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The effect of an 8-week hydrotherapy programme on selected fitness parameters in patients with lower back pain (LBP)

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Abstract
Lower back pain (LBP) is a common condition in clinical medicine and one that individuals will experience sometime over their lifespan. This disorder has significant impact on a patient's physical well-being. As one ages, the spine becomes delicate and susceptible to pain. LBP can cause, among others, decreased mobility, reduced flexibility and poor posture. The ability to lift, walk, stand and sit is affected. Consequently, pain disrupts the body functions and limits one's ability to participate in sports and in routine physical activities of daily living. The diagnosis can be complicated since the pain may result from, among others, damage to the intervertebral discs, compression of nerve roots, improper movement of the spinal joints and the consequences of aging. This study aims to determine the effects of a programme of an eight-week hydrotherapy intervention on physical recovery in patients with non-specific LBP. The effects of hydrotherapy programme on balance, flexibility and muscle strength required for body movement were also considered. This is a case series study on patients who underwent an 8-week hydrotherapy programme for LBP. Ethical clearance was obtained from the University of KwaZulu-Natal Research Ethics Committee. Twenty participants aged 35 – 58 years were recruited from volunteers from selected Biokinetic practices in Gauteng. Patients who were confirmed as having non-specific LBP volunteered to participate in this study. A review of literature supports physical exercises as a prescription for patients with LBP. The finding of this study is that hydrotherapy posed no risks to participants afflicted with LBP. Accordingly, hydrotherapy was found to promote muscular strength, flexibility and aerobic fitness thus making hydrotherapy beneficial for rehabilitation of LBP. The important contribution of this study is the beneficial effects of hydrotherapy in the rehabilitation of patients with LBP and the improvement in functional capacity. Improved physical fitness and a sense of well-being were noted. There were significant improvements in muscle strength, agility and joint flexibility post-hydrotherapy-intervention. The improvement in fitness and ultimately functional capacity suggests the efficacy of hydrotherapy in the treatment of LBP should be researched more widely in clinical settings.

Keywords: Lower back pain (LBP), fitness, hydrotherapy, case series method, water based

Introduction
Physical fitness is the ability to perform activities of daily living without undue pain. Morris *et al*. (2018) [20] research into the prevalence of LBP in Africa, suggests that LBP as a common health problem, is one of the most prevalent musculoskeletal condition found among developed and developing nations. Research effort to consider forms of therapy is required to address the heightened health concerns of patients with LBP. Common non-surgical medical treatments include the administration of muscle relaxants; narcotic pain medication; back braces; and epidural steroid injections. While the lumbar spine is sturdy and resilient, from the list of functions, one would not be surprised as to why the lower back is susceptible to pain. Studies by Shipton (2018) [26] and Pretorious (2019) [23] indicate that the prevalence of lower back pain (LBP) have increased over the years and is one of the leading causes of limited activity, lack of fitness and ultimately reduced productivity, incapacitation and disability. This is a cause for concern. Findings by Grabovac and Dorner (2019) [9] indicate that LBP can cause movement anxiety that results in movement avoidance, decreases in activities of daily living, depression, anxiety, and stress-related disorders. Strong muscles and bones, flexible tendons and ligaments, and sensitive nerves contribute to a healthy spine. When affected by strain,

injury, or disease, pain is the consequence.

Well-considered physical rehabilitation programmes can diffuse pain and improve mobility and strength. Abdelraouf and Abdel-aziem (2016) [1] identify poor core endurance, as a likely cause of pain. This entails the inability to use the right muscles at the right time, at the right intensity to control the trunk appropriately for activities to take place, Injury risk reduction and LBP interventions should emphasize endurance of the core muscles especially the trunk extensors. To this end, Smith and Merwin (2021) [29] indicate that exercises increase physical body strength, develop range of motion, activity, and functionality.

