EFFECT OF BACK EXTENSORS ENDURANCE EXERCISES ON PHYSIOLOGICAL AND PSYCHOSOCIAL VARIABLES IN PATIENTS WITH LONG-TERM MECHANICAL LOW-BACK PAIN

By

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DEDICATION

This work is dedicated to my beautiful wife (Kikelomo Aboyowa Mbada) for her immense support and encouragement during the course of this study and above all, to the King eternal, immortal, invisible, the only wise God (2 Corinthians 2:11).

ABSTRACT

Management of Long-Term Mechanical Low-Back Pain (LMLBP) poses a challenge to clinicians. McKenzie Protocol (MP) is a common efficacious conservative therapy but its use in addressing back muscles inhibition accompanying LMLBP is doubtful. However, back endurance exercise is suggested to enhance muscle reactivation. This study was designed to investigate the effect of static or dynamic back extensors endurance exercise in combination with MP on physiological and psychosocial variables in patients with LMLBP.

Eighty four consecutive patients with LMLBP were recruited from the physiotherapy department of Obafemi Awolowo University Teaching Hospitals-Complex, Ile-Ife. They were randomly assigned to one of three treatment groups; the MP Group (MPG) (n=29), MP plus Static Back Endurance Exercise Group (MPSBEEG) (n=27) and MP plus Dynamic Back Endurance Exercise Group (MPDBEEG) (n=28). MP involved standardized extension exercises, static exercise involved 10-seconds (sec) static-hold in five exercise progression positions in prone-lying while dynamic exercise was a 10-repetition (rep) variant of static exercise. At baseline, physiological and psychosocial variables were measured. Treatment was given thrice weekly for eight weeks and outcomes were assessed at the end of 4th and 8th week. Physiological variables namely pain intensity, muscle fatigue, static and dynamic endurance were measured using quadruple visual analogue scale, Borg Scale (BS), Biering-Sorensen Test (BST) and Repetitive Arch-Up Test (RAUT) respectively. Psychosocial variables measured were activity limitation, disability, fear-avoidance behaviour, and pain self-efficacy belief using Roland-Morris Back Pain Questionnaire (RMBPQ), Oswestry low-back disability questionnaire, fear-avoidance beliefs questionnaire, and Pain Self-Efficacy Questionnaire (PSEQ) respectively. Data were analyzed using mean, ANOVA, Kruskal-Wallis and post-hoc tests at p=0.05.

A drop-out rate of 20.2% was observed in the study. Twenty five, 22 and 20 participants in MPG, MPSBEEG and MPDBEEG respectively whose ages range between 38 and 62 years completed the study. Within-group comparison across the 3 time-points of the study showed significant differences in the physiological and psychosocial variables in MPG, MPSBEEG and MPDBEEG. There were significant differences in groups mean change scores on BST (14.6±8.44, 45.7±17.0 and 17.1±10.2 sec), RAUT (2.88±1.88, 12.9±11.1 and 10.7±6.51 rep), BS (12.6±2.16, 10.1±2.08 and 10.8±2.19), RMBPQ (3.36±0.76, 3.72±0.70 and 4.20±0.52) and mean rank score on PSEQ (26.6, 36.5 and 40.5) at week 4. Also, significant differences were observed in BST (29.6±8.44, 60.7±17.1 and 32.1±10.2 sec), RAUT (8.36±2.22, 18.1±10.1 and 16.6±6.24 reps), BS (3.88±1.67, 5.41±2.32 and 4.35±1.63) and mean rank score on PSEQ (23.5, 37.4 and 43.5) at week 8. Post-hoc test showed that MPSBEEG had significantly higher mean change in BST, RAUT and BS scores at week 4 and 8 respectively. The MPDBEEG had higher mean change in RMBPQ and PSEQ at week 4, and in PSEQ at week 8.

Combining static back endurance exercise with Mckenzie protocol led to higher improvement in physiological variables of muscle endurance and reduction in fatigue while the addition of dynamic back endurance exercise resulted in higher improvement in psychosocial variables of activity limitation and pain self-efficacy. Combining static and dynamic back endurance exercise with Mckenzie protocol may be recommended in improving physiological and psychosocial variables in patients with LMLBP.

Keywords: Back endurance; McKenzie protocol; Mechanical low-back pain

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Mbada C.E

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

Low-Back Pain (LBP) is defined as the constellation of symptoms of pain or discomfort originating from the lumbar spine with or without sciatica (Waddell, 1998; Burton et al., 2004). LBP is also described as pain, muscle tension, or stiffness localized below the costal margin and above the inferior gluteal folds, with or without leg pain (sciatica) (van den Bosch et al., 2004). LBP is typically classified as being specific or non-specific (Manek and MacGregor, 2005). The non-specific LBP refers to mechanical back pain of musculoskeletal origin in which symptoms vary with physical activity (Waddell, 1996).

Low-Back Pain (LBP) is often classified as acute, sub-acute and chronic according to duration of pain (Bouter et al., 1998). Chronic LBP is defined as spinal pain persisting for at least twelve weeks (Abenheim et al., 2000). Using the International Classification for Functioning, Health and Disability (ICF) framework, it is believed that the word "chronic" may be associated with negative expectations, therefore the word "long-term" is preferred (Ljungquist, 2002). Long-term mechanical LBP results in both physical and psychological deconditioning that traps the patient in a vicious circle characterized by decreased physical performance, exacerbated nociceptive sensations, depression, impaired social functioning, and work disability (Demoulin et al., 2006).

Low-Back Pain (LBP) is a complicated condition which affects the physiological and psychosocial aspects of the patient (Elfving, 2002; Kool et al., 2002; Carragee et al., 2005; Young et al., 2011). Long-term LBP is considered to be a patho-anatomical disorder (Bernard and Kirkaldy-Willis, 1987), in addition to a multifactorial biopsychosocial problem such as fear of movement, anxiety, a faulty coping strategy which has an impact on social life and thus require a multi-dimensional approach based on biopsychosocial model in its assessment and treatment (Haggman et al, 2004; Woby et al, 2004; Weiner, 2008). The evaluation of the psychosocial factors regarded as yellow flags are useful in identifying patients with chronic LBP who have a poor prognosis (Price, 2005; Last and Hulbert, 2009). Whether psychosocial factors are causes or consequences of LBP has been the subject of debate (Simmonds et al., 1996). However, LBP is associated with significant disability and with psychosocial dysfunction (Simmonds et al., 1996). Variables such as attitudes, beliefs, mood state, social factors and work appear to interact with pain behaviour, and are cumulatively referred to as psychosocial factors (Innes, 2005). From the bio-psychosocial model paradigm, patients' performance during physical performance tests may be influenced by biological, psychological and social factors (Reneman et al, 2008) which include self-efficacy expectations, self-esteem and fear-avoidance behaviour.

Epidemiological reports indicate that 70 to 85 % of all people have LBP at some time in their life (Waddell, 1998; Andersson, 1999; Goodwin and Goodwin, 2000; van Tulder, 2001). It is estimated that 80-90% of these patients will recover within 6 weeks, regardless of treatment (Indahl et al., 1995; Bronfort et al., 1996; van Tulder et al., 1997; Jackson, 2001). However, 5-15% of all people that have LBP will develop long-term LBP (i.e. LBP of 12 weeks and longer) (Johannsen et al., 1995; Bigos et al., 2001; Quittan 2002). Over 80% of patients with long-term LBP will develop recurrent episodes (Waddell, 1998) and about 93% will have intermittent or recurrent episode of LBP again in the following 12 months (de Vet et al., 2002) and this significantly impact on patients functioning (Picavet and Schouten, 2003). Long-term LBP is more difficult to treat (Cottingham and Maitland, 1997; Hildebrandt et al., 1997; Frost et al., 2000) and treatment outcomes give variable results (CSAG, 1994; Rainville et al., 1997; Carpenter and Nelson, 1999). The patient subgroup with long-term LBP accounts for 75-90% of the socioeconomic cost of LBP (Deyo and Tsui-Wu, 1987; Nachemson, 1992). Over 30% of these patients with long-term LBP seek healthcare for their back complaints and about 66% of subjects with recurrent long-term LBP who sought care for complaints at baseline, did seek care again during follow-up (IJzelenberg and Burdorf, 2004).

Results of systematic reviews are often used to formulate clinical guidelines and recommendations for best practice (Glover and May, 2009). The Clinic on Low-Back Pain in Interdisciplinary Practice Guideline (Rossignol et al., 2007) reported that there was strong evidence for multidisciplinary programmes, behavioural therapy and exercise for long-term LBP. The European Guidelines (Airaksinen et al., 2004) found moderate evidence for the use of exercise therapy in long-term LBP and conflicting evidence for the effectiveness of programmes involving specific types of exercise. Recent American Family Practice Guidelines recommended exercises conducted under the supervision of a therapist as the first-line therapy in treatment of long-term LBP (Nguyen and Randolph, 2007). Systematic reviews of the evidence concerning the effectiveness of exercise concluded that exercise may be helpful for patients with long-term LBP in terms of decrease in pain and disability (Hayden et al., 2005a), decrease in fear of avoidance behaviour (van Tulder et al., 1997; Liddle et al., 2004) and return to normal activities of daily living and work (van Tulder et al., 2002).

Exercises of various types have been used in managing LBP with varying reported successes (Shiple, 1997) and they appear to be the central element in the physical therapy management of patients with long-term mechanical LBP (Bigos et al., 1994; van Tulder et al., 2003; Hayden et al., 2005). Exercise in physical therapy is probably the cheapest intervention and one in which the patient has some measure of direct control (Brukner and Khan, 1993). These exercises encompasses a heterogeneous series of specific movements or interventions ranging from general physical fitness or aerobic exercise to muscle strengthening and various types of flexibility and stretching with the aim of training or developing the body by a routine practice or as physical training to promote good physical health (Abenhaim et al., 2000; Hayden et al., 2005). Nonetheless, it remains inconclusive which exercise regimen is better than the other and intensity that may offer the greatest value to patients (Shiple, 1997; Nordin and Campello, 1999; Samanta et al., 2003; Hayden et al., 2005; Nguyen and Randolph, 2007).

