lumbar spine. Main considerations of pelvic dysfunction that leads to lumbar dysfunction includes excessive alteration in length or muscle power of muscles that control pelvic tilt (Magee 1997) and therefore the lumbar lordosis or scoliosis.

Appendix A

Intervertebral Disc

The lumbar intervertebral discs are 10mm thick, wedge-shaped (Palastanga, 1998) hydrodynamic-elastic structures (Cailliet, 1991), consisting of a nucleus pulposus surrounded by the annulus fibrosus, and capped at each end by a cartilaginous end plate.

The nucleus pulposus is a centro-posteriorly located mass of proteoglycan gel containing randomly layered collagen fibrils that interlock at 60^0 (Cailliet, 1991). The gel-like part of the nucleus provides intrinsic hydration pressure upon the surrounding annulus, through imbibition, thereby assisting in weight-bearing (Cailliet, 1991) whilst the nuclear collagen fibres mechanical arrangement provides elasticity and tensile strength.

The outer Annulus Fibrosus is a strong fibro-cartilaginous structure arranged in parallel-layered sheets. These are composed of collagen fibres that span the disc space increasingly obliquely as rings become more central with corresponding fibre length decrease, but with more irregularities in the posterior region of the annulus. The annular fibre arrangement allows the annulus to expand (bulge slightly) upon pressure from the nucleus and provides mechanical resistance to vertebral movement through efficient elastic physiologic compliance (Cailliet, 1991).

The response of the intervertebral disc to static loading is that of creep deformation lasting for hours (Palastanga, 1998; Adams, 1994), and actual loads supported both by the discs and by the vertebral bodies may be very high without problems. Palastanga (1998) mentions that lumbar disc tension failure is observed at 3000N and the bodies at 5000N. He describes such loading as being initially (for 1 sec) supported by the nucleus and thereafter by the entire disc. In response to a dynamic load, Palastanga (1998) notes that the disc initially vibrates (for 1 sec), possibly damping oscillations and acting as an efficient shock absorber. When the disc is loaded statically and then dynamically, the vibrations set up may exceed the tensile limit of the disc or its attachment to the bone, resulting in disc injury (Palastanga, 1998).

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We get you moving

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Chapter 5:
Recommendations and Conclusion

5.1 Recommendations

Both the results of the study as well as the experience gained by the researcher, as reflected by previously mentioned limitations, allows the researcher to make a number of recommendations:

- It is recommended that further studies be carried out to explore the benefits of hydrotherapy upon LBPR. With reference to the limitations of this study, it is advised that use of a power analysis be made to determine the size of sample necessary to demonstrate significance and to avoid the occurrence of a type II error (Polit and Hungler 1978).
- Future studies may use different outcome measures with respect to pain and functionality measurement. Sensitivity to small changes would be the most important characteristic.
- Future studies may be of double-blinded nature to decrease any bias or one-sided Hawthorne effect. This would require the involvement of more than 1 researcher.
- The possibility of group hydrotherapy with respect to LBPR may be explored locally. The added psychological component of group therapy may alter the improvement rate and further increase the level of rehabilitation attained.

5.2 Conclusion

This 4-week research study investigated the influence of hydrotherapy upon patients suffering from low back pain with radicular components, under the premise that the treatment in the environment of the hydrotherapy pool allows such patients to reach a higher level of rehabilitation in comparison to patients suffering from the same condition, who are treated on land.

The exercise program prescribed to the subjects considered adequate warm-up and cool-down with intervening exercises that addressed lumbar spine mobility, muscular strengthening and general fitness. Session timing and frequency were planned according to set criteria imposed by the condition.

The results obtained were not statistically significant so that the differences obtained between the hydrotherapy treatment group and the land treatment group cannot be applied to the larger population as information backed by hard scientific data. Despite this, the hydrotherapy subjects were found to have improved further with regards to functionality and light touch sensation, whilst the land subjects showed greater progress within general lumbar mobility. Furthermore, none of the subjects in either group deteriorated in condition. Indeed, they all measurably improved their status with respect to functionality, pain and lumbar mobility, in a manner that was statistically significant, albeit only to show that the exercise was effective in both environments without preference for either.

Lumbar pain in Malta is the highest reason for referral to physiotherapy, documenting the anecdotal evidence that physical therapy on land or in an aquatic environment plays a major and successful role in treating this condition. Given the increasing incidence of LBP and LBPR and the greater disability resulting from the latter, it is imperative that the best mode of treatment be found.

This study suggests that hydrotherapy may play an effective role in the rehabilitation of subjects suffering from low back pain with radicular components. It is also furthermore suggested than an exercise program such as the one used in the study is effective in the rehabilitation of such patients.

In a goal-oriented society, it is no longer tolerable that such an extensively disabling condition as low back pain with radicular components be allowed to run its course for years-on-end, without investigating the best possible way to treat it. The psycho-socio-economic burden to society must be relieved. Even more important, the individual can no longer be allowed to suffer for so long from a condition simply because of lack of research. The anecdotal benefits that hydrotherapy offers directly to these patients are well established. Serious scientific backing would give them far more prominence and help win the fight against low back pain with radicular components.

Chapter 4:
Discussion

4.1 The Low Back Pain problem

The low back pain problem has a high incidence in the Western world (Wieisinger et al. 1997) and is therefore a major factor affecting populations from physical, social, psychological and also economic points of view (Frymoyer and Cats-Baril 1991).

The massive amount of research being carried out, in the main, attempts to validate scientifically the best ways to treat this condition. Nonetheless, low back pain cases increase in number every year. Kodish (1998) states that 35% of all low back pain cases develop sciatica, which leads to greater disability and a higher level of pain than caused by low back pain (Lee and Simmonds 1999). Radicular components are also of economic importance as Frymoyer and Cats-Baril (1991) highlight the channelling of resources mainly to the worst affected low back pain sufferers, presumably containing a high degree of peripheral involvement.

A review of the literature brings to light the major lack of research determining the impact of treatment environment upon the outcome of treatment of patients with LBPR. What research has been carried out of LBP and LBPR treatment in the aquatic environment has mostly led to positive results, in that subjects have improved their condition.

This study attempted to make use of various widely used exercises routinely used as part of land and hydrotherapy programs, slightly adapted to improve in similarity, so as to compare the outcome.

Therefore the environment treatment variable was manipulated to see for its effect upon treatment outcome. An attempt was made to reject a null hypothesis that treatment environment does not bear relation to outcome of treatment, so as to accept the hypothesis that hydrotherapy creates a better environment for more complete rehabilitation of low back pain with radicular involvement in the lower limbs, than land-based physiotherapy.

Following the treatment of LBPR patients in both environments, termed land treatment group (LTG) and hydrotherapy treatment group (HTG), the outcome variables defining the level of rehabilitation reached by the patient in the experimental period selected of 4 weeks, were tabulated. The mean values (with standard deviation) of these values, namely pain, disability, lumbar mobility and neurological status were used to compare the practical improvements made by members of the group, through descriptive statistics. The data was also statistically analysed for relevance to the greater population, providing inferential statistics.

4.2 Results

Findings suggested a mixed outcome, but with overall rejection of the hypothesis and validation of the null hypothesis.

The unrelated t-test for different groups provided no statistical difference in treatment outcome measurements between both groups. Therefore both groups reached a similar statistical level of rehabilitation notwithstanding different environments of treatment. In conclusion, it would incorrect scientific procedure to apply the findings in context to the larger population (Hicks 1997) of LBPR sufferers.

However, there was a descriptive data difference between both groups within the context of disability, lumbar mobility and a neurological component that may be of clinical relevance.

Also, a tangential analysis of comparison of treatment with time for both group's subjects achieved statistical significance (p <0.05) Therefore the modes of treatment (as compared to the environment) chosen were apparently valid with reference to particular aspects of rehabilitation, and may, in turn, be applied to larger populations without discriminating between treatment environments, but with scientific backing.

4.3 Methodological Factors

The researcher identifies a two chief possible ways to interpret the results of rejection of hypthesis.

On the one hand, it may be considered that hydrotherapy does in fact make little difference to most subjects with chronic LBPR.

On the other hand, a statistically significant difference between outcome measurements for either group might have been present, but was nullified by a sample size that was too small to be successfully used for interferential statistical analysis (a type II error). Had the study design catered for a larger sample size, the differences in outcome measure for each group may have reached significance and supported anecdotal reports and existing studies which show that hydrotherapy can significantly benefit people with LBPR more than land treatment. Had different measures been used, perhaps a different outcome might have been identified.

McIlveen and Robertson (1998) identify the possibility of a Hawthorne effect, whereby patients improve simply because they expect to improve. Perhaps this study did not achieve significant difference in environment treatment outcome because it conveyed a measure of 'double Hawthorne effect' (Polit and Hungler 1978); that is, a measure of the progress obtained was conveyed through both the researcher and the patient's wish to progress their condition. The novelty of being included in a study, combined with the novelty of hydrotherapy for the HTG may have contributed to increasing patients' expectations and therefore altering their perception of condition, and possibly perception of pain and neurological symptoms (Wells, Frampton and Bowsher 1996) with resultant increase in mobility.