Since the back muscles support much of one's weight and are responsible for many movements, injuries to these muscles are not uncommon. Pretorious (2019) [23] points out that these injuries can cause low back pain and further adds that the symptoms of LBP may include discomfort or pain in the lower back that is aching, burning or stabbing. The pain may radiate into one or both buttocks or even into the thigh or hip area. The symptoms may appear like other health problems. The most common type of back pain is pain in the lower back (lumbar spine). This area carries the body weight throughout the day. LBP ranges from a dull ache to a stabbing or shooting sensation resulting in difficulty to move or stand up straight. Sudden pain is referred to as acute caused during sports or heavy lifting. Pain that lasts more than 3 months is considered chronic. Most acute lower back pain is mechanical in nature, meaning that there is a disruption in the way the components of the back (the spine, muscle, intervertebral discs, and nerves) fit together and move. Sometimes, this pain is the result of disc degeneration, strain from overuse or poor lifting, or perhaps a fall or injury. In other cases, however, the pain may be the result of a congenital skeletal abnormality. Need to lead to what non-specific LBP is. Sawant and Shinde (2019) [25] point out that non-specific LBP is the pain where the patient cannot find any specific cause for more than 12 weeks. Accordingly, non-specific LBP is a result of heavy physical exertion that include lifting heavy objects, static posture or repetitive movement. Occasionally, chronic LBP is relieved with rest. Sawant and Shinde (2019) [25] further add that stretching and strengthening exercises provide useful relief for patients with non-specific LBP.

The effectiveness of exercise therapy continues to be uncertain and the evidence is not adequate. Karlsson *et al*. (2020) [15] findings suggest very low to moderate certainty of evidence that exercise therapy may result in little or no important difference in pain or disability, compared with other interventions, in adult patients with LBP. Smit, De Vet and Dekker (2005) [28] in their seminal work contend that there is insufficient evidence to support or refute the effectiveness of exercise therapy for patients with neck pain, shoulder pain, repetitive strain injury, rheumatoid arthritis, asthma, and bronchiectasis. They also found that exercise therapy is not effective for patients with acute low back pain. Notwithstanding these findings, a recent study by Harvard Health Publishing (2019) [12] contends that there is sufficient evidence that exercise therapy forms an essential intervention in a rehabilitation programme that may include: balancing; stretching; strengthening; and aerobic.

Hydrotherapy is an enjoyable form of exercise, safe and may very well be efficacious in the treatment of LBP. Sawant and Shinde (2019) [25] compares the effect of hydrotherapy-based exercises and conventional physiotherapy in chronic non-specific low back pain. The experimental study highlights the effect of hydrotherapy-based exercises for chronic non-specific low back pain. A convenient sample of 30 patients who were equally divided into two randomly allocated groups. Group A was assigned conventional therapy and Group B, hydrotherapy. The findings indicate that that there was significant difference in participants who underwent conventional therapy and hydrotherapy. Both conventional therapy and hydrotherapy group showed significant relief of pain, with hydrotherapy bringing relief sooner. Recently, Mirmoezzi, *et al*. (2021) [19] determined the efficacy of 20 hydrotherapy sessions for the management of chronic LBP in a sample of 28 participants. Participants showed improvements after 10 sessions of hydrotherapy. Similarly, Walean and Nyimas (2020) [33] found that after one session of hydrotherapy per week over a 4-week period, with participants presenting with LBP, reported that the pain was reduced and hydrotherapy had a positive effect and provided relief from pain. Carrying out active and passive movements in a heated pool increases blood circulation, this helps in easing pain and loosening stiff muscles and joints.

Hydrotherapy is not listed as a potential treatment for LBP. However, should balance and coordination be enhanced and fitness is improved through hydrotherapy, then it should be considered a mode of therapy. Therapeutic exercises in water are safer. Christakou and Boulnta (2020) [7] identify hydrotherapy as having a positive effect in patients exhibiting different pathological conditions. Water activities are known to promote and enhance physical fitness and are suitable for different age groups in the treatment of several ailments. The use of hydrotherapy forms the basis of this study, to manage and control LBP symptoms, correct posture and body movements, to reduce back strain, improve flexibility and core strength. Hence this study aims to determine the effects of an eight-week hydrotherapy intervention on physical recovery in patients with non-specific LBP. The effects of hydrotherapy programme on balance, flexibility and muscle strength required for body movement were also considered.