Consequent on the foregoing, there is a proliferation of exercise programmes which varies from provider to provider depending on professional orientation (Keller, 2006). Still, there does not appear to be a consensus of opinion on the most effective programme designed to maintain exercise benefits (Bronfort et al., 1996; Faas, 1996; Lahad et al., 1996; Carpenter and Nelson, 1999; Kenny, 2000; Taimela et al., 2000). Glover and May (2009) submitted that the fact that previous research has investigated the management of LBP as a homogenous group could account for the lack of support for the prescription of specific exercise programmes. Similarly, some others studies identified not sub-grouping patient samples as a possible flaw with much of the previous research (Fritz et al., 2003; Long et al., 2004; Brennan et al., 2006). Sub- grouping of patients with LBP according to their signs and symptoms where treatment is then prescribed according to these subgroups is considered as an important advance in the management of LBP (Fritz et al., 2003; Long et al., 2004; Brennan et al., 2006). Therefore, identifying sub-groups of patients more amenable to specific treatments has been recognized as one of the promising recent developments in back pain research (Koes et al., 2006).

One of the more commonly used methods of sub-grouping amongst physiotherapists is the McKenzie Method (McKenzie and May, 2003). This method is based on the patient's pain response to certain movements and postures during assessment. During assessment, the physiotherapist identifies the patient's directional preference. Directional Preference is defined as the movement or posture that decreases or centralizes pain that emanates from the spine and/or increases range of movement (McKenzie and May, 2003). Directional preference and centralization occur only in the substantial derangement group (McKenzie and May, 2003). The separate, but associated, phenomenon of centralization refers to the abolition of distal pain in response to repeated movements or sustained postures. Although, the McKenzie method is a popular classification-based treatment for LBP among physical therapists (Battie et al., 1994; Foster et al., 1999; Ayanniyi et al., 2007) with documented effectiveness in some studies (Ponte et al., 1984; Nwuga and Nwuga, 1985; Stankovic and Johnell, 1990; Reddeck, 1997; Cherkin et al., 1998; Machado et al., 2006), however, a systematic review submitted that there is limited evidence for its use in long-term mechanical LBP (Machado et al., 2005). Furthermore, there seems to be inconclusive evidence whether the McKenzie protocol addresses the accompanying back muscles inhibition in patients with long-term mechanical LBP. Long-term LBP results in inhibition and atrophy of the deep segmental muscles such as multifidus and overactivity of the longer superficial muscles of the trunk with consequent decreased dynamic activity and increased fatiguibility (Sihvonen et al., 1991; Cassisi et al., 1993; Sihvonen et al., 1998; Richardson et al., 1999). Some studies considered the McKenzie's extension exercises as passive and presumably opined that it may not counter the back muscles' inhibition and atrophy resulting from long-term LBP (Donelson et al., 1990; Bookhout, 1991; Wayne, 1991), however, a study by Fiebert and Keller (1994) among apparently healthy individuals demonstrated that the McKenzie's extension exercises were not truly passive for lumbar back extensor muscles.

On the other hand, back endurance exercise is believed to enhance muscle reactivation and reconditioning (Biering-Sorensen, 1984; Risch et al., 1993; Luoto et al., 1996; Mayer et al., 2008; Liddle et al., 2010). There is emerging evidence to suggest that endurance training of the low-back extensors in patients with LBP can be effective in reducing pain, disability and work loss, and improving fatigue threshold and physical performance (Plum and Rehfeld, 1985; Manniche et al., 1988; Lindstrom et al., 1992; Gundewall et al., 1993; Moffroid et al., 1993; LeFort and Hannah, 1994; Chok et al., 1999). Unfortunately, assessment and training of endurance of the back extensor muscles compared with muscular strength has been reported to be less frequently carried out (Pollock et al., 1989), though, endurance capabilities of these muscles may be as important or even more important than strength in the treatment and prevention of LBP (Udermann et al., 2003). In addition, clinical trials on the effect of endurance exercise training of the back extensor muscles in well defined populations of patients with LBP are scarce (Moffroid, 1997). Therefore, the objective of this study was to investigate the effect of static or dynamic back extensors endurance exercise in combination with McKenzie Protocol on physiological (pain intensity, muscle fatigue, static and dynamic muscle endurance) and psychosocial (activity limitation, disability, fear-avoidance behaviour, pain self-efficacy belief, belief of the consequences of back pain and general health status) variables in patients with long-term mechanical LBP using the bio-psychosocial model which is the state of the art in rehabilitation and disability perspectives (WHO-ICF, 2001).

1.2 STATEMENT OF THE PROBLEM

Low-Back Pain (LBP) is one of the most frequent reasons that patients visit primary care physicians (Frymoyer, 1988; Deyo et al., 1991) and constitutes the highest percentage of referrals and workload for physical therapy utilization (Frymoyer and Cats-Baril, 1991; Battie et al., 1994; Margo, 1994). The McKenzie Protocol is one of the most frequently used types of physical therapy for back pain in some Western nations (Battie et al., 1994; Foster et al., 1999; Gracey et al., 2002) and has the potential advantage of encouraging self-help (Moffett and McLean, 2006). Nonetheless, there is limited evidence in term of randomized trials to support its effectiveness in long-term LBP. The McKenzie Protocol identifies with the school of thought that spinal joint dysfunction such as disc protrusion, loss of joint play, stress and strain are the major causes of back pain.

Another school of thought in LBP management in physical therapy is that impairment of muscles (Biering-Sorensen, 1984; Moffroid, 1997; Kankaanpää et al., 1999) and/or trunk extensor-to-flexor muscles imbalance (Quinn and Bird, 1996) are major contributors to aetiology of back pain. Under this paradigm, muscle strength and endurance training are believed to be important in the management of LBP. However, muscular endurance training of the back extensors is believed to be more important in the treatment and prevention of LBP than muscular strength (Udermann et al., 2003). Unfortunately, few studies have investigated the effect of endurance exercise on LBP. Furthermore, there seems to be a dearth of studies involving dynamic endurance exercise of the back extensor muscles compared with a chronicle of studies that have investigated the effect of static muscular endurance exercise training in patients with acute (Plum and Rehfeld, 1985), sub-acute (Chok et al., 1999) and long-term LBP (Thompson, 1992) respectively. Meanwhile, dynamic endurance may be needed more than static endurance as most of the daily tasks involve dynamic movement (Leigh and Sheetz, 1989; Burnett and Glenn, 1990). In addition, most of the previous studies involving endurance exercise of the back extensor muscles lacked randomized controls (Coxhead et al., 1981; Plum and Rehfeld, 1985), standardized and clearly defined exercise guidelines or protocols (Plum and Rehfeld, 1985; Manniche et al., 1988) and outcome assessment of general health measures, disability and functional status (Deyo et al., 1998).

In spite of the importance of back extensors endurance exercise for patient with long-term LBP, there appears to be a paucity of studies as to the most efficacious type of muscular endurance training of the back extensor muscles in the management of patients with long-term mechanical LBP. Furthermore, there seems to be dearth of studies investigating the effect of the addition of the back extensor muscles endurance exercise on the MP in patients with long-term mechanical LBP, thus incorporating the two different schools of thought in the management LBP.

Louw et al., (2007) advocated further research into the most effective strategies to manage and prevent LBP especially in Africa owing to increasing prevalence. While

Hayden et al., (2005b) recommended clinical trials that will investigate specific exercise intervention strategies in well defined populations of patients with LBP and take care of the short-comings of previous studies. Moreover, group of back pain researchers recommended standardized use of outcome measures in back pain research, suggesting a minimum of pain, functional status, and general health measures (Deyo et al., 1998). The primary aim of this study was to evaluate whether the addition of static or dynamic back extensors endurance exercise to the McKenzie protocol will be efficacious on physiological variables of pain, muscle fatigue, static and dynamic muscle endurance; and psychosocial variables of activity limitation, disability, fear-avoidance behaviour, pain self-efficacy belief, belief of consequence of back pain and general health status in patients with long-term mechanical LBP using the ICF framework (bio-psychosocial model) in conducting LBP research.

The study provided answers to the following research questions:

(1) Would the addition of static back extensors endurance exercise to the McKenzie protocol be efficacious in the management of patients with long-term mechanical LBP when effect is measured in terms of pain, muscle fatigue, muscle endurance, activity limitation, disability, fear-avoidance behaviour, pain self-efficacy belief, belief of consequence of back pain and general health status?

(2) Would the addition of dynamic back extensors endurance exercise to the McKenzie protocol be efficacious in the management of patients with long-term mechanical LBP when effect is measured in terms of pain, muscle fatigue, muscle endurance, activity

limitation, disability, fear-avoidance behaviour, pain self-efficacy belief, belief of consequence of back pain and general health status?

(3) Would the treatment outcomes of the addition of either static or dynamic back extensors endurance to the McKenzie protocol in patients with long-term mechanical LBP be comparable in terms of pain, muscle fatigue, muscle endurance, activity limitation, disability, fear-avoidance, pain self-efficacy belief, belief of consequence of back pain and general health status?

1.3 AIMS OF STUDY

The aims of the study were:

1) To investigate the effect of McKenzie protocol only on pain, muscle fatigue, muscle endurance, activity limitation, disability, fear-avoidance behaviour, pain self-efficacy belief, belief of consequence of back pain and general health status in patients with long-term mechanical LBP.

2) To investigate the effect of the addition of static back extensors endurance exercise to the McKenzie protocol on pain, muscle fatigue, muscle endurance, activity limitation, disability, fear-avoidance behaviour, pain self-efficacy belief, belief of consequence of back pain and general health status in patients with long-term mechanical LBP.

3) To investigate the effect of the addition of dynamic back extensors endurance exercise to the McKenzie protocol on pain, muscle fatigue, muscle endurance, activity limitation, disability, fear-avoidance behaviour, pain self-efficacy belief, belief of consequence of back pain and general health status in patients with long-term mechanical LBP.