4.4 The exercise regime

Treatment was aimed to attenuate the pain and neurological problems present, whilst increasing lumbar mobility. The relative simplicity of the exercise program was designed to decrease extraneous factors, thereby allowing the difference in environment to have a greater bearing upon the progress of patients. The time exercise period of 4 weeks was considered to be a standard time for hydrotherapeutic treatment and attempted make use of the benefits of water without causing the subject to become dependent upon it, and having to be 'weaned' off it (Wells, Frampton and Bowsher 1996)

All patients reached a similar stage in the exercise program, in which case it was thought that the effects exercised upon them by the regime were of parallel significance in all cases, with variance due to different conditions. Limits were set on the intensity and number of repetitions per exercise, considering possible neural denervation in the radicular component and the adverse effect of effort of high intensity upon it (Bohnannon and Gajdosik 1987).

The frequency of treatment sessions was set at twice weekly. This is comparable to the study by Ariyoshi et al. (1999) who investigated the efficacy of aquatic exercise on patients with LBP, and concluded that subjects who performed general aquatic exercises twice or more in a week showed a more significant physical score improvement than subjects who only exercised once weekly.

Lumbar mobility exercises have been frequently mentioned in the literature. Flexion and extension exercises reposition the nucleus pulposus more centrally and therefore correctly within the intervertebral disc, according to the dynamic internal disc model described by McKenzie (Donelson et al. 1997). Lumbar flexion and rotation stretches collagen fibre where scar tissue is thought to be present (Cailliet 1991), possibly because of long term maltreatment of the spine (Moss 1994). Associated soft tissue structures are also stretched, and facet joint approximation altered (Robinson 1994) according to direction of movement. Choice of direction during treatment was made on the basis of directional preference, thereby attempting to decrease the symptoms by relieving stenosis and releasing pressure upon the nerve root and its dura (Donelson et al. 1997, Robinson 1994).

Abdominal stabilization exercises provide lumbar stability. Directed towards activating preferentially the deeper abdominal muscles, particularly the transversus abdominis and internal obliques; they provide lumbar stability in static positioning without affecting anterior pelvic tilt by increasing intra-abdominal pressure (Cresswell and Thorstensson as cited in O'Sullivan et al. 1997). Strohl et al. (cited in O'Sullivan et al. 1997) also note that activation of the transversus abdominis and internal oblique muscle during movement provides dynamic stability of the lumbar spine in movement, without restricting ribcage mobility or affecting respiration.

General fitness is another well-expressed factor in LBP rehabilitation literature, (Reid 1990), cardiovascular examples of which are bicycling and walking (McIlveen and Robertson 1998). That the latter may also be used as a gentle warm-up and cool-down in an exercise program is an important factor (Reid 1997).

4.5 Disability

HTG subjects registered a mean greater improvement in function than LTG subjects, through a decrease in disability percentage noted by the ODQ, although this difference was not statistically significant. The chronic nature of the patient's conditions was indicated by mean ODQ initial score of moderate disability (20-40%) (Fairbank et al. 1980). This decreased significantly with time to a mean well within the limits set by Fairbank et al. (1980) as minimal disability (0-20%), especially the experimental hydrotherapy group.

This trend is supported by the literature. McIlveen and Robertson (1998) contrasted the improvements in various outcome measures between an experimental HTG and control delayed-LTG for LBP and LBPR group treatment and found a statistically significant greater functional improvement in ODQ in the HTG. Sjorgen et al. (1997) compared the improvements of an experimental hydrotherapy group and a land group and found that a greater improvement of ODQ had occurred in the hydrotherapy group, though not a statistically significant one. The most important aspect of the ODQ is that it indicates the subject's quality of life (Fairbank et al. 1980) and therefore may well be the most important outcome variable since, given the fact that most patients regard pain and decreased mobility as their current complaint, the ODQ implies a decrease in the pain level and increase in subject mobility as part of its decrease in disability. The latter in particular refers to the concurrent improvement in lumbar flexion exhibited, since the lumbar spine is most commonly used in the flexed position (Moss, 1994), so that an improvement in ability to flex the lumbar spine may directly result in an improvement of quality of life.

Whilst being a reliable and valid tool in recording accurate pain intensity when used correctly (Fairbank et al. 1980), a number of authors have noted its apparent decreased sensitivity to small changes in disability improvement, especially when used in chronic conditions (Beattie and Maher 1997, Beurskens, de Vet and Koke 1996), in comparison to other questionnaires, such as the Roland Morris Questionnaire. Since the study population had a mean condition duration of approximately 2 years, this characteristic may account for the resultant statistically insignificant status of the visible difference between both groups.

4.6 Pain

In this study, pain intensity decreased for subjects in both groups similarly over the 4 weeks treatment period. The initial measurement for subjects was close to the maximum intensity noted on the scale, whilst the final measurements were close to the minimum marking on the scale. Once again, given the chronic nature of the condition, the difference was satisfyingly significant, even statistically for both groups. This benefit has been reproduced by other studies too. In the only study to compare land-based with hydrotherapy treatment, Sjorgen et al. (1997) noted that hydrotherapeutic treatment benefited subjects with a greater reduction in pain, though not statistically significantly. McIlveen and Robertson (1998) also reported discernible improvement with hydrotherapy, using the McGill Questionnaire that encompasses pain intensity, rank and scale rating and description with respect to the patient. Langridge and Philips (1988) supervised group hydrotherapy exercises, and noted that pain levels were reduced by 85%. Cailliet (1991) notes that such pain is caused by irritation of the dural sheath and neural tissue with possible adhesion formation in chronic conditions.

It follows that stretching of the nervous tissue with concomitant relief of pressure was adequately supplied by the exercise regime chosen. Given the claimed benefits of pool therapy upon pain that were obviously not present on land during the exercise regime, a greater correlation between the HTG and pain decrease than LTG was expected. Several factors may explain this apparent non-sequitur.

Following a study of pain intensity felt by osteoarthritic patients, Bellamy, Campbell and Syrotuik (1999) noted a positive correlation between initial pain rating and subsequent pain response, and concluded that patients with more severe pain may achieve greater overall reductions in pain than those with mild pain. This principle may be applied to this study in that the LTG had a greater initial mean pain intensity than the HTG. Considering that the higher a gradient (R^2), the greater the rate of improvement and considering that the gradient for the LTG scatter graph trendline was 0.9251, and that for the HTG 0.7977, it is thought by the researcher that the effect observed by Bellamy, Campbell and Syrotuik (1999) may be, in part, nullifying the beneficial effects of water.

The effect of muscular relaxation obtained from various benefits of water, especially heat, (Reid 1997) may have adversely affected pain relief. Muscular support of the lumbar spine could possibly have decreased to the point where painful structures in the spine were brought into excessive use, such as painfully arthritic facet joints, exacerbating pain that theoretically should have been relieved.

The role of decrease muscle spasm in relief of chronic LBP is also doubtful. Anecdotally, muscle spasm relief in hydrotherapy is obtained by relaxation from a variety of factors, including chiefly the warmth of the water (Davis and Harrison 1988). Miller (1985) compared the electromyographic activity in the lumbar paraspinal muscles of subjects with chronic LBP of mean 5.3 years duration with those of pain-free subjects. No difference in activity was noted during quiet sitting, active sitting and standing, and Miller (1985) concluded that muscular spasm does not significantly affect the intensity of chronic LBP. Therefore, the contribution of heat with regards to the vicious circle created by muscle spasm and pain, may not have been large enough to provide measurable pain relief variation between treatment environments.

Pain in this study was measured using a subtype of the VAS, the NRS (numerical rating scale). The simplicity and ease of use of this method causes less room for error (Bellamy, Campbell and Syrotuik 1999). However, Waterfield and Sim (1998) also note its relative decreased sensitivity to small changes when compared to other types of VAS. Such sensitivity may have been required in this study, due to the chronic nature of the condition being investigated (LBPR).

4.7 Lumbar Mobility

There was considerable variation in the progress of lumbar mobility made by patients. Those in the HTG improved most with respect to lumbar flexion, as compared to no measurable improvement in the LTG. Subjects treated on land, however, progressed more with respect to lumbar extension and left and right SLRs than those in the HTG.

In general the literature describes hydrotherapy as having a beneficial effect upon lumbar mobility.

Smit and Harrisorn (cited in McIlveen and Robertson 1998) found that hydrotherapy for chronic LBP resulted in increased lumbar flexion and extension. Roberts and Freeman (1995) performed an audit of patients attending for hydrotherapy and concluded that there was measurable progress with regards to general lumbar mobility, though they did not specify the nature of the precise movements. McIlveen and Robertson (1998) found that a greater percentage of subjects in the hydrotherapy experimental group improved with respect to lumbar flexion and extension than in the delayed hydrotherapy control group. In contrast, Sjorgen et al. (1997) could not measure any difference between the hydrotherapy and the land physiotherapy group outcome when measuring thoracolumbar mobility, though there was a general improvement in both.

The outcome measures used to investigate lumbar mobility changes have been proven reliable and valid (Beattie, Rothstein and Lamb 1987, Hsieh et al. 1983, Macrae and Wright 1969), so that their effect upon the results obtained are considered negligible by the researcher.

The researcher considers the nature of the exercises in relation to the discrepancy in results, especially in the light that both SLR results, whilst not of statistically significant difference between the groups, were however of statistically significant improvement throughout both groups over the number of sessions.