Methodology

This is case series study that presents findings on patients who underwent an 8-week hydrotherapy programme for LBP. El-Gilany (2018) [8] identifies case series method as a variation of a single case report in which the researcher describes several cases and their relation to one another and to the existing body of literature. Case series method is a variation of a single case report in which the researcher describes several cases and their relation to one another and to the existing body of literature. This approach has become increasingly important in health sciences research and provides a better understanding of patients' behaviours, attitudes, beliefs, preferences and how these change over time. A case series has no control group. This approach has become increasingly important in health sciences research and provides a better understanding of patients' behaviours, attitudes, beliefs, preferences and how these change over time. According to Petersen (2016) [22], in the self-controlled case series study design, as the participants themselves serves as their own control. Comparisons are made within individuals who have experienced an event pre and post intervention. Twenty participants between the ages of 35 to 58 were selected from a group of volunteers. The volunteers were recommended by biokineticists. All 20 participants were confirmed as patients suffering from non-specific LBP.

Ethical clearance was obtained from the University of KwaZulu-Natal Research Ethics Committee (add the ethics number).

A series of progressive water-based exercises was administered to treat non-specific LBP. This focused on developing aerobic, strength, balance, core stability and functional movements. The guidelines for flexibility of the quadriceps and hamstrings, which would relieve the muscular imbalances were followed and all tests were conducted in a standardized fashion in accordance with the 2013 American College of Sports Medicine American College of Sports Medicine Guidelines for Exercise Testing and Prescription. All pre-intervention and post-intervention physical tests were land-based and these included: Figure of eight agility test, six-minute walk test and measure the range of motion of hip flexion, hip internal rotation and hip external rotation. These tests were chosen for two specific reasons, namely, they were easily administered and the data gathered from these tests provided adequate information to make statistical inferences.

The hydrotherapy intervention consisted of exercises that included: deadlifts, squats, lunges, dynamic hamstring stretches, leg extension and hip flexor training. The buoyancy of the pool noodles used for some of these exercises proved to be challenging. If the participants reported a low-rate perceived exertion (RPE), an extra pool noodle was added to increase the resistance of the exercise. Participants were able to progress with their prescribed exercises. At the Synergy Holistix Aqua Therapy facility, there are 3 different depth levels. The higher the platform, the participant is less submerged. The load on the body increases and the participant's exertion is higher. Squats were done in the pool at the second platform (submerged till their waist) and slowly progressed to the higher platform. The same procedure was applied to deadlifts. For extra resistance, kettlebells ranging from 8kg to 24kg were used depending on the participants' level of exertion. According to Fischer, Calley and Hollman (2021) deadlifts, with the proper technique is crucial to get participants to hinge at the hips and keep balance. This helps prevents further injury and provides relief from non-specific lower back pain. The sets and repetition of the deadlift exercises were 3 sets and 10 repetitions unless the patient felt any discomfort. All squat and deadlift techniques were explained before the patients entered the pool. Khruakorn and Chiwarakranon (2021) used similar exercises with the pool noodles in their study on hydrotherapy and knee osteoarthritis. Since there are only concentric body movements within the pool, adding the pool noodles provides an eccentric contraction. While holding onto the sidebar, two or three pool noodles were attached to the participant's leg. They would try and push their foot towards the floor and slowly come up to have an eccentric contraction by resisting the buoyancy of the pool noodle. This was done at 3 sets 10 repetitions. The hip flexor and quadriceps were also trained with standing marches. While standing, two pool noodles were placed under one foot and the participant was told to slowly bring their knee up and to push down once the knee is at 90 degrees. This would also force them to balance which increases their proprioception. In a study done by Resende and Rassi (2008) on elderly women, a dynamic hamstring stretch was done within in the pool for 45 seconds and 2 sets. This is to increase the flexibility of the hamstring as well as strengthening the gluteal muscles and hip flexor. The rapid movement upwards would stretch the hamstring and the hip extension would work the gluteal muscles. This was very useful to use after the squats and deadlifts to feel a relief in their lower back. The intervention would end in light marching around the perimeter of the pool to cool down the body.

Table 1 provides details of the three testing parameters that are critical in the assessment of pain.

Table 1: Testing parameters

Test	Purpose	Equipment	Author
Figure of 8 Agility Run Test	This test measures patients' agility, muscular power and the ability to manoeuvre the body around obstacles while running.	2 cones, stopwatch, measuring tape	Hess *et al*. (2010) [13]
Six Minute Walk Test (6MWT)	6MWT is a test used to assess aerobic capacity and endurance. The distance covered within 6 minutes is used as the outcome by which to compare changes in performance capacity. The goal is for the patient to walk as far as possible in six minutes.	Stopwatch Measuring/trundle wheel to measure distance. 30-metre stretch of unimpeded walkway. Two cones to mark the distance.	Guyat *et al*. (1985) [11]
Flexibility Assessment	Assessment of hip rotation, hip internal and external rotation (range of motion) is a necessary consideration of patients with LBP. This test measures the flexibility of a joint, which is important for injury prevention and execution of many sporting movements. Without adequate internal rotation, the body would require various compensatory techniques to get by – resulting in LBP.	Goniometer	Herrero *et al*. (2011),