4) To compare the effects of the McKenzie protocol only, the addition of static or dynamic back extensors endurance exercise to the McKenzie protocol on pain, muscle fatigue, muscle endurance, activity limitation, disability, fear-avoidance behaviour, pain self-efficacy belief, belief of consequence of back pain and general health status in patients with long-term mechanical LBP.

1.4 HYPOTHESES

1.4.1 Major Hypothesis

The major hypothesis for this study was that:

1) There would be no significant difference in the effects of the three treatment regimens on pain, muscle fatigue, muscle endurance, activity limitation, disability, fear-avoidance behaviour, pain self-efficacy belief, belief of consequence of back pain and general health status in patients with long-term mechanical LBP.

1.4.2 Sub Hypotheses

The following sub-hypotheses were tested in this study:

1. There would be no significant difference in the pain intensity of participants in the McKenzie Protocol Group (MPG) across weeks 0, 4 and 8 of the study.
2. There would be no significant difference in the static muscle endurance of participants in the MPG across weeks 0, 4 and 8 of the study.
3. There would be no significant difference in the dynamic muscle endurance of participants in the MPGacross weeks 0, 4 and 8 of the study.
4. There would be no significant difference in the muscle fatigue of participants in the

MPG across weeks 0, 4 and 8 of the study.

5. There would be no significant difference in the activity limitation of participants in the MPG across weeks 0, 4 and 8 of the study.
6. There would be no significant difference in the disability of participants in the MPG across weeks 0, 4 and 8 of the study.
7. There would be no significant difference in the fear-avoidance behaviour of participants in the MPG across weeks 0, 4 and 8 of the study.
8. There would be no significant difference in the pain self-efficacy belief of participants in the MPG across weeks 0, 4 and 8 of the study.
9. There would be no significant difference in the belief of the consequences of back pain of participants in the MPG across weeks 0, 4 and 8 of the study.
10. There would be no significant difference in the general health status of participants in the MPG across weeks 0, 4 and 8 of the study.
11. There would be no significant difference in the pain intensity of participants in the McKenzie Protocol plus Static Back Endurance Exercise Group (MPSBEEG) across weeks 0, 4 and 8 of the study.
12. There would be no significant difference in the static muscle endurance of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.
13. There would be no significant difference in the dynamic muscle endurance of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.
14. There would be no significant difference in the muscle fatigue of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.
15. There would be no significant difference in the activity limitation of participants in

the MPSBEEG across weeks 0, 4 and 8 of the study.

16. There would be no significant difference in the disability of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.
17. There would be no significant difference in the fear-avoidance behaviour of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.
18. There would be no significant difference in the pain self-efficacy belief of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.
19. There would be no significant difference in the belief of the consequences of back pain of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.
20. There would be no significant difference in the general health status of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.
21. There would be no significant difference in the pain intensity of participants in the McKenzie Protocol plus Dynamic Back Endurance Exercise Group (MPDBEEG) across weeks 0, 4 and 8 of the study.
22. There would be no significant difference in the static muscle endurance of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.
23. There would be no significant difference in the dynamic muscle endurance of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.
24. There would be no significant difference in the muscle fatigue of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.
25. There would be no significant difference in the activity limitation participants in the MPDBEEG across weeks 0, 4 and 8 of the study.
26. There would be no significant difference in the disability of participants in the

MPDBEEG across weeks 0, 4 and 8 of the study.

27. There would be no significant difference in the fear-avoidance behaviour of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.
28. There would be no significant difference in the pain self-efficacy belief of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.
29. There would be no significant difference in the belief of the consequences of back pain of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.
30. There would be no significant difference in the general health status of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.
31. There would be no significant difference in the effect of the three treatment regimens on pain intensity at week four of the study.
32. There would be no significant difference in the effect of the three treatment regimens on static muscle endurance at week four of the study.
33. There would be no significant difference in the effect of the three treatment regimens on dynamic muscle endurance at week four of the study.
34. There would be no significant difference in the effect of the three treatment regimens on muscle fatigue at week four of the study.
35. There would be no significant difference in the effect of the three treatment regimens on activity limitation at week four of the study.
36. There would be no significant difference in the effect of the three treatment regimens on disability at week four of the study.
37. There would be no significant difference in the effect of the three treatment regimens on fear-avoidance behaviour at week four of the study.

38. There would be no significant difference in the effect of the three treatment regimens on pain self-efficacy belief at week four of the study.
39. There would be no significant difference in the effect of the three treatment regimens on belief of consequences of back pain at week four of the study.
40. There would be no significant difference in the effect of the three treatment regimens on general health status at week four of the study.
41. There would be no significant difference in the effect of the three treatment regimens on pain intensity at week eight of the study.
42. There would be no significant difference in the effect of the three treatment regimens on static muscle endurance at week eight of the study.
43. There would be no significant difference in the effect of the three treatment regimens on dynamic muscle endurance at week eight of the study.
44. There would be no significant difference in the effect of the three treatment regimens on muscle fatigue at week eight of the study.
45. There would be no significant difference in the effect of the three treatment regimens on activity limitation at week eight of the study.
46. There would be no significant difference in the effect of the three treatment regimens on disability at week eight of the study.
47. There would be no significant difference in the effect of the three treatment regimens on fear-avoidance behaviour at week eight of the study.
48. There would be no significant difference in the effect of the three treatment regimens on pain self-efficacy belief at week eight of the study.
49. There would be no significant difference in the effect of the three treatment regimens

on belief of consequences of back pain at week eight of the study.

50. There would be no significant difference in the effect of the three treatment regimens on general health status at week eight of the study.

1.5 DELIMITATION OF STUDY

This study was delimited to the following:

A. *Participants*:

1. Individuals diagnosed as having symptoms of long-term mechanical LBP.

2. Having directional preference for extension based McKenzie Institute's Lumbar Lumbar

Spine Assessment Format

B. *Facility*:

1. Out-patient Physiotherapy Department of the Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Nigeria.

2. Department of Medical Rehabilitation, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Osun state, Nigeria.

C. *Physical Performance tests:*

1. Biering-Sørensen test of Static Muscular Endurance (BSME) was used to assess static endurance of the back extensor muscles.

2. Repetitive Arch-Up Test (RAUT) was used to assess dynamic endurance of the back extensor muscles.

1.6 LIMITATION

The following were the limitations of this study:

1. The researcher was not blinded to the treatment outcomes of the different regimens and this is a possible threat to generalizability of the study.

2. This study did not assess the long-term effects of treatment outcomes of the different regimens. This could be the focus of futue studies in this area.

3. The endurance exercises used in this study seems to be able to recruit erector spinae comprising of the longissimus, spinalis and iliocostalis muscles that are basically trunk mobilizers at the expense of the trunk stabilizers that are also affected by LBP.

1.7 SIGNIFICANCE OF THE STUDY

The outcome of this study may:

1. Add to clinical evidence on the efficacy of McKenzie protocol at improving physiological and psychosocial variables in patients with long-term mechanical LBP.

2. Provide clinical evidence on the efficacy of static and dynamic back extensors endurance exercises at improving physiological and psychosocial variables in patients with long-term mechanical LBP.

3. Serve as a basis for recommending the most efficacious endurance exercise that may offer the greatest value to patients with LBP in clinical practice.

4. Add to the few available studies on endurance exercise of back extensors in individuals with long-term mechanical LBP and also contribute to the expanding knowledge on the management of long-term mechanical LBP in general.

1.8 DEFINITIONS OF TERMS

The following terms were defined:

Activities: What people can do inherently without assistance or barriers (WHO-ICF, 2001).

Dynamic endurance: This is the ability of an isolated muscle group to perform repeated contraction over a period of time (Burnett and Glenn, 1996; Hui, 2001).

Efficacy: Biological effect of treatment delivered under carefully controlled conditions, usually determined by randomized controlled trials (Domholdt, 2000).

Long-term low-Back Pain – Low-Back Pain which has been persistent for three months or more (Ljungquist, 2002; Paul et al., 2008).

Mechanical Low-Back Pain – Back pain that results from inflammation caused by irritation or trauma to the disk, the facet joints sufficient enough to stress, deform or damage the ligaments or the muscles of the back (McKenzie, 1981; Mora, 2004).

Participation: Functioning taking into account the impact of barriers and facilitators in the environment (WHO-ICF, 2001).

Static endurance: This is the ability of an isolated muscle group to generate tension, sustain that tension, and resist fatigue over a prolong period of time (Delateur, 1982).

CHAPTER TWO

LITERATURE REVIEW

2.1.0 LOW-BACK PAIN

Low-Back Pain (LBP) is a symptom of pain or discomfort in the lumbo-sacral region of the back, between the lower margins of the 12th rib and the gluteal folds (Porter, 1993; Omokhodion, 2002; Hipp et al., 1989). LBP is regarded as a symptom from impairments in the structures in the low back which originates e.g. from muscles, ligaments, disc etc. (Elfving, 2002). It is also referred to as a complex disorder where pain, anatomical, physiological, psychological and social aspects are involved (Elfving, 2002, Roach et al., 1997) and it occurs in a wide variety of medical, musculoskeletal, and neurologic conditions (Roach et al., 1997). LBP is not a diagnosis (Roach et al., 1999) but an irksome syndrome which has challenged mankind for ages (Cypress, 1983; May, 2001).

McCombe (1989) submitted that there is considerable research aimed at elucidating aetiology of various forms of back pain; in spite of this, only those syndromes associated with neurologic compression of cauda equina or nerve root have reasonably well understood clinical presentations. Nonetheless, LBP is typically classified as being specific or nonspecific (Manek and MacGregor, 2005). The specific aetiology of LBP is difficult to ascertain in most patients at the onset of the initial episode (Ehrlich, 2003; Airaksinen et al., 2004). Between 80 – 90% of patients with LBP have no identifiable cause or precise patho-anatomical diagnosis and are designated as non-specific (Valkenburg and Haane, 1982; Nachemson, 1985; Deyo and Weinstein, 2001; Manek and Macgregor, 2005). The non-specific LBP is described as a "mechanical" back pain of musculoskeletal origin in which symptoms vary with physical activity (Waddell, 1996). Mechanical LBP is back pain that results from inflammation caused by irritation or trauma to the disk, the facet joints sufficient enough to stress, deform or damage the ligaments or the muscles of the back (McKenzie, 1981; Medial Multimedia Group, 2002; Mora, 2004).