The land flexion and extension exercises compared to the hydrotherapy flexion and extension exercise apparently influenced lumbar extension more than lumbar flexion. By virtue of the buoyancy of water, the patient was assisted when extending the trunk during the hydrotherapy exercise. Also, the position of the patient in the exercise, whilst emulating as far as possible the land mobility exercises apparently did not bring the lumbar spine into extension to the degree that it was brought by the press-ups performed on land; the opposite may be said of lumbar flexion.

Hall, Hepburn and Elvey (1993) describe the SLR as a commonly used test to determine the presence or absence of abnormal neural tissue in the lumbosacral plexus and associated nerve roots. Bohannon, Gajdosik and LeVeau (1985) document the relation between pelvic anteversion and passive SLR relating increased pelvic anterior mobility with increased SLR. In this study, results reflected a measurable converse relation between the two, as HTG improved most with respect to lumbar flexion but benefited less with respect to SLR. The researcher concludes that, whilst not being statistically significant, this may be a measure of successful neural stretching as advocated by Butler (1992), perhaps achieved by virtue of both the lumbar mobility exercises and the bicycling exercise, through hip flexion coupled with knee extension.

4.8 Neurological changes

The neurological aspect of LBPR was considered with respect to three aspects, namely muscular strength, reflex response, and light touch sensation. Whilst the first two were not measurably improved in either group, light touch sensation was found to have significantly improved in all subjects within the hydrotherapy group.

The literature with respect to outcome of neurological symptoms of LBPR cases is sparse. McIlveen and Robertson (1998) conducted the only study previous to this one to incorporate such factors, when comparing an experimental HTG with a control delayed HTG, and found a beneficial trend associated with hydrotherapy.

Caillet (1991) attributes neurological impairment to pressure upon the nerve roots, as compared to pain caused by pressure upon the dural sheath. Such pressure may result. in neurapraxia or an axonotmesis, of which the latter is more likely in this study in view of the chronic condition. Bohannon and Gajdosik (1987) note that the large myelinated fibres are the first to be affected by this pressure, followed by the small unmyelinated fibres. Cailliet (1991) notes that motor fibres make up a small percentage of the large myelinated fibres, as compared to sensory fibres. Therefore, it would be possible that relief of pressure on the nerve will first and foremost benefit the sensory fibres that, amongst others, convey light touch sensation. Such relief of pressure would be brought about by decreasing stenosis of the vertebral canal or intervertebral foramen.

The aquatic environment may have contributed also by decreasing pressure present by virtue of its property of buoyancy, and by stimulating the sensory Aß fibres, as discussed previously.

4.9 Psycho-social Influence

The benefits of hydrotherapy with regards to the psychological aspect of the subject were not directly addressed in this study, as the aim was to search for improvements in pain, disability, mobility and neurological deficits. However, both the VAS and the ODQ address the effects of an altered psychological state (Wiesinger et al. 1997). Lageard and Ronbinson (1985) state that a 40% placebo effect has to be acknowledged in all chronic back pain studies. They also note that chronic back pain tends to accumulate an increasing factor of psychological influence through time.

Zusman (1998) notes that most research has been structure-oriented and concludes that such a demand is self-limiting, thereby creating an environment that supports such conditions and finally resulting in inadequate treatment. Zusman (1998) concludes that greater importance is to be given to psychosocial factors that involve both the system and individual bio-behavioural factors such as fear-avoidance, belief-management, and empowerment. In particular, chronic LBP patients place increasing responsibility upon medical and therapeutic treatment that in most cases is not adequately successful creating further sense of 'failure' (Langrige and Phillips 1988).

Perhaps an outcome measure of psychological progress, such as patient satisfaction (McIlveen and Robertson 1998) made by the subjects would have resulted in a significant difference, given the many claims that warm water affects chronic spinal pain primarily psychologically and secondarily physically and physiologically (Reid 1997).

Whilst the subject characteristics in relation to age, gender, weight, height, pain duration and analgesics/ NSAIDS were taken into consideration to provide a stable baseline measurement, the researcher recognizes that risk factors associated with LBP may have borne an influence upon the results, possibly skewing them away from what exercise regimes alone in different environments would have brought about. Although the subjects in the study agreed to notify the researcher before performing any action, within a set list, that may affect the results, it is recognized that human errors may occur, and that these are of increasing significance in a small sample size like that considered in this study (Hicks 1997).

4.10 Limitations of the Study

- The main limitation of the study was sample size. The small number of subjects involved was not enough to achieve statistically significant results when comparing one treatment group to another. This must be taken into account when considering the reliability of results obtained and their application to the greater population. Time factors involved in the assessment and treatment of subjects placed a limit on including a greater number of subjects.

- The study period of 4 weeks may not have been of adequate duration. The chronic nature of the condition may have required a longer time to resolve, especially with relevance to lumbar mobility and neurological symptoms, as the accepted time period for resolution of an axonotmesis varies considerably (Thomson, Skinner and Piercy 1997).

- Assumptions were made that agreement with the subjects regarding notification of any change of lifestyle was maintained. This may not be practical, since lifestyles do vary and the influence of risk factors and personality vary from person to person.

- The same researcher carried out the entire study with respect to initial assessments, measurement of outcome measures and treatment. Whilst randomisation and single-blinded techniques were introduced, observer and operational bias may have resulted in erroneous measurement and interpretation of results.

- Retrospectively, the outcome measures selected may have been improved upon. Both the ODQ and VAS have been noted to be less sensitive to minor changes than similar counterparts. In particular, pain was simply of numerical nature. Whilst simple, this does not consider the centralization phenomenon, considered to be a good indication of condition progress (Donnelson et al. 1997).

Chapter 3:
Results and Data Analysis

Eight patient initially included for assessment, were assessed over a 2 day period. 1 subject was excluded due to an additional condition that may have affected the outcome variables. Of the resulting 7, 1 patient refused to participate so that viable subjects were 6 in total. The first session for all patients occurred subsequently within a mean of 3 ± 2 (SD – standard deviation) days following patient assessment. All patients attended for 8 sessions of 45 minutes each, twice weekly for 4 weeks. Two patients, one from each group, missed their appointments but were seen that same week, the next day. Final assessments for final outcome measures were performed within two days following the last treatment session of each patient.

3.1 Subject Description

In this study, subject characteristics were taken into account due to their influence upon the data, to be considered during interpretation of the results (Appendix L1). Similar patterns of use of analgesics and NSAIDS were identified in both groups of subjects at the start of the study. The 6 subjects were randomly allocated to one of 2 treatment groups.

The experimental (hydrotherapy) group comprised 3 males (100%). The control group (land) comprised 1 male (33%) and 2 females (67%). All patients (100%, n=6) completed the study.

Subjects in the experimental treatment (hydrotherapy) group were on average 39 ± 4.08 years old whilst those in the control treatment group (land) were on average 47 ± 9.2 years old.

Subjects in the experimental treatment (hydrotherapy) group were an average height of 168 ± 3.74 cms tall, as compared to the subjects in the control treatment group (land) who were of an average height of 159.7 ± 5.91 cms tall.

Subjects in the in the experimental treatment (hydrotherapy group) had been suffering from low back pain with radicular components for an average of 20.3 ± 21.01 months, whilst those in the control treatment (land) group had been suffering from the condition for an 20.3 ± 17.75 months.

The most common diagnosis with which patients were referred, were both prolapsed intervertebral disc (PIVD) with sciatica and non-specific low back pain with sciatica (NSLPBR). Both were reasons for the referral of 33% (n=2) of patients. The remaining two patients were respectively diagnosed as suffering from mild degenerative osteoarthritic changes with sciatica (17%, n=1) and facet osteoarthritic joint changes with sciatica (17%, n=1). As per study requirements, all patients (100% n=6) suffered from radicular components, invariably referred to as sciatica in the medical diagnosis.

An unrelated two-tailed t-test for independent groups was carried out (Microsoft Excel 2000) to check for differences between these subject characteristics of each group with regards to age, height, weight and duration of condition. No significant difference was found between groups. There was no change in height or weight throughout the study period.

3.2 Baseline Measurements

Pain was tested using the VAS, in cms. Disability was tested using the ODQ as a %, lumbar mobility was tested using lumbar flexion and extension in mms, and left and right SLRs in degrees. The neurological levels were treated as ordinal values in that values below normal strength, light touch sensation and reflexes were accordingly graded as –1, those that were normal as 0, and those above normal for all 3 were graded as +1 for purposes of analysis. The initial measurements for pain, disability, lumbar mobility and neurological symptoms were tested (BMDP) for significant differences over both treatment groups using an unrelated t-test and found to be insignificant, so that there was no difference between either groups initially.

3.3 Outcome Measure Results

At the end of the study, the outcome measures for both groups were compared, using an unrelated t-test to analyse the final measurements across both groups. No statistically significant difference was found between both groups, and therefore type of treatment. None of the outcome measures was found to have significantly altered its position with respect to its counterpart measure in the other treatment group i.e. no group fared better than the other.