Statistical analysis

Descriptive and inferential statistics were used to analyse the data. Variance, mean and standard deviation were obtained using computer software. To compare statistically significant differences associated with pre-intervention and post-intervention data, the *t test* was used to determine whether the treatment actually had an effect on the patients. The statistical tests to demonstrate the presence of a particular effect were conducted using $\alpha = 0.05$ as critical alpha value that is, statistically significant at the 5% level.

Presentation of results

A brief demographic overview of the sample is provided in Table 2. The sample was equally divided between males (nmales = 10) and females ($nfemale_s$ = 10). The mean age of the sample was 41.05 years.

Table 2: Demographics of the Sample

Sample	Mean age	Mean Height	Mean Weight	Occupation
Female n = 10	42.1 ±7.03	1.594 ± 0. 08	66.3±12.31	Artist; Biokineticist; Doctor; Teacher (2); Stay at home mom; Judge; Fitness Instructor; Forensics analyst; Marketing Manager
Male	40 ± 4.422	1.74 ± 0.12	81.48 ± 18.82	Lecturer; Solution Architect; Chiropractor (2); Sales Rep

n = 10				(3); Medical Rep; Businessman; Sport Scientist
Total n = 20	41.05 ± 5.817	1.66 ± 0.12	73.89 ± 17.32	

Based on the occupational positions the participants held, the sample included individuals who were well educated. Patients were articulate and were able to relate their pain symptoms and provided better description of their responses to pain. The results of the Six Minute Walk Test and the Figure-of-Eight Agility Run Test that assessed patients' aerobic capacity and endurance are provided in Table 3.

Table 3: Results of the 6MWT and Figure of 8 Agility Run Test

Females n = 10 Males n = 10	Pre-intervention Maen	Post Intervention Mean	P Value
6 Minute Walk Test – Females (Pre – Post Intervention)	522.3 ± 110.72	553.2 ± 105.66	$p<0.05$ p = 0.005181
6 Minute Walk test Males (Pre-intervention – Post Intervention)	548.3 ± 117.44	576.5 ± 103.16	$p<0.05$ p = 0.02384
6 Minute Walk Test – Total (Pre - Post Intervention) n = 20	535.3 ± 111.89	564.85 ± 102.33	$p<0.05$ p = 0.000983
Figure of 8 Females n = 10	9.465 ± 3.26	8.347 ± 2.86	$p<0.05$ p = 0.0143
Figure of 8 Males n = 10	7.791 ± 2.20	7.136 ± 1.69	$p<0.05$ p = 0.0122
Figure of 8 Total sample n = 20	8.628 ± 2.84	7.741 ± 2.37	$p<0.05$ p = 0.000946

In the case of females and males, there was significant improvement in their performance in the 6MWT - post intervention, which was statistically significant at the 5% level. This improvement is also shown in the total. For both males and females, there was significant improvement in their performance in the Figure of 8 Agility Test - post intervention at the 5% level which was also shown in the total group's improvement. The impact of hydrotherapy on the performance of the patients using the 6MWT as an instrument produced significant results. The 6MWT was used to assess exercise capacity in LBP. The change in performance levels resulting from hydrotherapy intervention was found to be significant. The 6MWT was a well-tolerated test for the assessment of the functional capacity of LBP patients post hydrotherapy intervention. Since the test measures the distance a patient can walk over a total of six minutes on a flat surface, it is a useful measure of functional ability and fitness. This finding is consistent with that of several studies. Beatty *et al*. (2013) [5] found that 30 minutes of daily moderate-intensity walking for 12 weeks improved 6MWT distance by 59 m among men and by 53 m among women. Kosak and Smith (2004) [16] in a study of 18 patients also found that patients suffering from stroke increased their distance by 2.4 folds. With specific reference to hydrotherapy, Graetz *et al*. (2015) [10] questioned whether hydrotherapy exercise programmes improve exercise tolerance and quality of life in patients with chronic heart failure. The authors conclude that hydrotherapy appears to be a safe and well tolerated exercise intervention in patients with chronic heart failure. The improvement in functional ability and fitness of patients suffering from LBP using the 6MWT as a measuring tool merits further investigation.