Low-Back Pain (LBP) is often classified as acute, sub-acute and chronic according to duration of pain (Bouter et al., 1998). Acute LBP is described as LBP episode within 6 weeks, sub-acute as duration more than six weeks and less than three months; and chronic LBP as duration more than three months (Ehrlich, 2003; Manek and MacGregor, 2005; Refshauge and Maher, 2006). The International Classification for Functioning, Health and Disability (ICF) framework has brought about a change of nomenclature or description of LBP classification (WHO-ICF, 2001; Elfving, 2002). The classification of LBP based on duration has recently been re-designated as short-term (for acute), intermediate (for sub-acute) and long-term (for chronic) (Abenhaim et al., 2000; WHO-ICF, 2001; Elfving, 2002). Previous findings indicate that acute and sub-acute episodes that last up to 3 months are the most common presentations of LBP and recurrent bouts of such episodes are the norm (Ehrlich, 2003; Manek and MacGregor, 2005). Another report showed that one percent of patients with acute LBP have sciatica, which is defined as pain in the distribution of a lumbar nerve root, often accompanied by neurosensory and motor deficits (Hadler, 1984). However, chronic LBP ultimately is more disabling because of the physical impediments it causes and its psychological effects.

2.1.1 Epidemiology of Low-Back Pain

Low-back pain (LBP) remains a major public health burden throughout the world (Papageorgiou et al., 1995; Hillman et al., 1996; Leboeuf-Yde et al., 1996). It is one of the most common problems in medical practice affecting 70% - 85% of adults during their lives (Andersson, 1999; Deyo and Weinstein, 2001; Goodwin and Goodwin, 2000; van Tulder, 2001). In many parts of the world, LBP is reported to be a major occupational health problem (Asuzu, 1995; Volinn, 1997; Andersson, 1999). It is a leading cause of morbidity and lost productivity (Deyo et al., 1992). Epidemiological data indicate an annual prevalence of about 39–54% (Hillman et al., 1996; Leboeuf-Yde et al., 1996) and a lifetime prevalence of 60–65% (Hillman et al., 1996; Leboeuf-Yde et al., 1996; Papageorgiou et al., 1995). According to Andersson (1999) LBP affects men and women equally, with onset most between the ages of 30 and 50 years.

Anecdotally, there is a general assumption that LBP prevalence in Africa is comparatively lower than in developed countries (Louw et al., 2007). The lack of information on the prevalence of LBP in developing countries is therefore a significant shortcoming (Walker, 2000; Sackett, 2000), particularly as it is predicted that the greatest increases in LBP prevalence in the next decade will be in developing nations (WHO, 2003). However, a recent systematic review, Louw et al., (2007) concluded that the global burden and prevalence of LBP among Africans is rising and is of concern. In Nigeria, Latunbosun (1998) posited that the rate of incidence of LBP increases yearly. Also, a prevalence of 38% (Asuzu, 1995) and 44% (Omokhodion, 2004) has been reported among rural and urban dwellers respectively. Nwuga (1993) found 80% prevalence among Nigerians of over 60 years of age. Asuzu (1995) reported that LBP contributed a sizeable loss of man hours per year, and it affected the ordinary lives of the sufferers to a large extent in Nigeria. The improvement in health outcomes with regards to LBP observed in most Western countries over the past few decades has not been achieved in Africa; therefore making the health of Africans is of global concern (Lopez et al., 2006).

Low-back pain commonly affects people during their most productive years thereby making it the most expensive medical condition for people in the 30 - 50 years age group (Bigos et al., 1986; Deyo and Bass, 1989; van Tulder et al., 1995; Hestbaek et al., 2003). Andersson (1999) in the United States of America reported that back pain is the most common cause of activity limitation in people younger than 45 years, the second most frequent reason for visit to a physician, the fifth ranking cause of admission to hospital, and the third most common cause of surgical procedures. In the United Kingdom back pain is responsible for about 12.5% of all sick days (Andersson, 1999). Over the past 30 years in Sweden, back pain has accounted for 11% to 19% of all sickness absence days (Andersson, 1999). Eight percent of the insured Swedish populations were listed as sick with a diagnosis of back pain at some time during 1987 (Andersson, 1999).

2.1.2 Aetiology of Low-Back Pain

In the vast majority of instances the cause of LBP is obscure or nebulous (Ehrlich, 2003). A minority of cases of back pain result from physical causes such as trauma to the back caused by a motor vehicle crash or a fall among young people and lesser traumas, osteoporosis with fractures, or prolonged corticosteroid use among older people are antecedents to back pain of known origin in most instances. Relatively less common vertebral infections and tumours or their metastases account for most of the remainder. Specific causes account for less than 20% of cases of back pain: the probability that a particular case of back pain has a specific cause is only 0.2% (Ehrlich, 2003). The rest have so called non-specific LBP. This is described as a “mechanical” back pain of musculoskeletal origin in which symptoms vary with physical activity (Waddell, 1996).

It has been reported that principal conditions that may give rise to disabling pain in the lower part of the back are numerous (Mankin and Adams, 1977; Cyriax, 1978). Ayanniyi (2003) summarized that inflammatory diseases such as rheumatoid arthritis, ankylosing spondylitis, colities and diverticulitis were implicated in the aetiology of LBP. Furthermore, neoplastic diseases e.g. multiple myeloma, Hodgkin’s diseases, and reticulum cell sacroma, metastatic carcinoma (breast, lungs, prostate, thyroid, kidney, gastro interestinal tract) affecting lumbar spine bones can cause LBP. Referred pain from viscera disease e.g. abdominal organs can be felt in the lumbar spine region of the back. Peptic ulceration or tumor of the wall of the stomach and of the duodenum can also refer to the low back. Referred pain from pelvic organs (urologic and gynaecologic diseases), menstrual pain, endometriosis or carcinoma, malposition of uterus (retroversion, descensus, and prolapse) is often felt in the lumbar and sacral regions of the back. Other causes of LBP are destructive and infectious diseases such as tuberculosis, osteomyelitis of the spine and acute discitis i.e. infection of the intervertebral disc. Metabolic disease such as osteoporosis of the spinal bones (Mankin and Adams, 1977; Cyriax; 1978); urinary tract infections including pyelonephritis and renal colic secondary to uretetro lithiasis (MacEvilly and Buggy, 1996), some neuralgia e.g. Herpes zoster (viral infection)

(Dickson and Wright, 1984); Vitamin B12 deficiency and Piriformis syndrome (Wiesel, 1996); diabetic lumbar radiculopathy (Naftulin et al., 1993) are also implicated in the aetiology of LBP. Binder and Nampiaparampil (2009): summarized that up to 85% of patients with LBP do not obtain a specific diagnosis even after work up (Nachemson, 1976; White and Gordon, 1982; Deyo et al., 1992). Schwarzer et al., (1994) posited that a very large percentage of individual complaints of LBP will have no accurately detectable pathology utilizing presently available technology and diagnostic procedures.

Researchers and clinicians in physical therapy currently subscribes to two schools of thought based on their understanding of the causes of back pain. One school of thought is that spinal joint dysfunction such as disc protrusion, loss of joint play; stress and strain etc. are the major causes of back pain (Mckenzie, 1981; Cyriax, 1982; Nwuga, 1990). This group prefer positional adjustments (McKenzie, 1981), back school (Ross, 1997), and spinal manipulative therapy among others (Cyriax, 1982; Nwuga, 1990). The other school of thought is that weak muscles and/or trunk extensor-to-flexor muscles imbalance are major contributors to aetiology of back pain (Quinn and Bird, 1996; Marras et al., 1987; Wilder et al., 1996; Nourbakhsh and Arab, 2002). Some authorities in this school of thought (Cady et al., 1979; Biering-Sorenson, 1984; Carr et al., 1985) suggest that muscle is a potential source of LBP. They argue that failure of muscles to protect passive structures from excessive loading may result in damage to these pain sensitive structures and produce pain (Siedel et al., 1987).

2.1.3 Risk factors for low-back pain

Many factors have been implicated in previous studies as risk factor for LBP however, only a few has been established in prospective studies (Lean et al., 1999). Several risk factors have been associated with increased risk of developing LBP which include smoking, obesity and psychological functioning. Smoking is one of the risk factors for LBP (Fogelholm and Alho, 2001). Smoking results in faulty synthesis of vertebral disc macromolecules, ischaemia and an imbalance between disc matrix proteineases and their inhibitors, these result in disc degeneration and spinal instability, and consequently LBP. Studies have shown an association between smoking and back pain that suggests risk is increased 1.5 to 2.5 times compared to non-smokers (Deyo and Bass, 1989). There is also an increase in proteolytic activity in cigarette smokers, which speeds up the disc degenerative process (Fogelholm and Alho, 2001; Ernst, 1992). Other implicated risk factors for LBP include sedentary work and lifestyle (van Dieen et al., 2001; Kesley et al., 1984), standing and sitting for extended periods, wearing high heeled shoes, overweight and obesity, alcoholism, psychological factors (Kesley et al., 1984; Frymoyer, 1992; Lean et al., 1999).

McKenzie (1981) identified three main factors that predispose an individual to mechanical LBP. The first is sitting posture, which according to him produces back pain itself without any additional strains of living. The second factor is the loss of lumbar extension or reduced range of extension, which influences the posture in standing, sitting, and walking. A reduced extension range will produce fully stretched position prematurely during prolonged and relaxed standing; pain then arises once sufficient stress is present. The third predisposing factor listed by McKenzie (1981) is high frequency of flexion and also unexpected and unguarded movements. He submitted that lifting produces strain, which is often a precipitating factor especially when heavy, prolonged and repeated lifting is involved. Individuals in jobs requiring heavy lifting and lifting while twisting are at increased risk of back pain. In addition, exposure to whole body vibration and jobs that require static postures are associated with back pain (Skovron, 1992).