The related t-test was use to analyse the raw data so as to examine the improvements made in both groups overall with time. Here, significant results were obtained for the VAS (p=0.0011), ODQ (p=0.0115), Left SLR (p=0.0293) and Right SLR (p=0.034), but not for lumbar extension and flexion. The neurological tests also revealed a significant improvement for light touch sensation (p=0.0253), but not muscle power or reflexes improvement. Therefore, treatment was found significant in improving VAS, ODQ, LSLR and RSLR, and LTS indiscriminately for all subjects in the study, regardless of treatment environment.

Appendix L3 gives the mean with standard deviation values for characteristics of pain, disability and lumbar mobility for both groups, as per final measurements. The average changes in all of these measures for both groups are displayed below graphically in Figure 4 below, in the form of bar charts of outcome variable per treatment type.

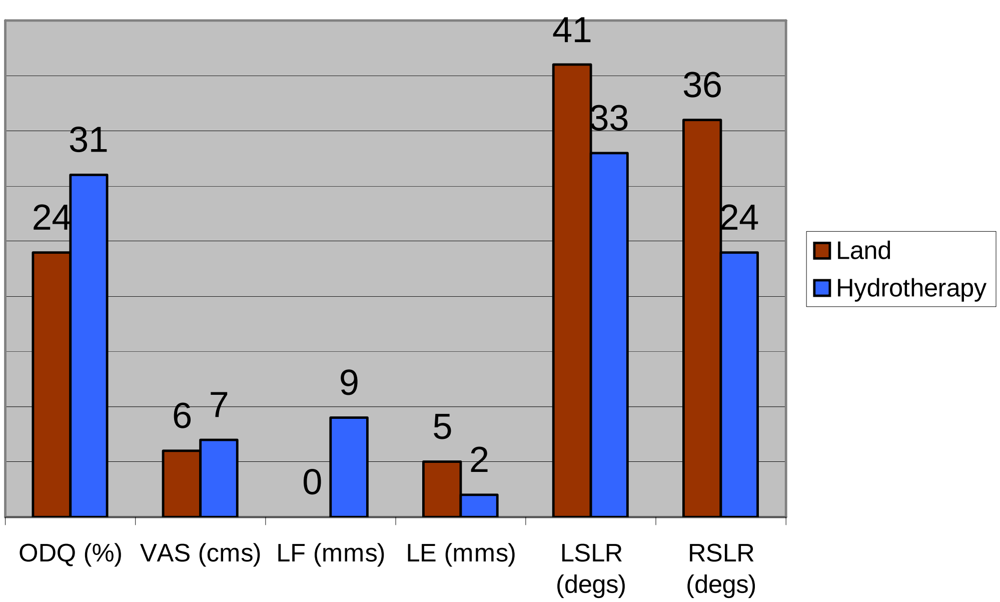

Figure 4. Outcome variables means of improvement as per treatment group.
(Key: ODQ – Oswestry Disability scale, VAS – visual analogue scale, LF – lumbar flexion, LE- lumbar extension, LSLR – left straight leg raise, RSLR – right straight leg raise.)

The ODQ percentage decreased most in the hydrotherapy-treatment group (HTG), by an average of 31% disability as compared to 24% disability decrease in the land-treatment group (LTG). The hydrotherapy group therefore decreased their disability by 83.8%, whilst the land group decreased their disability by 66.6%.

The VAS recorded a marginally greater median decrease of pain in the hydrotherapy group than in the land group, as compared to 7cms and 6 cms respectively. Therefore the HGT measured an average decrease of pain intensity of 87.5% whilst the LTG decreased pain felt by 75%. Since values of the VAS were available for all sessions, a scatter graph (Figure 5) of average VAS per session for all members of each treatment group was drawn, and the gradients (rate of change) for each set of session values calculated. The overall rate of change (R^2) for the LTG was 0.9251, and that for the HTG 0.7977.

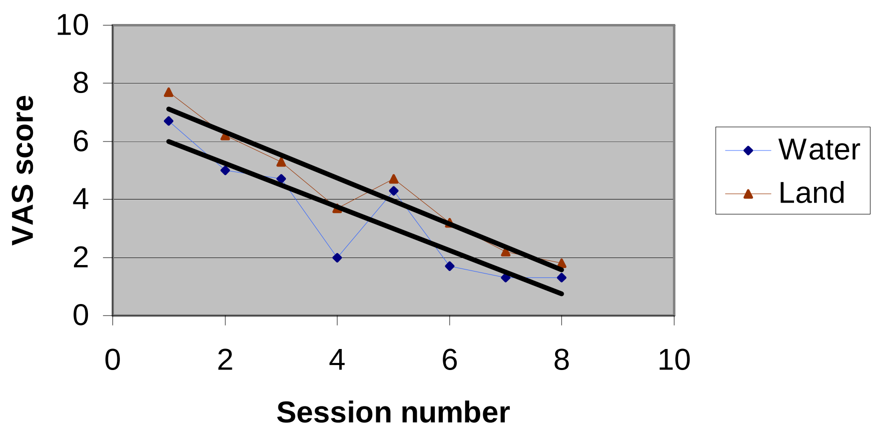

Figure 5. Average change in VAS recorded per group for each session.

Lumbar flexion was surprisingly varied, in that the control LTG measured no mean increase, as compared to the experimental HTG that measured a mean 9mms increase, or 28%.

Lumbar extension increased most in the LTG, by a median 5mms, as compared to the median 2 mms of the HTG. Percentage wise, the LTG increased by a 29.4% as compared to the 9.5% increase registered with the HTG.

Left and Right straight leg raise both indicated the control LTG to have benefited most, with a median increase of 41 (77.4%) and 36 (62.1%) degrees respectively, as compared to the increased median HTG values of 33 (55.9%) and 24 (31.2%) degrees respectively.

The neurological status of the subjects (Appendix L3) was taken mainly as improved, remained same, or deteriorated for subjects. Muscle power registered a marginal greater improvement for the experimental HTG in which 2 patients improved and one remained the same as compared to the control LTG in which one patient deteriorated and the other 2 improved and remained same respectively. The change in reflexes was precisely the same for both groups in that 2 patients within the HTG and LTG remained the same, and 1 in both improved in reflex response. The biggest variance between treatment groups was exhibited by light touch sensation grades, which registered improvements in all experimental hydrotherapy groups and no change in the land control group.

Chapter 2:
Methodology

2.1 Recapitulation of Research Problem

The bulk of research into an optimum treatment for LBP has focused upon land-based treatment. Relatively few studies have considered LBP rehabilitation via hydrotherapy and even fewer LBPR. Also, recent experimental research documents the previous anecdotal evidence that additional radicular components cause the LBP even sufferer greater disability. There is therefore a need for additional data about the rehabilitation of low back pain with radicular component by hydrotherapy.

2.2 Hypothesis and Research Design

This study is a randomised, single-blinded, controlled, matched subject intervention designed to disprove the null hypothesis that hydrotherapy does not provide a better environment for more complete rehabilitation of low back pain with radicular components than land-based physiotherapy.

The hypothesis is that hydrotherapy creates a better environment for more complete rehabilitation of low back pain with radicular involvement than land-based physiotherapy.

Being an experimental study, the dependant variable is the level of rehabilitation reached by subjects being treated in different environments by a combination of mobilization, movements, exercises, home exercise programme and advice; the treatment environment being the independent variable. Attainment of results is on the basis of comparison between the hydrotherapy (experimental) group and the land-based (control) group with control of extraneous variables, yet also not detrimental to patient rehabilitation. Due to time constraints, the independent variable could not be tested for reliability and validity.

2.3 Operational Definitions

2.3.1 Level of rehabilitation

In this study, level of rehabilitation was defined as value of the subjects

- functional ability as a %,
- pain in cms,
- neurological level of mytomal muscle power grading, tendon reflex grading and dermatomal light touch sensation and
- range of measured spinal movements including lumbar flexion and extension in mms, and left and right passive straight leg raise in degrees.

2.3.2 Low Back Pain with Radicular Involvement

In this study, low back pain with radicular involvement was defined as pain felt in the lower lumbar area radiating down a lower limb, present for more than 3 months.

2.4 Sampling Techniques and Grouping of Subjects

A list of 8 subjects newly referred for treatment at the Physiotherapy Out-patients Department at St. Luke's Hospital and presenting with LBPR, was randomly collected within 3 days from the department waiting list.

The criteria for inclusion were:

- Patients of either gender
- Referral diagnosis of LBPR according to operational definition
- Aged between 35-65
- Able and willing to participate fully in study

The patients were then assessed over the next 2 days by the researcher as per SOAP format (Parry, 1994). This included taking a detailed medical history, performing an objective physical examination and examining X-Rays. In addition, the height and weight of each patient was recorded, and each patient marked a visual analogue scale (VAS)(Appendix C) and Oswestry Disability Questionnaire (ODQ)(Appendix D), and was checked for exclusion criteria (Appendix E). This screening procedure

- ascertained the referral medical diagnosis ,
- provided subject description data,
- provided an initial baseline for comparison of values
- provided data for analgesics and NSAIDs currently in use by the subjects and,
- excluded from the study unsuitable candidates.