In health care practices, the use of time as a measurement of performance is widely used. The Figure-of-Eight Agility Run Test used time as a simple measure of agility and muscular power of lower extremities, involving running around two cones. In research the Figure-of-Eight Agility Run Test has been considered as a valid measure of performance in both agility and power. The test measures patients on agility, muscular power and the ability to manoeuvre the body around obstacles while running. For both females and males in the Figure-of-Eight Agility Run Test, there was significant improvement (at the 5% level of significance) in patient performance post hydrotherapy intervention. Taulaniemi *et al*. (2016) found that the Figure-of-Eight Agility Run Test fulfil the reliability and validity of the test as a measure of strength. To this end this study found that hydrotherapy post intervention provided significant improvement in agility and muscular power. The results of this study imply that improvement in core endurance is likely to reduce LBP. Hydrotherapy for LBP management resulted in the endurance of the core muscles required for the improvement in the test. This is consistent with the findings of Abdelraouf and Abdelaziem (2016) [1]. The decrease in time – post intervention indicates improvement in basic mobility of the patient. This is a significant finding of the study that the 8-week hydrotherapy intervention improved patient performance, overall agility and muscular power of lower extremities. The findings are consistent with studies Foley *et al*. (2003) that provide evidence that hydrotherapy improves strength and physical function in patients with osteoarthritis. Moreover, Stanciu *et al*. (2023) [30] found that hydrotherapy assists in reducing the amount of medication needed as part of rehabilitation treatment. Marinho-Buzelli *et al*. (2019) noted that patients who perform aquatic exercises can improve on expiratory muscle strength.

Table 4 presents the Statistical Findings related to Hip Flexion measured in degrees. Since hip rotation range-of-motion (ROM) impairment has been proposed as a contributing mechanical factor in the development of LBP symptoms, this study considered hip flexion, hip internal rotation and hip external rotation pre-intervention and post intervention. According to Cholewicki *et al*. (2019) [6], LBP interventions are transitioning from focusing on reducing pain symptoms to biomechanical approaches that consider how areas of the body impact LBP. Biomechanical approaches are effective in locating dysfunctional movements to prevent injury and to relieve symptoms. With the exception of females' left hip flex, there was an overall significant improvement in hip flexion post-intervention. Zeppieri Jr. *et al*. (2015) [34] found that restrictions in hip rotational range of motion interferes with physical activity and disrupts the efficient transfer of energy. In this study, the hydrotherapy intervention had an effect on hip flexion range of motion and

are positively associated. Lee and Kim (2015) note that 23% - 69% of chronic low-back pain cases are related to hip range of motion. Therefore, an assessment of the limitations of hip-joint functions plays an important role in selecting the treatment. To this end, the findings of the study provide hydrotherapy as an intervention. In considering hydrotherapy in the management of LBP, Eversden *et al*. (2007) identify that hydrotherapy, not only relaxes the muscle, but improves joint motion and reduces pain. These findings are also consistent with the work of Al-Qubaeissy *et al*. (2012) [2] who contend that there is some evidence to suggest that hydrotherapy has a positive role in reducing pain and improving the health status of patients with rheumatoid arthritis compared with no or other interventions in the short term. Sadeghisani *et al*. (2015) [24] found correlation between hip rotation range-of-motion impairment and low back pain. The authors found hip rotation range-of-motion (ROM) impairment has been proposed as a contributing mechanical factor in the development of LBP symptoms.

Table 4: Hip Flexion Statistical Findings

	Pre- intervention	Post- intervention	P Value
Hip Flex – Females Left n = 10	96.1°±19.52°	99.3°± 17.41°	$p>0.05$ p = 0.07389
Hip Flex Females Right n = 10	97.3°±20.27°	101.4°±17.77°	$p<0.05$ p = 0.01237
Hip Flex – Males – Left n = 10	79.8°±12.17°	84.4°±10.36°	$p<0.05$ p = 0.0022
Hip Flex – Males – Right n = 10	79.6°±12.41°	84.4°± 10.67°	$p<0.05$ p = 0.00
Hip Flex – Total – Left n = 20	87.95°±17.907°	91.85°±15.905°	$p<0.05$ p = 0.00164
Hip Flex – Total – Right n = 20	88.45°± 18.712°	92.9°±16.726°	$p<0.05$ p = 0.00205

From Table 4, it can be observed that with the exception of females' ability to improve on their left hip flexes, there was significant improvement in females' right, males' right and left, and overall left and right hip flexion. The improvement post intervention is significant at the 5% level which was also shown in the total group's improvement both left and right.