Lack of back extensor muscles' endurance has frequently been cited as a suspected factor in the aetiology of LBP (Nordin et al., 1987) and it has also been associated with prolonged or recurrent back pain (Jorgensen and Nicolaisen, 1987). On the other hand, back pain in itself has been reported to precipitate decreased muscle endurance resulting from increased muscle metabolite from prolonged muscle tension and spasm (Armstrong, 1984), muscle deconditioning (Roy and Oddsson, 1998) and inhibition of the paraspinal muscles (Roy and Oddsson, 1998) in response to pain and decreased activity.

2.1.4 Classification of low-back pain

Low-Back Pain (LBP) is primarily a symptom and not a sign, a diagnosis or disease entity (Nwuga, 1990). It is typically classified as being specific or non-specific (Manek and MacGregor, 2005). The non-specific LBP is refers to mechanical back pain of musculoskeletal origin in which symptoms vary with physical activity (Waddell, 1996). LBP is often classified as acute, sub-acute and chronic according to time duration of pain (Bouter et al., 1998). The lack of diagnosis of pathology of most low-back disorders has led specialists to derive classification schemes to qualify the extent of disorder, facilitate care and improve research (Serge and Lars, 1998). Ogunlade (1998) classified LBP as spinal and non-spinal. Nwuga (1990) classified LBP into local pain, referred pain, radicular pain and pain from muscular spasm. While, Waddell (1982) classified the symptoms of back pain into pathological and mechanical. Among chiropractors LBP is classified as simple mechanical LBP, LBP with radiculopathy, serious pathological LBP and LBP with a psychological overlay (Jenkins, 2002).

One of the more commonly used methods of classifying patients with LBP among physiotherapists is the McKenzie Method (McKenzie and May, 2003). This method is based on the patient's pain response to certain movements and postures during assessment. McKenzie (1989) identified three distinct mechanical syndromes relating to pain in the low-back viz, derangement, dysfunction and postural syndromes. Derangement syndrome involves a change in the position of internal joint material. Dysfunction syndrome occurs when abnormally shortened tissue restricts normal pain free movement while postural syndrome results from prolonged loading of normal tissue leading to pain.

McKenzie submitted that centralization is characteristic of only the derangement syndrome. A small portion of patients with the dysfunction syndrome would present with peripheral symptoms from an adherent nerve root. The derangement syndrome is characterized by pain that can be constant or intermittent depending on the size and location of the internal derangement and individuals with the syndrome may present with peripheralizing and centralizing symptoms (McKenzie, 1981). The McKenzie Method is reported to have high psychometric properties (*e.g.* validity, reliability and generalisability) (McCarthy et al., 2004) and therefore enjoys wide application in the clinical setting.

2.1.5 Models in low-back pain

Many models have been postulated in order to improve the understanding and management of LBP. However, there are three frequently used models regarding management of chronic (long-term) LBP and these are:

1) The physical deconditioning model assuming that loss of muscle strength and endurance including aerobic capacity is responsible for reduced activity levels and hence functional limitations (Mayer et al., 1998; Verbunt et al., 2003).

2) The cognitive-behavioural model postulating that functional limitations results from maladaptive beliefs and avoidance behaviors that are maintained by learning processes (Vlaeyen et al., 1995; Turk and Okifuji, 2002).

3) The bio-psychosocial model assuming that loss of functional abilities results from both the deconditioning and the cognitive-behavioural model (Wadell, 1998). The bio-psychosocial model is currently the state of the art in rehabilitation and disability perspectives and has been adopted by the WHO under the new ICF classification (WHO-ICF, 2001). This model related the development of LBP to clinical, radiological, physiological, and psychological factors (Malcolm, 1995). Based on the aetiology factors, this model helps to identify the bio-psychosocial factors related LBP and they are categorized as red flag (organic and biomedical factors), yellow flag (iatrogenic, belief, coping strategies, distress and behavioural factors), blue flag (social and economic factors), orange flag (psychiatric factors) and black flag (occupational factors) (Price, 2005).

Other models in LBP used in literature include: The pathophysiological model which integrates connective tissue plasticity mechanisms with pain psychology, postural control, neuroplasticity on chronic LBP (Langevin and Sherman, 2007). The postural–structural–biomechanical (PSB) model which is somewhat close to the physical model. The physical model is based on assumption that a causal relationship exist between physical pathology and pain complaint, impairment and disability (Rose et al., 1995). The PSB model proposes postural deviations, body asymmetries and pathomechanics as the predisposing/maintaining factors for LBP (Lederman, 2010). The physical model explained the failure to recover from an acute episode of LBP, implicating that LBP is a function of physical impairment alone (Rose et al., 1995). However, Waddell et al., (1993) submitted that distress is an important mediator of outcome of acute back pain and functional restriction due to pain may be more important than any anatomical or structural impairment. The inconsistencies between the physiologic, nociceptive element and the psychosocial components of chronic LBP were central to the construct 'Fear Avoidance Model of Exaggerated Pain Perception' (Lethem et al., 1983; Slade et al., 1983).

2.1.5.1 Bio-psychosocial model and long-term low-back pain

In 2001, the WHO presented the International classification of functioning, disability and health (ICF), a bio psychosocial model which currently is the state of the art in rehabilitation and disability perspectives (WHO-ICF, 2001; Steiner et al., 2002). The Paris task force on back pain provided a framework linking ICF and back pain (Abenhaim et al., 2000). Using this framework, psychosocial as well as physical aspects of LBP are important in its assessment (Hope, 2002; Staal et al., 2002). It is believed that patients with long-term LBP may be impaired in body functions and structures, limited in performing activities and restricted in participation (Kuijer, 2006a; Kuijer et al., 2006b). There is also a possibility of having back pain impairment without having activity limitation, and to have activity limitation without having restriction in participation (Abenhaim et al., 2000). It is recommended that concepts and measures used in rehabilitation should address all aspects encountered and considered important by health professionals caring for patients with musculoskeletal conditions (Weigl et al., 2006).

In general, disability seems to be one of the most important determinants for seeking healthcare in patients with long-term LBP (IJzelenberg and Burdorf, 2004; Van den Hoogen et al., 1998; Molano et al., 2001). In 1980, the World Health Organization (WHO) defined disability as 'any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner of within the range considered normal for a human being' (WHO, 1980). This definition assumes that the normal is to have no disability or restriction of any kind and that disability is 'due to an impairment' (Waddell, 1998).

The ICF has two parts, with two components each. Part 1 includes the components body functions and structures, as well as activities and participation, and can be described in terms of functioning and disability. In this classification, disability is defined as an umbrella term for impairments, activity limitations and participation restrictions. Part 2, contextual factors, includes the components environmental and personal factors. It denotes the negative aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal factors) (WHO-ICF, 2001). The WHO-ICF (WHO, 2001) classifies components of health into three domains: body functions and structures, activities and participation. Dysfunctions in each respective domain are called impairments, activity limitations and participation restrictions. Impairments are "problems in body function or structure as a significant deviation or loss". Activity limitations are "difficulties an individual may have in executing activities". Participation restrictions are "problems an individual may experience in involvement in life situations". Functioning is the umbrella term that encompasses all body functions, activities and participations. Disability is the umbrella term for dysfunction across the three domains.

It is reported measuring impairments in body functions and structures solely could not explain the complete concept of disability in long-term LBP (Kuijer, 2006). This also means that in rehabilitation treatment, the focus on disability has shifted, in that the pain and complaints are no longer determining the level of disability but more the interaction between the concepts, with the focus on activity and participation. The guiding principle in rehabilitation treatment has shifted from a complaint contingent approach to a more time-contingent approach (Koes et al., 2004). The ICF is a classification system and not a measurement tool; it aimed to provide a scientific basis for the consequences of health conditions, to establish a common language to improve communications, to permit comparisons of data across countries, health care disciplines, services, and time and to provide a systematic coding scheme for health information systems (WHO-ICF, 2001). Using the recent ICF model (WHO 2002), the health of an individual is based on the categories of impairment, activity (previous disability) and participation (previous handicap).

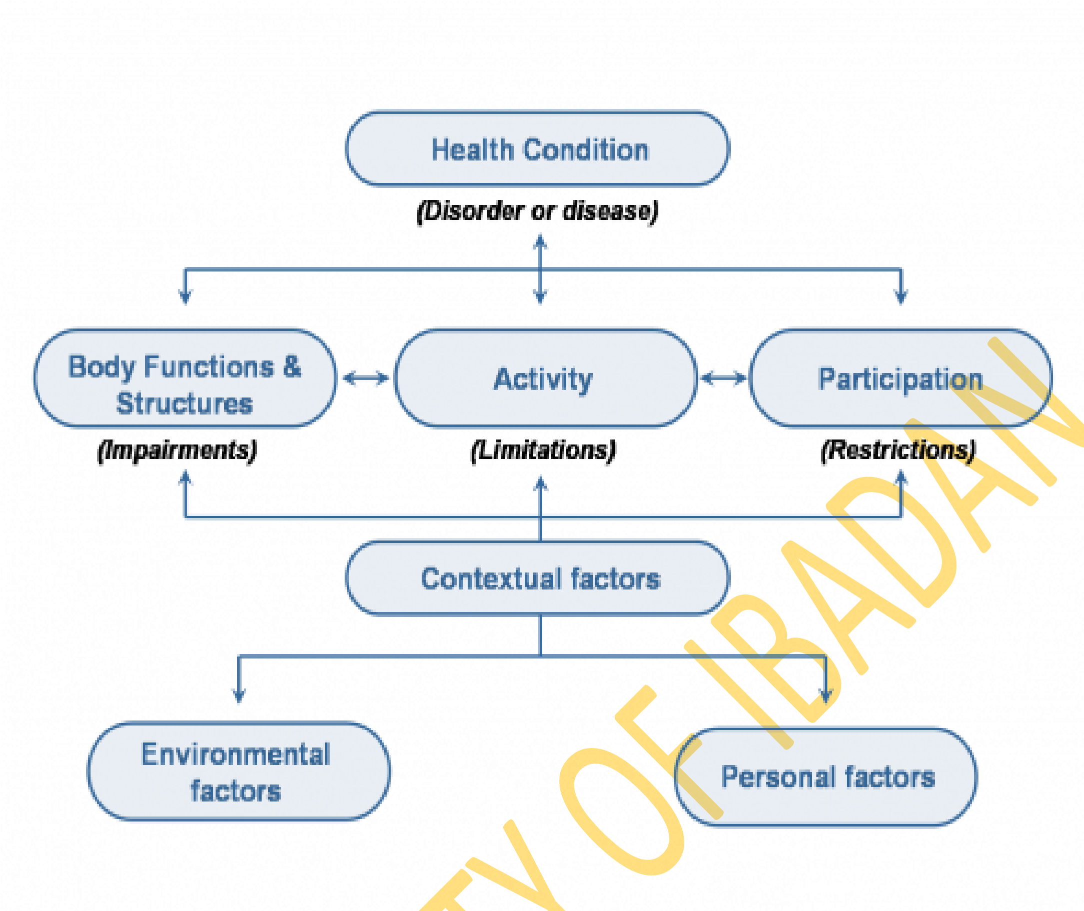

Figure 1: International Classification of Functioning, Disablity and Health (ICF) framework