One patient was excluded from the study because he was found to suffer from the intermittent claudication in addition to his LBPR. The remaining seven patients were explained the nature of the study but not the hypothesis, and asked whether they were willing to participate. One refused for personal reasons. The remaining 6 subjects were given appointments for the first treatment sessions, and agreed not to initiate any other exercise program, treatment or therapy of any kind outside the prescribed study program without first informing the researcher, and to be contacted by telephone later to be informed within which environment their treatment would be taking place. Following completion of all assessments, 3 of the remaining 6 acquiescent subjects were randomly assigned to the hydrotherapy group and 3 to the land-based control group, by making use of random number tables. Each patient was successfully contacted by telephone as agreed and informed about the nature of treatment. Those who were assigned to hydrotherapy were also advised to bring a bathing suit, hygienic washing products, towel, bathing cap and bathrobe.

2.5 Measurement and Reliability of Outcome Variables

The literature does not establish a single suitable clinical method of assessing subjects with LBPR (McIlveen and Robertson 1998), so a range of reliable tests measuring the different parameters usually examined by physiotherapists was adopted, together with the Oswestry Disability Questionnaire.

2.5.1 Lumbar Mobility

Lumbar flexion and extension

These measurements were made using the modified Schöber method (Macrae and Wright 1969) as follows. The subject stood facing away from the researcher who marked the subject's skin over both posterior superior iliac spines (PSIS), drawing a horizontal line between them. At the intersection of this line with the spinous processes of the spinal column, a vertical line is drawn and marked 10cms caudal and 5 cms cephalad to the intersection. A Dean-fibreglass™ measuring tape was placed on both markers and the increase and decrease in length noted as the subject is respectively instructed to bend forward and backwards (Batti'e et al. 1987). This measure is highly valid and reliable both for flexion (Macrae and Wright 1969) and extension (Beattie, Rothstein and Lamb 1987).

Passive Straight Leg Raise (SLR)

Hsieh et al. (1983) demonstrated a high intra and intersessional reliability in SLR testing as follows. SLR was measured separately for each leg with the patient supine and instructed to relax completely (AAOS 1988). A Baseline™ 360^0 goniometer was used with one arm bandaged to the subject's extended knee and kept so as the researcher slowly lifted the leg up till maximum tolerable pain was felt by subject, at which point the angle indicated by the goniometer was recorded as the passive straight leg raise ROM (Hsieh et al. 1983).

2.5.2 Neurological Charateristics

Tendon Reflex grading

Quadriceps and Calf tendon reflexes were tested with the patient supine and instructed to relax. The researcher struck the distal tendon of each muscle group was with a Rieste™ flexible patella hammer three times or until a constant response was achieved (McIlveen and Robertson 1998) that was rated as absent, reduced, normal or increased and marked accordingly.

Dermatomal Light Touch Sensation (LTS)

LTS was assessed by the researcher lightly stroking the skin in each relevant dermatome with cotton wool (McIlveen and Robertson 1998). The regions L1-S2 were examined following the pattern depicted by Kendall (1993). The researcher then rated the response as absent, reduced, normal or increased and marked accordingly (.

Myotomal Muscle Power (MP)

The researcher manually assessed MP, with the subject in lying as necessary. The strength of groups for L2-S2 were examined following Grieve (1991) and rated using the 0 to 5 Oxford Scale (Hollis 1989).

Reliability of Neurological Tests

McIlveen and Robertson (1998) investigated reliability of these neurological tests for subjects with LBP and concluded that there was an excellent intra-rater reliability, but moderate inter-rater reliability.

2.5.3 <u>Pain</u>

Visual Analogue Scale (VAS)

The VAS is a measure of intensity of pain of which there are several subtypes. The one used in this study is the numerical rating scale (NRS)(Appendix C): an 11 cm long scale divided into 10 1cm intervals each of which is numbered from 0 to 10. Demonstrated to be reliable and valid by McDowell and Newell (1987), Waterfield and Sim (1998) describe it as the simplest version of VAS to use and least prone to error. Bellamy, Campbell and Syrotuik (1999) note its usefulness since numbers, unlike words, are commonly equally expressed across different cultures. The patient was shown the scale and asked to mark the level of his current pain.

2.5.4 Disability

Oswestry Disability Questionnaire

The Oswestry Low Back Pain Disability Questionnaire (ODQ)(Appendix D) is a widely used 10-item paper and pencil measure of disability resulting from low back pain. It’s reliability to reflect changes in the status of LBP is well reflected (Tibbles, Waalen and Hains 1998, Fairbank et al. 1980).

2.6 Ethical Considerations

A verbal explanation of the nature of the study was given to each patient, together with an introductory letter (Appendix F). Both exercise and control group patients were told what would be expected of them but not the hypothetical outcome.

- The participant’s rights were verbally explained. Every patient was assured that treatment would be adequate regardless of grouping. Each subject was also informed on his/her right to refuse to participate, and to stop participating in each time; in either case, the patient would be immediately handed over to an out-patient physiotherapist with minimal waiting period. The patients were also informed that treatment period would be prolonged past the experiment window if necessary for the optimum rehabilitation result.

- Strict confidentiality was guaranteed to each subject at all stages of the study except to the researcher and his thesis clinical supervisor.

- Each subject signed an individualized consent form (Appendix G), making him/her viable as participant.

Informed consent for this study was also obtained from:

- Co-ordinator of Physiotherapy Courses, IHC (Appendix H)
- Principal of Physiotherapy Department, SLH (Appendix I)

Informed consent to use the ODQ, and translate it into Maltese, was obtained from:

- Dr. Stephen Eisenstein, co-developer of the ODQ, through personal communication.

2.7 Intervention

Subjects in both groups attended for eight 45 minute individual treatment sessions twice weekly for 4 weeks.

All subjects underwent a similar treatment program that focused upon a combination of individually progressed exercises including lumbar flexion and extension exercises, abdominal stabilization exercises and bicycling (Appendix J). Walking backwards, forwards and sideways both began and concluded treatment. The choice of exercises aimed at the minimum number, to eliminate the maximum variables yet providing effective treatment.

If a subject missed an appointment, another one was arranged within 3 days. The patients' VAS value was recorded for study purposes as part of a brief re-assessment preceding each session. Each patient was also given and explained a modified SLH Physiotherapy Leaflet (Appendix K) for postural advice.

Following the 4-week experimental period, subjects were again reassessed for all the outcome variables by the researcher at the same time of the day, when possible.

2.8 Data Analysis

Except for subject charateristics' analysis, all statistical caculations were carried out by an experienced statistician independent of the researcher without knowledge of the study's hypothesis.

The outcome measures' changes were tested from baseline for each group over time by related one-tailed t-test to test for statistically significant comparable overall changes with time. The initial baseline values across both groups, was compared overall to the final values to check for significant relations in the final values reached for both groups by unrelated one-tailed t-test. Differences in each case were considered significant if $p < 0.05$. Subject's descriptive (Appendix L1) and baseline characteristics (Appendix L2) were presented in table form.

Chapter 1:
Literature Review

1.1 Incidence and Cost

The prevalence of LBPR has not been accurately researched, despite the fact that this condition causes significantly more disability than LBP alone (Lee and Simonds 1999).

Frymoyer and Cats-Baril (1991) remain inconclusive about the true LBPR incidence after citing prevalence values ranging from 40% to 1.5%. In America, LBP prevalence is 80% (Koes et al. 1991) and point prevalence 5% (Loney and Stratford 1999). Kodish (1998) states that 90% of LBP patients will have recurrences and 35% of these will develop sciatica. Researchers agree that LBP is most prevalent in Western industrial countries (Wiesinger et al. 1997).

Certainly LBP is the main condition for patient referral to physiotherapy both abroad (Feuerstein and Beattie 1995), and also in Malta to the Physiotherapy Department at St. Luke's Hospital (SLH), as shown in Figure 1.

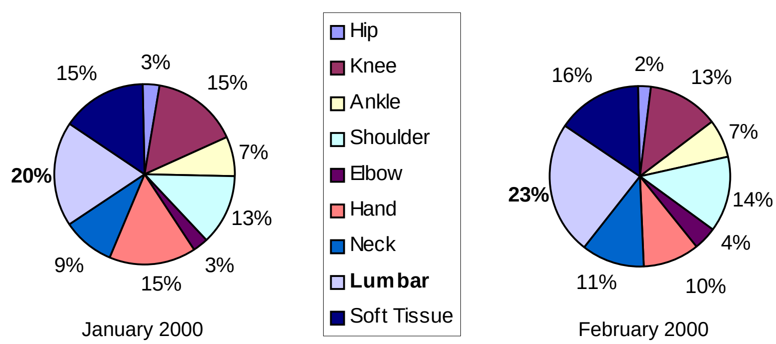

Fig 1. *Patient Audit Figures for referral to Physiotherapy Department, SLH, Malta (from PTD, SLH Figures Book)*

Loney and Stratford (1999) define 40-60 years, as the age with highest prevalence of LBP.

Heliovaara (1988), cited in Frymoyer and Cats-Baril (1991), gives no gender difference for incidence of sciatica in America. Patient admission figures for LBP to

SLH from 1994-1999 reveals that 53% were males and 47%, but history or level of pain are not specified.

The costs of LBP are very high, reaching US$ 24.3 billion a year in the U.S. for direct medical costs alone (Frymoyer and Cats-Baril 1991).

1.2 Risk Factors

A number of psychosocial and physical factors predispose to low back pain with radicular involvement.