Table 5 provides the statistical findings relative to the internal and external hip rotation movements. With exception of males' right internal hip range of motion, there was significant improvement in females' right and left, males' left, and overall left and right internal hip rotation. The improvement post intervention is significant at the 5% level which was also shown in the total group's improvement both left and right internal hip rotation movement. With exception of females' right external hip range of motion, there was significant improvement in females' left, males' left and right, and overall left and right external hip rotation. The improvement post intervention is significant at the 5% level which was also shown in the total group's improvement both left and right internal hip rotation movement.

Table 5: Internal and External Hip Rotation Movement Statistical Findings

	Pre- intervention	Post- intervention	P Value
Internal Hip – Females Left n = 10	37.3° 11.79°	45.8° ± 8.46°	$p<0.05$ p = 0.001533
Internal Hip Females Right n = 10	36.4° ± 12.99°	44.5° ± 8.356°	$p<0.05$ p = 0.000
Internal Hip – Males – Left n = 10	32.2° ± 8.59°	37.5° ± 7.98°	$p<0.05$ p = 0.00904
Internal Hip – Males – Right n = 10	33.9° ± 10.846°	36.6° ± 8.24°	$p>0.05$ p = 0.10958
Internal Hip – Total – Left n = 20	34.75° ± 10.38°	41.65° ± 9.074°	$p<0.05$ p = 0.000
External Hip – Females Left n = 10	51.6° ± 13.39°	Mean = 57.6° Std Dev = 14.615°	$p<0.05$ p = 0.00017
External Hip Females Right n = 10	53.7°± 17.72°	56.8°±12.95°	$p>0.05$ p = 0.0566
External Hip – Males – Left n = 10	43.4°± 8.19°	50.6°±9.17°	$p<0.05$ p = 0.000
External Hip – Males – Right n = 10	45.3°± 11.518°	50.4°±9.27°	$p<0.05$ p = 0.0133
External Hip – Total – Left n = 20	47.5°± 11.596°	54.1°± 12.409°	$p<0.05$ p = 0.000
External Hip – Total – Right n = 20	49.5°±15.174°	53.6°±11.445°	$p<0.05$ p = 0.00504

Table 6 summarises the overall findings of the effect of hydrotherapy. Using the 5% level of significance, the 9 variables in respect of females, males and total were assigned an equal probability to the proportion of significant. A weighted value was determined. The weighted value of 0.85 suggests that there was a very high (strong positive) effect of hydrotherapy on the overall fitness level of the patient and that LBP decreased overall.

This was compared with the overall exercise benefit scale presented in Table 7 which shows the benefit exercise scale used for the purpose of this study.

Table 6: Determining Overall Effect of Hydrotherapy

	Exercise	Proba-bility	Females Finding	Males Finding	Total Finding	Proportion	Overall Score
1	6MWT	$\frac{1}{9}$	Significant	Significant	Significant	$\frac{3}{3}$	$\frac{1}{9}$
2	Figure of 8	$\frac{1}{9}$	Significant	Significant	Significant	$\frac{3}{3}$	$\frac{1}{9}$
3	Hip Flex L	$\frac{1}{9}$	Not Significant	Significant	Significant	$\frac{2}{3}$	$\frac{2}{27}$
4	Hip Flex R	$\frac{1}{9}$	Significant	Significant	Significant	$\frac{3}{3}$	$\frac{1}{9}$
5	Internal ROM L	$\frac{1}{9}$	Significant	Significant	Significant	$\frac{3}{3}$	$\frac{1}{9}$
6	Internal ROM R	$\frac{1}{9}$	Significant	Not Significant	Significant	$\frac{2}{3}$	$\frac{2}{27}$
7	External ROM L	$\frac{1}{9}$	Significant	Significant	Significant	$\frac{3}{3}$	$\frac{1}{9}$
8	External ROM R	$\frac{1}{9}$	Not Significant	Significant	Significant	$\frac{2}{3}$	$\frac{2}{27}$
9	VAP	$\frac{1}{9}$	Significant	Not Significant	Significant	$\frac{2}{3}$	$\frac{2}{27}$
	Total	$\frac{9}{9}$ **1.00**					$\frac{23}{27}$ **(0.85)**