Source: The ICF comprehensively covers the spectrum of health problems encountered by health professionals in patients with musculoskeletal conditions by Weigl et al., (2006)

2.2.0 MANAGEMENT OF LOW-BACK PAIN

Low-back pain (LBP) is a costly health problem in the western society (Andersson, 1999). LBP is an irksome syndrome which has challenged homosapiens for ages (May, 2001). Although the omnipresence of LBP is recognized but there are little empirical evidence about its causes and treatment (Waddell, 1987; Harding and Watson, 2000; El Zaher, 2001). Nwuga (1990) stated that BP has shown itself to be ubiquitous and disturbingly prevalent and has also maintained a defiant stance against various therapeutic strategies.

Extensive research efforts are replete in literature as regards the causes and treatments of LBP (Andersson, 1999). Recent decades have witnessed tremendous and praiseworthy advances in surgical, pharmacological and physical management for a limited number of patients with LBP, and most of these approaches are applicable only to clearly defined conditions (Troup et al., 1987; Troup and Videman, 1989). In spite of clinical and research efforts, LBP has remained elusive and treatment effects are unsatisfactory (Andersson, 1999). It is often suggested that the occurrence of LBP should be accepted as a fact of life and efforts of researchers and clinicians should be focus on preventing LBP from becoming chronic rather than at prevention of first-time occurrence (Andersson, 1999).

The Working Group (WG) on the European Guidelines for Prevention in LBP (2004) considered that, overall, non-specific LBP is important not so much for its existence as for its consequences. Therefore, the WG guideline considers the consequences of common LBP to be a primary concern for prevention. However, few preventive solutions are on offer, either for primary prevention or for preventing the recurrence of presenting symptoms (Troup and Videman, 1989). A panel on clinical practice guideline in a systematic review submitted that there are a wide variety of treatments for LBP that are currently in use. The clinical care methods reviewed by the panel were: patient education about symptoms, structured patient education ("back school"), medications to control symptoms, physical treatments to control symptoms, and activity modifications, bed rest, exercise, special diagnostic tests, and surgery (Bigos et al., 1994). Therefore, the management of LBP can require conservative approach or non-conservative (surgical) means or both (Jacqueline, 2002).

2.2.1 Non-conservative management in Low-back pain

Non-conservative management of LBP often refers to surgical management of LBP. It is reported that most cases of LBP do not require surgery (Weber, 1983; Alaranta et al., 1990; Wilson, 2008). Surgical management is necessitated only when all conservative treatment methods have failed. Surgical intervention is usually indicated in LBP where there are co-morbidity like, bowel- or bladder-sphincter dysfunction, particularly urinary retention or incontinence; diminished perineal sensation, sciatica, or sensory-motor deficits; and bilateral or unilateral motor deficits that are severe and progressive (Johnson, 2010). Johnson (2010) summarized that surgical management of LBP is usually necessary, though not urgent in cases of weakness of the ankle and great toe dorsiflexors, loss of ankle reflex, sensory loss in the feet as manifestations of disc herniations, neurogenic claudication or pseudoclaudication (Wilson, 2008). Furthermore, surgery may be necessary to relieve pressure on nerve roots (Bogduk and McGuirk, 2006; Guzman et al., 2008).

Laminectomy is one of the most common surgical approaches in cases of cauda equina syndrome or other symptoms of lumbar disc herniation. Decompressive laminectomy is usually indicated for spinal stenosis, suspected cord or cauda equina compression (Wilson, 2008) and patients with root entrapment of a nerve root or fusion (Haraldsson and Willner, 1983). Patients with instability in the spine as it is in spondylolisthesis will benefit from posterior or anterior fusion, while those with spinal stenosis are usually treated with lateral fusion (Porter, 1993). Neurolysis is employed in the treatment of adhesive radiculitis, a condition in which the nerve root is found to be extensively involved in fibrous tissue in proximity to disc space (Lipson, 1989). Spinal fusion is however indicated only when acute severe symptoms are unbearable and when absenteeism looms and individual's quality of life is adversely affected (Porter, 1993; Herkowitz and Sidhu, 1995). Immobilization in plaster jacket or spica cast and anterior surgery are used in managing infective spinal disorders (Lipson, 1989).

Other forms of surgery are foramenotomy, fenestration, discectomy (Nwuga and Egwu 1999). A recent and minimally invasive surgical management of LBP is called intradiscal electrothermal annuloplasty (IDET) (Saal, 2000; Heary, 2001). Intradiscal electrothermal annuloplasty is a minimally invasive treatment for chronic LBP that results from degenerative disease of the spine and disc herniation (Lester, 2004). It is considered for well selected patients with discogenic pain (Verrills and Vivian, 2004). Following such treatment, around 20% of patients will have complete relief despite many years of incapacitating pain, and 60% of such patients will have at least a 50% relief of their long term pain (Bogduk and Karasek, 2000; Bogduk and Karasek, 2002).

2.2.2 Conservative management for Low-Back Pain

Conservative approach to managing LBP can be pharmacological and non-pharmacological (Wooliscroft, 2001). Pharmacologic treatment involves the use of drugs (Lipson, 1989). The treatment approach employed is dependent on the primary physician and on the specific diagnosis (Lipson, 1989). Non-steroidal anti-inflammatory drugs are used in treating acute back pain to arrest the inflammatory processes that result from back pain but bed rest beyond two weeks could be deleterious (Jacqueline, 2002). Conservative therapy especially for lumbar disc herniation centres on bed rest, use of traction, analgesics, muscle relaxants and anti-inflammatory medications. Facet blocks, radio frequency facet denervation, intrathecal and epidural steroids, intradiscal steroids and nerve root sleeve infiltrations with steroids are used for patients with disc herniation (Lipson, 1989). Calcitonin injections are also given intramuscularly in patients with Paget's disease and spinal stenosis (Porter and Hibbert, 1984).

The non-pharmacologic conservative approach often involves the use of physical agents. The Philadelphia panel on evidence-based clinical practice guidelines on selected rehabilitation interventions for LBP in a systematic literature review submitted that a number of rehabilitation interventions are used in the management of people with LBP (Philadelphia panel, 2001). Among current musculoskeletal interventions specific for LBP available to rehabilitation specialists, there are body mechanics and ergonomics training, posture awareness training, strengthening exercises, stretching exercises, activities of daily living training, organized functional training programs, therapeutic massage, joint mobilizations and manipulations, mechanical traction, biofeedback, electrical muscle stimulation, transcutaneous electrical nerve stimulation, thermal modalities, cryotherapy, deep thermal modalities, superficial thermal modalities, and work hardening (Philadelphia panel, 2001).

Physical therapy has from inception played an active and pivotal role in the management of LBP and also in lessening its economic burden (Utti et al., 2006). Johnson (2010) submitted that physiotherapy is probably the treatment most widely used for back complaints. LBP is reported to constitute the highest percentage of referrals and workload for physical therapy utilization (Frymoyer and Cats-Baril, 1991; Battie et al., 1994; Margo, 1994). The cardinal aims of physical therapy in the management of patients with long-term LBP are to relieve pain, improve function; return to work; develop coping strategies for pain, with minimal adverse effects from treatment (Bigos et al., 1994; Evans and Richards, 1996). In armamentarium of physical therapy for the management of patients with long-term mechanical LBP are modalities and equipment (such as ultrasound, short-wave and micro-wave diathermy, electromyographic biofeedback, interferential current, electrical stimulators, transcutaneous electrical nerve stimulators, laser, corsets and collars); cold therapy; specific techniques and therapies (such as spinal manual therapies) and various types exercises (Low and Reed, 1994; Foster et al., 1999; Li and Bombardier, 2001; Gracey et al., 2002).

Physiotherapists usually give exercise therapy, alone or in combination with other treatments (for example, massage, heat, traction, ultrasound, or short wave diathermy), and back care education. It involves the use of physical agents and modalities to manage LBP. The agents include rest, heat therapy, cold therapy, spinal manipulation, electro-analgesia, and exercises (Low and Reed, 1994; Foster et al., 1999; Li and Bombardier, 2001; Gracey et al., 2002). Many of these treatment approaches requires intensive supervision and sophisticated equipment and their treatment effects remain elusive and unsatisfactory from most systematic reviews (Bigos et al., 1994; EC, 2004ab; Poitras and Brosseau, 2008). However, exercise therapy has been recommended from systematic reviews as effective in the management of long-term mechanical LBP and it appears to be the central element in the physical therapy management of patients with long-term mechanical LBP (Bigos et al., 1994; van Tulder et al., 2003; Hayden et al., 2005).