Psychosocial factors include alcoholism, divorce, education, religiosity and job dissatisfaction (Frymoyer and Cats-Baril 1991), depression, hypochondriasis (health state preoccupation), hysteria, psychasthenia (susceptibility to mental stress)(Adams Ravey and Bell 1994) and deep-seated anxiety ('tension myositis syndrome')(Cailliet 1991). Wells, Frampton and Bowsher (1996) further identified back pain perception differences between extroverts and introverts.

Physical Predisposing Factors traditionally include age (Einkauf et al 1987), motor vehicle driving (Levangie 1999), parity and smoking (Levangie 1999, Frymoyer and Cats-Baril 1991) and occupation, especially involving heavy repetitive pushing, pulling, exposure to vibrations (Levangie 1999, Moss 1994) and heavy repetitive lifting (Moss 1994), multilevel degenerative disease, excessive height and weight (Frymoyer and Cats-Baril 1991) and various ergonomic aspects (Linton and Kamwendo, 1987). However, in a recent study of risk factor significance, Levangie (1999) did not find any relation between the role of lifting or excessive weight and LBP so that aspect remains controversial.

1.3 Functional Anatomy of the Spine

Chief amongst the various causes of low back pain and disability is abnormal spinal function that is mechanical in nature (Palastanga 1998, Cailliet 1991). Both the properties of individual spinal structures and their role within the biomechanical properties of the spine, in terms of functional units of vertebra-disc-vertebra are well documented (Palastanga 1998, Adams 1994b, Cailliet 1991, Panjabi and White 1980, Nachemson 1976).

1.3.1 <u>The Functional Unit</u>

The anterior part of the functional unit consists of two adjacent vertebral bodies, with an intervertebral disc between them, serving to separate the vertebrae and act as a weight-bearing, shock-absorbing mechanism, yet holding them together for facet joint posterior action (Appendix A).

The posterior non-weight-bearing part basically consists of a ‘neural arch’ since it contains and serves to protect the spinal cord and emerging neural tissue, as well as directing functional movement with the facet joints, that act as fulcrum, and providing attachment for muscular and ligamentous structures.

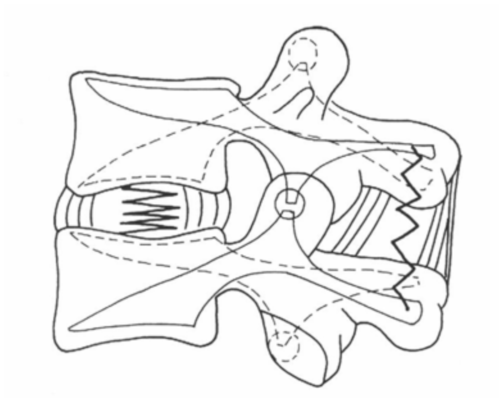

Fig 2. F*unctional Lumbar Unit (from Palastanga, 1998: 663)*

Schneider (1994) considers the functional unit as a connected system. Therefore changes in part of the unit will necessarily reflect upon other parts of the same unit, ultimately affecting other units and therefore total lumbar stability.

The functional unit is further composed of :

- small ligaments and muscles that span individual units (Appendix B)
- larger ligaments, muscles and facia spanning over several units (Appendix B)
- its blood supplying vessels and nerve supply.

1.3.2 Lumbar Kinematics

Lumbar spine mobility mainly involves flexion and extension, with restricted side-flexion and very little rotation. The functional unit above can be described by a model in which the vertebral bodies and discs act as static structures, the facet joints as fulcrums and the articular and transverse processes assume a dynamic role of performing, guiding or limiting movements (Palastanga 1998). The vertebral foramina alter in shape with spinal movement, as does the spinal canal, but neural tissue is not normally compressed (Cailliet 1991).

The influence of the lumbosacral angle and lumbar-pelvic rhythm is an important aspect of spinal kinematics. Various authors (Palastanga 1998, Magee 1997, Cailliet 1991) relate the amount of sagittal or coronal pelvic tilt with a corresponding variance in lumbar lordosis or scoliosis.

The literature describes various factors that affect normal lumbar kinematics, namely a decrease with increasing age (Vachalathiti, Crosbie and Smith 1995, Batti'e et al. 1987, Einkauf et al. 1987, Fitzgerald et al. 1983), gender with females being overall less mobile but losing mobility less rapidly with age (Vachalathiti, Crosbie and Smith, 1995, Batti'e et al. 1987) and speed of movement mainly in consequence to inertia (Vachalathiti, Crosbie and Smith 1995).

For a detailed account of <u>normal</u> lumbar and related pelvis kinematics, the reader is referred to Appendix B.

1.4 Low Back and Radicular pain.

1.4.1 <u>Nociceptive production within the low back.</u>

Cailliet (1991) identifies the anterior and posterior longitudinal ligaments, erector spinae muscles, thoracolumbar fascia, and facet joints as main pain producing structures upon irritation or trauma, according to the amount of innervation received.

These structures may be either directly mechanically affected by pressure or overstretch, or indirectly affected via ischaemia, excessive metabolites from fatigued muscles or chemical products of inflammation. The relation of the latter two to pain has been described (Melzack and Wall 1989) as follows:

1. The fluid exudates cause an increasing pressure in the surrounding tissues thus causing them further to be sensitised.
2. Many of the chemicals released directly stimulate the nociceptors
3. Many of the chemicals actually interact with the nociceptor terminals to lower their firing thresholds i.e. sensitising them
4. Ongoing inflammation results in central sensitivity changes.

A protective muscle spasm over the affected areas itself may form part of a vicious circle (Bogduk 1994) that could lead to increased ischaemia and metabolite accumulation (Cailliet 1991).

Radicular pain commonly affects the sciatic nerve (Cailliet 1991), resulting in different effects due to pressure or traction on a nerve root and dural sheath. According to Cailliet (1991), the well-documented (Fritz et al. 1998) stenosis of vertebral canal or intervertebral foramina causes stress upon the nerve root that may cause paresthesia, dysesthesia, analgesia or motor paresis depending upon whether the motor or sensory fibres are being affected. Cailliet (1991) stresses that it is pressure upon the sensitive dural sheath that causes painful stimuli. However, the possible formation of inflammatory products by local irritated structures may additionally sensitise the nerve and result in pain transmission upon pressure (Melzack and Wall 1989). Also, the lumbar dorsal ramus syndrome (Bogduk 1994) discussed below may caused referred radicular pain down the lower limb.

1.4.2 Low Back Pain Classification and Patho-mechanics.

The immense range of possible causes of low back pain (Moss 1994) has resulted in various attempts to classify the low back syndrome.

Cailliet (1991) describes low back pain as being either static or dynamic in origin.
He attributes static low back pain to postural pelvic rotation that alters the lumbar lordosis and results in particular postures (Kendall 1993).

Dynamic origin on the other hand can be of 3 main types:

a. Normally acceptable stress is placed upon a consciously or physiologically unprepared normal low back. The former is a matter of wrong anticipation of stress, whilst the latter relates to decreased flexibility of the lumbar muscles themselves possibly affected by an altered lumbar-pelvic rhythm. Incorrect lifting would classically cause such injury.
b. Abnormal Stress caused by prolonged or repeated application upon a normal low back or by deep-seated anxiety (‘tension myositis syndrome’). Muscle fatigue causes increasing metabolite accumulation, until the muscles relax (Cailliet 1991), thereby releasing stress upon ligaments.
c. Normal Stress on an abnormal low back condition that may include structural or segmental scoliosis, short leg syndrome, spondylosis, spondylolysis or spondlyolisthesis, facet arthritis or bone pathology.

McKenzie's classification (Moss 1994) groups conditions by virtue of pain location, pain aggravating range and direction of lumbar motion, and presence or absence of acute spinal deformity. Reflecting the concepts of Cyriax and, partially, Kaltenborn (Cookson 1979), his method revolves mainly around the theory of low back pain resulting from disc pathology and classified into the Postural, Dysfunction and Derangement syndromes. Donelson et al. (1997) notes that most patients presenting for treatment would be diagnosed with derangement.

Postural syndrome is a mechanical deformation of postural origin causing pain of a strictly intermittent nature, which appears when the soft tissues surrounding the lumbar segments are placed on prolonged stretch (Moss 1994).

Dysfunction pain is caused by soft tissue shortening with painful loss of mobility, especially lumbar extension, because of which, spinal curves may appear distorted and posture poor. Adaptive shortening of muscles, joints, ligaments and other soft tissues may be at fault, secondary to habitual poor posture or tissue shortening may be present from scarring following injury (Kodish 1998). Whilst diagnosis of pure low back dysfunction pain is difficult (Moss 1994), the presence of nerve root or dural sheath adherence is more easily assessed.

Derangement syndrome is caused by change in shape of the intervertebral disc, the structure that Nachemson (1976) believes is most likely to cause back pain. According to McKenzie (cited in Moss 1994), the nucleus migrates excessively away from the direction of an unsuitable spinal movement, causing the disc shape to change and bulge, possibly injuring the annulus itself with related consequences in mechanics of the articular surfaces of two adjacent vertebrae. Joint stability is thus affected, in turn affecting spinal movements. McKenzie states that flexion in standing and prolonged sitting, with subsequent posterior nuclear movement and disc bulge, is the main predisposing factor to derangement (Moss 1994). Certainly, within the annulus, the posterior fibres are least organized (Cailliet 1991), and also there is less ligamentous support as the posterior longitudinal ligament is narrow (Cailliet 1991) and less resistant to tensile stress (Adams 1994), when compared to the anterior longitudinal ligament.