Table 7: Exercise benefit scale

Overall Score	Effect
x< 0	Negative effect – physical fitness deteriorated
0 < x ≤ 0.19	Very low effect
0.20 < x ≤ 0.39	Low effect
0.40 < x ≤ 0.59	Moderate effect
0.6 < x ≤ 0.79	High effect
0.8 < x ≤ 1.00	Very high effect – physical fitness improved

Table 8 presents the findings related to the Visual Analog Scale and the patients' body mass index. The 11-point visual analog scale (VAS) was used to determine the pain intensity of patients. The scale ranged from no pain (0) to worst possible unbearable excruciating pain (10).

Table 10: Visual Analog Scale and BMI

	Pre-Intervention Mean	Post- Intervention Mean	P value
VAS F	4.1 ± 1.37	2 ± 1.05	p<0.05 p = 0.00
VAS M	3.7 ± 1.88	2.5 ± 1.35	p>0.05 p = 0.06
VAS Total	3.9 ± 1.62	2.25±1.21	p<0.05 p = 0.00

The statistical findings suggest that the pain intensity of the sample post intervention decreased. The pain intensity of female patients too decreased. However, there is no indication to suggest that the pain intensity of male patients decreased.

Discussion

This study considered the effect of an 8-week hydrotherapy programme on selected fitness parameters in patients with LBP. Pain can hinder individuals from exercising and also impacts on one's ability to engage in activities of daily living and accordingly affects a one's physical and psychological well-being. The participants in this study were engaged in therapeutic exercises in water. These exercises included warm-up, aerobic, and rehabilitation. Generally, warm-up exercises are prescribed to reduce any injuries. However, warm-up exercises also increase the heart rate and blood flow enabling more oxygen to reach the muscles. Warm-up exercises activate the connections between the nerves and muscles to improve movement. Physical activities that are aerobic increase breathing and heart rate to supply the oxygen-rich blood throughout the body. Aerobic exercises strengthen the heart muscles, improve lung functioning, and increase healthy blood circulation. The rehabilitation exercises provide pain relief. Overall, the findings of the study suggest that the programme produced beneficial results.

The effectiveness of hydrotherapy in the management of LBP was clearly established in this study. The fitness parameters included muscular strength, endurance and flexibility and these showed improvement post hydrotherapy interventions. Hydrotherapy can relieve the pain intensity of patients with LBP. Participants pointed out that hydrotherapy exerted less pressure on the hips and knees compared to land-based physical therapy. Accordingly, it is particularly well-suited for managing LBP. Hydrotherapy offers several advantages that include buoyancy and resistance that provide for improvements in muscular strength, endurance and flexibility. In addition, warm water aids in muscle relaxation and loosens the joints.

The 8-week programme yielded many significant changes in the participants. The 6MWT was used to assess exercise capacity in LBP. Since the test measures the distance a patient can walk over a total of six minutes on a flat surface, it is a useful measure of functional ability and fitness. The quantitative findings of the study suggest significant improvements in the 6MWT. The impact of hydrotherapy on the performance of the patients using the 6MWT as an

instrument produced significant results.

The Figure-of-Eight Agility Run Test has been considered as a valid measure of performance in both agility and power. For both females and males in the Figure-of-Eight Agility Run Test, there was significant improvement in patient performance post hydrotherapy intervention. The results of this study imply that improvement in core endurance is likely to reduce LBP. Hydrotherapy for LBP management resulted in the endurance of the core muscles required for the improvement in the test. The decrease in time – post intervention indicates improvement in basic mobility of the patient. This is a significant finding of the study that the 8-week hydrotherapy intervention improved patient performance, overall agility and muscular power of lower extremities.

Restrictions in hip rotational range of motion (ROM) interfere with physical activity. Since hip rotation ROM impairment has been proposed as a contributing mechanical factor in the development of LBP symptoms, this study considered hip flexion, hip internal rotation and hip external rotation pre-intervention and post intervention. Biomechanical approaches are effective in locating dysfunctional movements to prevent injury and to relieve symptoms. With the exception of females' left hip flex, there was an overall significant improvement in hip flexion post-intervention. In this study, the hydrotherapy intervention had an effect on hip flexion range of motion and are positively associated. Therefore, an assessment of the limitations of hip-joint functions plays an important role in selecting the treatment. To this end, the findings of the study provide hydrotherapy as an intervention.