2.2.3 Exercise in long-term mechanical low-back pain

Systematic reviews of the evidence concerning the effectiveness of exercise concluded that exercise may be helpful for patients with long-term LBP in terms of decrease in pain and disability (Hayden et al., 2005a), decrease in fear of avoidance behaviour (van Tulder et al., 1997; Liddle et al., 2004) and return to normal activities of daily living and work (van Tulder et al., 2002). Exercise therapy encompasses a heterogeneous group of interventions ranging from general physical fitness or aerobic exercise to muscle strengthening and various types of flexibility and stretching exercises (Hayden et al., 2005). It is defined as "a series of specific movements with the aim of training or developing the body by a routine practice or as physical training to promote good physical health" (Abenhaim et al., 2000). It aims at abolishing pain, restoring and maintaining full range of motion and improving the strength of lumbar muscles, thus contributing to the early restoration of normal function (Nachemson, 1990; Brukner and Khan, 1993).

Exercise therapy is probably the cheapest physiotherapeutic intervention and one in which the patient has some measure of direct control (Brukner and Khan, 1993).

Exercises of various types have been used in managing LBP with varying reported successes (Shiple, 1997). Based on the foregoing, there is a proliferation of exercise programmes which varies from provider to provider depending on professional orientation (Keller, 2006). Nonetheless, it remains inconclusive which exercise regimen is better than the other and intensity that may offer the greatest value to patients (Shiple, 1997; Nordin and Campello, 1999; Samanta et al., 2003; Hayden et al., 2005). Hayden et al., (2005b) in a systematic review concluded that exercise therapy encompasses a heterogeneous group of interventions that vary in type, intensity, frequency, and duration of exercise and the setting in which it is provided. There continues to be uncertainty about the most effective approach; and the literature on the hypothesized mechanism of the effect of exercise interventions provides little guidance. Furthermore, there does not appear to be a consensus of opinion on the most effective programme designed to maintain exercise benefits (Bronfort et al., 1996; Carpenter and Nelson, 1999; Faas, 1996; Kenny, 2000; Lahad et al., 1996; Manniche et al., 1991; Taimela et al., 2000).

Many randomized clinical trials (RCT) have been carried out to find the effectiveness of different exercise programmes by comparing varying forms of generic back exercise with no exercise (Hayden et al., 2005; Slade and Keating, 2006; Ferreira et al., 2006) or other exercise programmes (Kofotolis and Kellis, 2006; Sherman et al., 2005). RCTs of either pragmatic or exploratory design are regarded as the most powerful method of determining cause-effect relationships between phenomena (Davidson and Hillier, 2002; Moher et al., 1999). Howbeit, the best way of selecting high-quality physical therapy trials for a systematic review has not yet been determined (Liddle et al., 2004). There is a need to develop and validate quality scales specific to physical treatments, as certain scales are more suited to a particular trial design (Colle et al., 2002). The van Tulder methodological quality criteria have been recommended by the Cochrane Collaboration Back Review Group for Spinal Disorders (van Tulder et al., 1997).

2.2.3.1 Types and characteristics of exercise

Based on systematic reviews, exercise therapy in LBP are generally characterized by the exercise programme design, delivery type, dose or intensity, inclusion of additional interventions and the types of exercises (Liddle et al., 2004). Exercise can be categorized based on programme design as individually designed, partially individually designed (exercise programme which include the same type of exercises but varies in intensity, duration, or both) and standard design (fixed exercise programme for all participants) (Liddle et al., 2004). Based on delivery type, exercise therapy can be classified as home exercises only (participants meet initially with therapist, then participate in the exercise programme with no supervision or follow-up), supervised home exercises (participants meet initially with therapist, participate in the exercise programme, and have follow-up with the therapist), group supervision (participants attends exercise therapy sessions with 2 or more participants) and individual supervision (participants receives one-on-one intervention or supervision). However, some exercise therapy programmes includes more than one type of delivery but are often classified according to their main delivery type (Bronfort et al., 1996; Bendix et al., 2000; Hildebrandt et al., 2000; Liddle et al., 2004).

Dose or intensity of the exercise in LBP is categorized by considering the duration and number of treatment sessions. Low dose are exercises with less than 20 hours of total intervention time. Mean dose are exercises within 20 hour of total intervention time while high dose exercise are exercise with more than 20 hours of intervention time (ACSM, 2000; Liddle et al., 2004). Adherence rate is often employed in prescribing exercise dosage if the exercise programme included a home exercise component. Adherence rate of 50% of the recommended time and number of sessions is for home exercise programmes without follow-up. 75% of the recommended time and number of sessions are often used for home exercise without follow-up. Adherence rate for home exercises are monitored using daily diary recordings and/or therapist and patient reporting of adherence to the prescribed programmes (ACSM, 2000; Liddle et al., 2004). When considering number of sessions**,** exercises with less than 18 numbers of sessions is considered low dose, those within 18 to 24 sessions is considered mean dose while those with more than 24 sessions as high dose (ACSM, 2000; Liddle et al., 2004) . In addition, exercise therapy in LBP is often categorized based on the inclusion of additional intervention. The practice of additional interventions to exercise in LBP abounds in literature. Examples of additional treatments to exercise in LBP include massage, thermotherapy such as hot packs and radiant heat bath, electro-stimulations such as the use of TENS, Interferential therapy etc. (Liddle et al., 2004).

2.2.4 McKenzie Protocol in the Treatment of Back Pain

The McKenzie protocol is a standardized approach to both the assessment and treatment of LBP. The McKenzie protocol or method is not simply a set of exercises but a defined algorithm that serves to classify the spinal problem so that it can be adequately treated. McKenzie protocol is a simple non-invasive mechanical approach of managing back pain that utilizes a disciplined system of clinical interviews and physical examinations (movement and positioning) that enables spinal mechanical pain to be classified into the three McKenzie syndromes (postural, dysfunction and derangement) for effective management (McKenzie, 1981; 1990). In 1981, McKenzie proposed a classification system and a classification-based treatment for LBP labelled Mechanical Diagnosis and Treatment (MDT), or simply McKenzie method (McKenzie and May, 2003). Of the large number of classification schemes developed by various authors in the last 20 years (Stiefel et al., 1999; van Dillen et al., 2003; BenDebba et al., 2000; Delitto et al., 1995; Klapow et al., 1993; Laslett and van Wijmen, 1999; Maluf et al., 2000; Petersen et al., 2003), the McKenzie method has the greatest empirical support (*e.g.* validity, reliability and generalisability) among the systems based on clinical features (McCarthy et al., 2004) and therefore seems to be the most promising classification system for implementation in clinical practice.

McKenzie protocol is a form of mechanical therapy, however, unlike the main stream manipulative therapy schools of thought, the McKenzie approach utilizes a system of patient self generated force to mobilize or manipulate the spine through a series of active repeated movements or static positioning. There is a gradual build-up of forces which are progressed from patient generated to therapist generated (McKenzie, 1981).

The McKenzie protocol is thought to promote rapid symptom improvement in patients with LBP thus making it a common treatment of choice among physical therapists (Delitto et al., 1993; Schenk et al., 2003). The McKenzie protocol also includes a set of back care education instruction. The McKenzie back care education comprise a nine item instructional guide on standing, sitting, lifting and other activities of daily living for home exercise for all the participants.

The McKenzie protocol is one of the most frequently used types of physical therapy for back pain (Battie et al., 1994; Foster et al., 1999; Gracey et al., 2002; Ayanniyi et al., 2007) and reportedly has the potential advantage of encouraging self-help (Moffett and McLean, 2006). The McKenzie protocol identifies with the school of thought that spinal joint dysfunction such as disc protrusion, loss of joint play; stress and strain among others are the major causes of back pain. The spinal discs have been implicated as pain generators (Harms-Righdahl, 1986; Schellhas et al., 1996). Similarly, the lumbar intervertebral discs are thought to be sources of intrinsic pain without nerve root involvement (Moneta et al., 1994; Schwarzer et al., 1995; Ohnmeiss et al., 1997). Some investigators corroborate that at least the outer third of the anulus fibrosus is innervated (Yoshizawa et al., 1980; Ashton et al., 1994) and that painful and degenerated discs are more extensively innervated (Coppes et al., 1997). The mechanical stimulation of the posterior anulus of the lumbar intervertebral discs in patient with chronic and severe LBP is believed to reproduce the symptoms (Kuslich et al., 1991; Schwarzer et al., 1995). Therefore, the McKenzie method school of thought in back pain management is targeted at addressing the disc pathology and its sequelae.

2.2.5 Back extensor muscles' endurance

Muscular endurance is the ability of an isolated muscle group to generate tension, sustain that tension and resist fatigue over a prolong period of time (static endurance) (Delateur, 1982; USDHHS, 1996) or the ability of an isolated muscle group to perform repeated contraction over a period of time (dynamic endurance) (Burnett and Glenn, 1996). The endurance of the back extensor muscles have been reported to be related to low-back health (Jorgensen et al., 1987; Latimer et al., 1999; Biering-sorensen, 1983). The assessment of the endurance capability of these muscles is seen to be important in the clinical setting as an outcome tool among healthy and patient populations (Alaranta, 2000; Moreau et al., Udermann et al., 2003). It has been reported that the evaluation of the endurance of back extensor muscles seems to have greater discriminative validity than evaluation of maximal voluntary contractile force (Biering-Sorensen, 1984; Holmstrom et al., 1992; Jorgensen, 1997; Luoto et al., 1995).

The back extensor muscles' endurance can be measured by both simple isometric and more sophisticated isokinetic dynamometers (Harkonen *et al.*, 1993; Hurri *et al.*, 1995). Back lifting and extension strength and endurance tests are commonly used methods for testing back function in epidemiological research into back performance in health and disease, as well as in assessment of work ability and rehabilitation (Biering-Sørensen, 1984; Mayer *et al.*, 1985; Kankaanpää *et al.*, 1999; Keller *et al.*, 1999; Käser et al., 2001; Ropponen, 2006).