Cailliet (1991) attributes annular failure also to the difference in angulation and length between outer and inner annular sheets' fibres, describing the outer fibres as being less able to elongate with rotation and resulting in their being 'torn on rotation forces exceeding 5 degrees' (Cailliet 1991: 11). This elongation is further enhanced by compressive forces. The remaining inner layers are, basically, not strong enough to maintain adequate force, resulting in an unstable functional unit.

Moss (1994) names an extensive number of studies supporting this derangement mechanism theory, but reports a lack of studies linking the mechanism to theory of subsequent pain production. McKenzie postulates (Moss 1994) that the disc bulges posteriorly or postero-laterally, causing spinal stenosis and intruding on adjacent pain sensitive soft or neural tissues. Pain increases and peripheralises (Melzack and Wall 1989), with increased disc deformation and pressure, possibly including nerve root pain. This would be evident during lumbar movement, and is slightly sustained on returning to normal posture. Symptoms centralize and decrease as the displaced disc material very slowly returns to a more central (with respect to annulus) position (Kodish 1998). McKenzie subclassifies lumbar derangements into 6 different types of posterior derangements and an anterior derangement, through posture and history and increasing pain distribution elicited by repeated movements that displace the nucleus accordingly more (Moss 1994). Both Palastanga (1998) and Moss (1994) relate the varying degrees of disc herniation (disc protrusion, prolapse, extrusion and sequestration) proportionally to increased disc degeneration and therefore to these levels of derangement, with the exclusion of advanced sequestration, for which surgery is the most viable option.

Bogduk (1994) mentions the term lumbar dorsal ramus syndromes (LDRS) to indicate the existence of nociceptive mechanisms other than those caused by disc problems. The lumbar zygapophyseal joints, interspinous ligaments, thoracolumbar fascia and multifidus, iliocostalis and longissimus muscles are supplied by branches of the lumbar dorsal rami (Bogduk 1994, Cailliet 1991), so that referred pain may cause similar symptoms to develop no matter which structures are affected, down the lower limb.

1.5 Low Back Pain Management

1.5.1 LBP and LBPR Treatment

Treatment of LBP and LBPR is well documented, and the efficacy of techniques and modalities extensively researched. It is of note that throughout the literature, the terms sciatica and leg pain are used interchangeably to describe radicular components in the lower limbs, whether neurological symptoms are present or not.

Passive modalities have been often advocated. In a large study of 873 patients, Wiesinger et al. (1997) highlighted the therapeutic potential of most widely described passive modalities such as massage, pelotherapy (water jet massage, mud baths and hot/mud packs), ultrasound and electrotherapy. Unfortunately, no control group was used, no definition of ‘back pain’ was given and criteria for inclusion were not defined. O’Donoghue (1984) examined a number of studies investigating LBP and concluded a lack of evidence supporting the beneficial effect of intermittent traction upon LBP. However, this is to be viewed with caution, as the duration of the LBP was not noted. Vroomen et al. (1999) conducted a randomised, controlled, single-blinded study of the effect of bed rest on patients with sciatica and concluded that it was just as effective as watchful waiting.

Better results were obtained by Manus-Garlinghouse (1985) who proposed a case study of a male 33-year old patient with diagnosed chronic (>3 months) lumbar posterolateral herniated nucleus pulposus. During the assessment, LBPR, abnormal posture and neurological signs, and decreased muscle power and lumbar mobility were noted. Following a combination of ultrasound, traction, and graduated McKenzie exercises, she assessed a significant improvement in all of the above parameters.

A substantial amount of research in the treatment of LBP considers the value of active exercise, but relatively few present randomised controlled methodology (Koes et al. 1991). Maher, Latimer and Refshauge (1999) reviewed an extensive number of chronic non-specific LBP clinical trials and concluded that supervised intensive structured general exercise programs, progressed according to time quota, are better than spinal manipulative therapy, heat, massage or TENS. They specifically also noted the lack of evidence supporting bed rest.

O’Donaghue (1984) cited a study by Kendall and Jenkins that advocated the use of abdominal exercises over extension and mobilizing exercises. Andersson (1985) also postulated a link between weak abdominal muscles and back pain. This trend was followed up more recently by O'Sullivan et al. (1997), who investigated abdominal muscle activation sequence in chronic LBP patients during supine abdominal drawing in. They found altered patterns in the deep abdominal and rectus abdominis muscles, which normal function is to provide lumbar stability, and suggested a need for further research of the subject.

Koes et al (1992) ran a randomised trial on the effectiveness of physiotherapy (varied combination of exercises, massage, heat and electrotherapy), manual therapy (spinal manipulation and mobilization) and GP (general medical treatment by analgesics, non-steroidal anti-inflammatory drugs, advice about posture, home exercises, sport participation, bed rest and other treatment modalities) and concluded that manual therapy was as effective as physiotherapy although through considerably less sessions, and both were more effective than treatment by the GP.

The effectiveness of manual therapy has long been accepted in the treatment of chronic low back pain, following the concepts of Cyriax, Kaltenborn, Maitland, Mc Mennell (Cookson 1979) and McKenzie (Moss 1994). O'Donoghue (1984) cites a well-designed (Koes et al 1991) randomised controlled study by Coxhead et al. in which patients with chronic LBP and LBPR with/out sciatic distribution were treated singly or in pairs by traction, manipulation, exercises or corset. Significant correlation was found between symptomatic improvement and greater number of paired-modality sessions. In conclusion, O'Donoghue (1984) recommended multi-faceted treatment with the inclusion of manual therapy, mobilization and patient education. More recently, Bergmann and Jongeward (1998) studied the effect of flexion-distraction and postural manipulation therapy on a patient with LBPR with neurological deficit, and in conclusion effectively named it as treatment of choice in the condition.

A number of studies back up the treatment of LBP and LBPR by a combination of modalities, notably manipulative therapy, stretching and exercise. Frost and Klaber Moffet (1992) concluded that manipulative therapy and exercise are preferable to passive therapy in the treatment of chronic LBP because of association of passive treatment and advice with reduced activity and fear of mobility. They particularly supported both the McKenzie approach, since this advocates actively involving patients in their own approach, and vigorous general fitness exercise both because of conditioning, and indirectly fostered psychological improvements. In one of the few studies that specifically treated a diagnosed condition, Khalil et al (1992) investigated the value of stretching in the rehabilitation of chronic LBP patients diagnosed with myofascial syndrome, coupled with their routine LBP treatment which was not specified. Systematic stretching sessions of the lumbar paraspinals, quadratus lumborum, tensor facia lata, hamstrings and glutei coupled with lumbar flexion and extension were found to significantly improve lumbar extension muscle power, lumbar extension and flexion range and straight leg in both legs. Following a controlled study of the effect of prone lumbar extension exercises upon healthy subjects, Smith and Mell (1987) concluded that there was only slight improvement in the male group whilst an insignificant increase was found in the female group. In a pilot study on group rehabilitation for chronic LBP by Davey and Broadbent (1998), significant results were obtained through the use of exercises, flexion and extension movements and proprioceptive neuromuscular facilitation (PNF) patterns for the lower limbs.

1.5.2 Application of the properties of Water.

The properties of warm water affect the patient both physiologically and therapeutically. The reader is referred to Appendix C for a summary list of both.

Buoyancy ‘is the force experienced as an upthrust on a body in water’ (Skinner and Thomson 1994: 823). The buoyancy of water allows objects to float upon it or to decrease their weight relative to the weight of the same object on dry land, in proportion to the percentage weight of body that is submerged. Harrison and Bultstrode (cited in Skinner and Thomson 1997) state that 20-30% less weight is born by the spine, effectively aiding disc rehydration (Reid Campion 1997). Enhanced joint space, decreased periarticular pressure (Reid Campion 1997), facilitated tissue stretching, graded strengthening, facilitation of relaxation and subsequent pain relief are therefore major benefits.

Hydrostatic pressure is ‘the thrust exerted by a fluid on the surface of any boy immersed within it’ (Skinner and Thomson 1994: 823), which, according to Pascal’s Law, is equal on all surfaces of an immersed body at a given depth. Also, fluid pressure is proportional to the depth of the fluid so that the deeper in the water, the greater the hydrostatic pressure.

Turbulence is the ‘irregular movement of water molecules’ (Skinner and Thomson 1994: 823). An object moving through water experiences both resistance caused by a preceding bow wave (displaced water) and drag caused by the turbulent water that has just flowed into the wake (area behind the object). Davis and Harrison (1988) estimate that turbulence accounts for 90% of resistance to movement in water, with the remaining 10% supplied by the bow wave and to a slight degree by friction and viscosity. The amount of turbulence created is directly proportion to the speed of movement and to the size and shape of the moving object. Therefore, resistance can be used to alter exercise difficulty through speed of movement, length of lever and use of objects of varying area. Turbulence also plays a major role in pain sensitivity reduction as the fast and erratic water movement bombards the sensory receptors in the skin so that the impulses caused travel on the Aβ fibers that are larger, faster and more conductive than pain fibers. In this manner, sensory input can compete successfully with pain input to block out the patient's pain perception via the pain gate (Melzack and Wall 1989).