Overall reduction of pain was reported by the participants. The exercise programme in the pool improved the key muscles that impact adversely on the lower back. These include the gluteal muscles, hamstring, quadriceps, hip flexors and core. Once participants were submerged in water, there was a reduction in pressure on the knees and hips. This provided comfort to participants as they exercised. Accordingly, they were moved to a higher platform. The participants were less submerged in water. Participants found the pressure on the knees and hips to be greater. When the participants were comfortable in the second platform, they were moved to the third platform. Using the pool noodles was a safe way to train the participants at the first platform. Commencing with one noodle and then moving on to the second and third allowed for greater resistance. Due to the buoyancy of the noodles, it provided some resistance and allowed for eccentric training. The more pool noodles, the greater the resistance and the more challenging the exercise is. The exercise programme included leg extensions and standing marches with the pool noodle. The leg extensions had the highest rate perceived exertion amongst patients especially with 3 pool noodles. The standing marches forced the patient to keep balance and trained the hip flexors as well. Participants were taught how to squat with an 8kg kettlebell. Due to the different levels of the platforms, they safely practiced a new squatting technique without feeling pain. Once they were comfortable at the lowest platform, they were told to squat with a heavier kettlebell. They are then moved to a higher platform with less kettlebell weight. This was to ensure that they were comfortable with less buoyancy. Eventually, the participants were able to do a controlled squat without feeling lower back pain. Participants also reported that they felt more comfortable getting up and sitting down throughout the day with reduced pain due to the exercise programme. Although hydrotherapy can be effective, it must complement land-based exercises. Should a patient suffer from LBP or any other related pain, hydrotherapy should be the first therapeutic modality before doing land-based exercise.

Conclusion

A review of literature supports physical exercises as a prescription for patients with LBP. The role of biokineticists is to identify and develop physical fitness characteristics that may contribute to sport performance and pain alleviation. In this study, an exercise programme using hydrotherapy was found to promote muscular strength, flexibility and aerobic fitness that is invaluable for rehabilitating LBP patients. The programme consisted of exercises that targeted the muscles to reduce non-specific lower back pain. The findings indicate that core muscular strength that supports the lumbar spine should be developed. Developing the flexibility of the ligaments and muscle-tendons increases the range of motion and the patients' functional movement. Moreover, hydrotherapy improved exercise tolerance and health related quality of life. The anti-gravity effect of water allowed patients to explore different ranges of motion and strength that they can use on land, which is the ultimate goal. The important contribution of this study is the beneficial effects of hydrotherapy in the rehabilitation of patients with LBP and the improvement in functional capacity, physical fitness and a sense of well-being. Patients were more confident with picking up movements and getting up throughout their ADL. These exercises and techniques had less stress on the lower back throughout the day which caused less pain. There were no indications of any harmful effects associated with hydrotherapy. There were significant improvements in muscle strength, agility and joint flexibility post-hydrotherapy-intervention. The improvement in fitness and ultimately functional capacity suggests the efficacy of hydrotherapy should be researched more widely. Hip range of motion and rotation mobility could be used to locate pain and to establish benefits of any intervention. The improvement in the range of motion as presented in the study, showed that hydrotherapy enhanced balance and coordination. Hydrotherapy can be used in the rehabilitation of patients with LBP and patients can complement land-based exercises. The therapeutic exercises in water were safe and effective. Hydrotherapy should be the first therapeutic modality that a LBP patient should progress through before doing land exercises. This would allow the patient to move freely with less load and to take cognizance of the biomechanics of their body. Once the patient is confident in their movement, adding weights or reducing how much the patient is submerged in the water, can result in a faster recovery. In using the visual analog scale (VAS) to determine the pain intensity of patients, this study found, overall, patients reported lower pain scores post intervention. VAS signify a clinically significant improvement of patients' pain perception post intervention. Aquatic physical therapy for LBP can relieve the pain intensity of patients. A wider research endeavour into the effects of hydrotherapy in the alleviation of LBP is recommended. This study found that there were no indications of any harmful effects associated with hydrotherapy.

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