The pool temperature is set at 35ºC, identified as the optimum temperature, since it is neither too cold to lose the beneficial effect of the warmth itself nor too hot to adversely affect body core temperature (Reid Campion 1997, Bates and Hanson 1994, Skinner and Thomson 1994, Golland 1991, Reid Campion 1990, Skinner and Thomson 1989, Davis and Harrison 1988). Unlike land treatment, the effects of warmth on the body are present throughout the treatment period. These include pain relief, muscle relaxation, increase movement, perceptual stimulation (and therefore body awareness leading to proprioceptive involvement), and increase in circulation (Reid Campion 1997, Preisinger and Quittan 1994).

A simplified diagrammatic illustration of the ways by which local tissue heating may alleviate pain is displayed below in Figure 3.

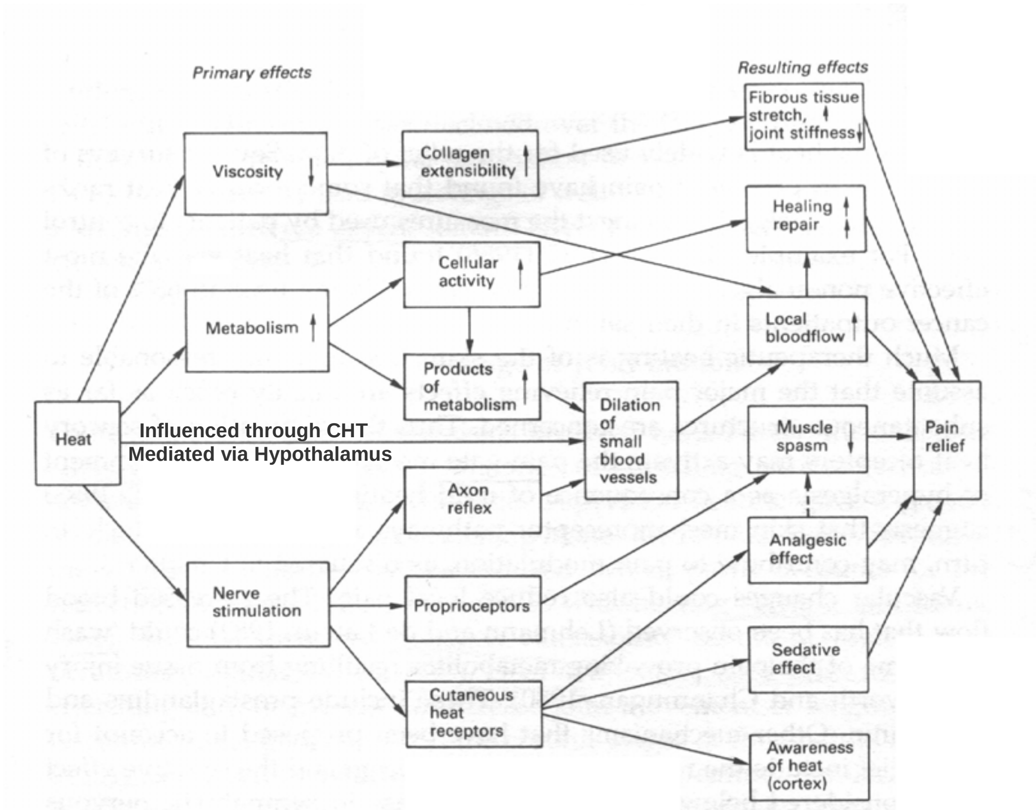

Fig 3. *The primary and secondary effects of local tissue heating upon pain; CHT=Cutaneous Heat Receptors. (modified from Low and Reed 1994: 199)*

Additional psychological benefits of water result in part indirectly from physiological changes, mainly pain relief and relaxation (Reid Campion 1997, McIlveen and Robertson 1998), and in part directly from the properties of water. The decreased weight bearing effect of buoyancy allows earlier progress in conditions lacking mobility, thereby increasing patient confidence and relaxation and improving his outlook (Atkinson et al. 1996, Bates and Hanson 1994).

1.5.3 Hydrotherapy for Low Back Pain

The trend of results following hydrotherapy management for LBP appears positive.

In a study of group hydrotherapy for chronic LBP, Langrige and Philips (1988) examined the effect of a 6-month regime of progressed exercises for trunk mobility and strengthening. They reported that 85% of participant’s pain levels were reduced, 96% experienced an improvement in the quality of life and 44% decreased the amount of medication they were taking. Two major methodological weaknesses involved poor outcome measures and no control group. Smit and Harrison (1991) also performed an uncontrolled pilot study of hydrotherapy for 20 subjects with lumbar spondylosis, and observed decreased pain levels and increased lumbar mobility. Roberts and Freeman (1995) performed an audit of LBP patients undergoing hydrotherapy and showed a statistically significant beneficial outcome when scores were combined for area and intensity of pain, range of lumbar spine movement, and ability to perform activities of daily living (ADL). However, results are viewed cautiously as post lumbar surgery conditions were included. A team of researchers (Ariyoshi et al. 1999) performed a qualitative study of 35 patients with LBP following a 6-month aquatic therapy exercise regime aimed at strengthening the abdominal, gluteal and leg muscles, stretching the lumbar spine, hips, hamstrings and ankles, walking in water and swimming. Ariyoshi et al. (1999) found that 90% of the patients felt they had improved, and concluded by strongly recommending exercises in water for LBP patients.

A methodologically stronger study was performed by Sjorgen et al. (1997), who compared the effectiveness of group hydrotherapy with group land-based treatment for 56 subjects with chronic LBP. They reported measurable decrease in pain levels and increase in functional ability, but no improvement in thoracolumbar mobility. Sjorgen et al (1997) concluded that, whilst no overall statistical significant difference resulted between the two groups, both methods of treatment were effective.

McIlveen and Robertson (1998) ran the only randomised controlled study that involved rehabilitation of patients with LBP and low back and leg pain. They compared pre-treatment values of functional ability, pain, range of measured spinal movements and neurological levels with the same values following 8 hour-long treatment sessions for general fitness for both groups, spread over a month. Whilst the subject data showed that the hydrotherapy group improved most, statistics revealed significant improvement only in functional outcome. McIlveen and Robertson (1998) concluded by acknowledging the relative greater improvements in the experiment group and calling for further research in the same area, perhaps individually tailored for better results.

Introduction

Introduction

A significant number of people born today in western countries are likely to suffer chronic low back pain with radicular involvement (LBPR), regardless of occupation (Wiesinger et al. 1997, Magee 1997).

LBPR is defined as pain felt in the lumbar region with associated radiating pain down one or both lower limbs.

The social effects and consequences of low back pain (LBP) are generally described in terms of high costs, presenting both a medical and economic problem. Indeed, low back problems with/out associated conditions are the most frequent reason for patients' referral to physiotherapy (Feuerstein and Beattie 1995).

Research interest in the topic is extensive, with over 600 publications on the aetiology and incidence of LBP alone, available by 1991 (Frymoyer and Cats-Baril 1991). Studies on the effectiveness of LBP and LBPR treatment *upon land*, focussing upon any or all of manual therapy, muscle strengthening, stretching, fitness postural correction, balance and co-ordination work, correct lifting techniques, electrotherapy, traction, bed rest, iso-machines and general or specific advice on back protection for all activities of daily living are abundant (Cherkin et al 1998, Davey and Broadbent 1998, Kodish 1998, Coulter and Langridge 1997, Donelson et al. 1997, Lewis and Thiel 1997, Koes et al. 1992, Koes et al. 1991, Smith and Mell 1987).

The beneficial use of water to treat the human body has been known to man for a long time, but it has been in relatively recent times that awareness of the possibilities of such treatment has grown. Hydrotherapy is the therapeutic use of the unique properties of warm water to treat a wide variety of problems (Reid Campion, 1997). Perhaps surprisingly, relatively little research has been carried out on LBP treatment in an *aquatic environment* (McIlveen and Robertson 1998, Roberts and Freeman 1995, Smit and Harrison 1991,Woods 1989, Langridge and Phillips 1988) and even less on LBPR (McIlveen and Robertson 1998).

Worldwide prevalence and disability due to low back pain continues to rise inexorably (Bartley 1999). Bartley (1999) attributes this to physiotherapeutic treatment that is excessively reliant upon anecdotal evidence rather than hard data, and is joined by Hicks (1997) in a call for better treatment based upon sound research. Another low back pain controversy involves its self-limiting nature. Kodish (1998) states that a significant number of patients suffering from LBP will feel better with the passage of time no matter what treatment is used. Therefore, although treatment effectively reduces this span of time, usefulness of such often expensive and time-consuming sessions seems questionable. Wiesinger et al. (1997) attributes an increasingly strong drive for more efficient, data-backed, quality management to paying insurance carriers. Following such demand, the need for research into such a sparsely documented region as treatment for LBPR in an aquatic environment would seem indicated.

The hypothesis of the study is that hydrotherapy creates a better environment for more complete rehabilitation of low back pain with radicular involvement in the lower limbs, than land-based physiotherapy.

The level of rehabilitation of a patient is defined by his functional ability, pain, neurological levels and range of measured spinal movements.