A literature review by Moreau et al., (2001) and another study by Ebrahimi et al., (2005) revealed that a number of back endurance tests exist to diagnose, prevent and rehabilitate LBP. These tests include the repetitive squat test (Alaranta et al., 1994), the

Biering-Sorensen test of static muscular endurance (BSME) or Sørenson test (Biering-Sorensen, 1984), the repetitive sit-up test (Alaranta et al., 1994), the repetitive arch-up test (Alaranta et al., 1994), the prone double straight-leg raise test (McIntosh et al., 1998), supine isometric chest raise test (Ito et al., 1996), and supine double straight-leg raise (Kendal et al., 1983). However, the BSME either in its original version or as variants has been widely used in previous research among healthy and patient populations (Mbada et al., 2009). The BSME provides a global measure of static back extension endurance capacity (Moreau et al., 2001) and it has been reported to be valid, reliable, safe, practical, responsive, easily administered, inexpensive, and there is a substantial quantity of compiled data (Alaranta, 2000; Moreau *et al.*, 2001; Udermann *et al.*, 2003). On the other hand, the repetitive arch-up test (RAUT) (Alaranta et al., 1994) provides the dynamic evaluation of trunk extensor muscles endurance without requiring the use of a dynamometer (Alaranta et al., 1994; Grönblad et al., 1997; Kuukkanen and Malkia, 1996; Rissanen et al., 1994; Rissanen et al., 2002).

2.2.5.1 The Biering-Sorensen test of static muscular endurance

The Biering-Sorensen test of static muscular endurance (BSME) in its original form or variants assesses the static endurance of the back extensor muscles. During the test, the participant lies prone on a table/plinth with the inguinal region is brought to the edge of the table, the arms are bent, the elbows held out, and the hands on the ears (Mannion et al., 1998), forehead (Ng and Richardson, 1996), or nape of the neck (Gibbons et al., 1997; Suter and Lindsay, 2001), while in another variant, the arms are held along the sides (Luoto et al., 1995; Alaranta et al., 1994; Simmonds et al., 1998). In order to ensure stability in the testing position, the ankles are fixed by the examiner or with the use of straps. The upper trunk is freely suspended and horizontality is ensured by simply trusting a visual evaluation (Holmstrom et al., 1992; Gibbons et al., 1997; Alaranta et al., ,1994; Latikka et al., 1995; Keller et al., 2001), other studies used measurement devices (inclinometer) (Moffroid et al., 1993; Chok et al., 1999; Latimer et al., 1999), goniometer (Ng and Richardson, 1996), or photoelectric cell Holmstrom et al., 1992; Hultman et al., 1993) or asked the patient to maintain contact between the back and a stadiometer or weight hanging from the ceiling or Guthrie Smith frame or other devices (Ng and Richardson, 1996; Kankaanpää et al., 1998; Koumantakis et al., 2001).

During the test, the participant is requested to stay in the horizontal position as long as possible or until he/she can no longer control the posture or losses contact with device or object used to define the horizontal position for more than 10 seconds (Rashiq et al., 2003) or the use of other specific test-stopping criteria such as trunk downsloping by more than 5–10° (Latimer et al., 1999; Chok et al., 1999; Moffroid et al., 1994). The examiner records the time the participant is able to keep the unsupported trunk (from the upper border of the iliac crest) horizontal while prone on the table to a maximum of 240 seconds (Biering- Sørensen, 1984) or longer (Jörgensen and Nicolaisen, 1986).

2.2.5.2 The repetitive arch-up test

The Repetitive Arch-Up Test (RAUT) provides the dynamic evaluation of trunk extensor muscles endurance without requiring the use of a dynamometer (Alaranta et al., 1994; Grönblad et al., 1999; Kuukkanen and Malkia, 1996; Rissanen et al., 1994; Rissanen et al., 2002). The inguinal region is brought to the edge of the table with the ankles fixed by the examiner or the use of straps. The upper trunk is flexed downward to 45 degrees, and the patient is asked to move the trunk up to the horizontal position (avoiding the hyperextended position) and back down. One repetition every 2 to 3 seconds is required, with a maximum number of repetitions set at 50. The examiner records the maximum number of repetitions the participant is able to perform (Alaranta, 1994). Moreland et al., (1997) in the assessment of dynamic endurance of the back extensors, put the participants in prone lying over 30 degrees foam wedge with iliac crests at the edge of the wedge. The arms were positioned alongside the trunk with the hands at the hips. Two straps were used to fix the lower part of body which one strap at the hips and one at the mid-calf. Participants were instructed to hold the trunk to neutral position and then to lower the upper body back so the nose touched the table. Speeds of movement were 25 repetitions per minute and the number of repetitions accomplished by the participant was counted.

As with the BSME, variants exist in literature for the RAUT. Moreland et al., (1997) used a variant in which the lower limbs were fixed to a triangular pad and the patients were asked to flex the trunk so as to touch the table with the nose then to return to the horizontal position at a rate of 25 arch-ups per minute. In another study by Mayer et al., (2003), the test was done using a Roman chair and patients were asked to arc up repeatedly over a 90^0 angle. Whereas the static version of the back muscles endurance tests has been widely used in previous studies, the dynamic variant has received less attention (Demoulin et al., 2004). For the reliability of this test, an intra-class correlation coefficient of 0.78 was reported by Moreland et al., (1997).

2.3.0 ANATOMY OF THE BACK

The back is the posterior aspect of the trunk and is the main part of the body to which the head, neck, and limbs are attached (Moore, 1992). It consist of skin, superficial fascia, which contains fatty tissue, deep fascia, muscles, vertebrae, intervertebral discs, ribs (in the thoracic region), vessels and nerves (Moore, 1992).

2.3.1 The Spinal Column

The spinal column (or vertebral column) extends from the skull to the pelvis (Bridwell, 2005). The spinal column constitutes the core of the locomotor apparatus and it is the key to posture of the trunk. It is a structure as well as a mechanism (Olaogun and Edewor, 1994). As a structure, it can resist a compression load exceeding ten (10) times the weight of the body segments that it supports and with the support of the trunk muscle it can remain rigid in response to horizontal pull of fifty kilogram (50Kg); yet as a mechanism, with a little effort, it can be bent forward, backward and sideways or twisted (Olaogun, 1999). The spinal column consists of 33 vertebrae; 24 of these are joined to form a flexible column. 7 vertebrae are in the neck and are called cervical vertebrae; 12 are in the region of the chest and are called thoracic or dorsal vertebrae; 5 are in the lumbar region; 5 are fused together to form sacrum, the rear portion of the pelvis; the lower 4 are only partially developed and form the coccyx. The spinal column is flexible above the sacrum, upon which the flexible portion rests (Bridwell, 2005).

The vertebrae range in size with the cervical as the smallest and lumbar the largest, vertebral bodies are the weight bearing structures of the spinal column (Bridwell, 2005). Each vertebra bears the weight of all parts of the body above it, and since the lower one has to bear much more weight than the upper ones, the former are much the larger (Nwuga and Walmsley, 1990). The natural curves in the spine, kyphotic and lordotic, provide resistance and elasticity in distributing body weight and axial loads sustained during movement (Bridwell, 2005). Lying between the vertebrae are pads of fibrocartilage, the intervertebral disc. The fibrocartilagenous disc is composed of the inner nucleus pulposus and the outer annular fibrosus (Nwuga and Walmsley, 1990). The former conferring on the disc a water inhibitive capacity makes for flexibility and height difference at the extreme of the day (Nwuga, 1986). The annulus comprises successive concentric lamellae of the fibres of fibro-cartilage (Nwuga and Walmsley, 1990). The space which the discs occupy adds up to one-fourth to one-fifth of the total length of the spine (Nwuga and Walmsley, 1990).

The spinal cord passes through a vertebral canal, the vertebral foramen, formed by the vertebrae. This foramen is triangular and smaller and circular in shape in the thoracic region. The intervertebral foramina, which are openings between adjacent vertebrae, give passage to the paired spinal nerves which convey impulses to and from the spinal cord. These foramina are smallest in the cervical and become larger in size toward the lower lumbar vertebrae (Nwuga and Walmsley, 1990).

A typical vertebra consists essentially of two parts, the anteriorly placed body and the neural arch at the posterior. Together these make up the walls of the vertebral foramen wherein the spinal cord lies (Nwuga, 1986; Nwuga and Walmsley, 1990). The body of the vertebra which is thickest part give attachment to the intervertebral discs on its flats superior and inferior surfaces. Piercing the body are a few small foramina which provide passage for nutrient vessels (Nwuga and Walmsley, 1990). The neural arch is made up of two pedicles originating from the postero lateral aspect of the body and two laminae which give rise to spinous process. The pedicles are short and thick and originate from the meeting point of pedicles and the laminae, the transverse process project laterally, bearing on its surface two superior and two inferior articular processes. A layer of hyaline cartilage covers the surfaces of the articular processes (Nwuga, 1986; Nwuga and Walmsley, 1990).

The structure and plasticity of the spinal column are maintained by the interplay of vertebrae, its transverse processes, shape and orientation of the interlocking facets as well as ligaments and tightening effect of paraspinal muscles (Olaogun, 1999). Running the length of the spinal column are anterior and posterior longitudinal ligaments which are distributed in front and back respectively. The ligamentum flavum lies between adjacent laminae, its elastic nature, helps to bring the spine back into the position of extension from flexion (Nwuga and Walmsley, 1990). The ligamentum flavum also acts in a protective capacity for the spinal cord by the completion of the spinal canal posteriorly. The interspinous ligaments connect adjacent spinous processes, connecting them this way. The supraspinous ligament enlarges in the cervical region to become the thick ligamentum nuchae. It is commonly described as extending from the cervical to the sacral regions (Nwuga and Walmsley, 1990). The mechanism and flexibility of the spine are afforded by the resiliences of the intervertebral discs aided by the water inhibitory property of the gelatinous nucleus pulposus and generally fusiform structure of the spinal muscles (Olaogun, 1999; Rasch and Burke, 1978).

Movement of the spinal column takes place by compression and deformation of the elastic intervertebral discs, and by the gliding of the articular processes upon one another. Except in the atlanto occipital joints and the joint between the first two cervical vertebrae, the range of movement in each individual is small, although the total movement in all the joints may appear large. In general, interspinal movements are limited by tautness of ligaments, the shape and orientation of the interlocking facets of the articular process, apposition of the spinous process (in the case of extension), and presence of the ribs in the thoracic region (Olaogun, 1999; Rasch and Burke, 1978).

The functions of the spinal column include: (1) Protection: of the Spinal Cord and Nerve Roots and Many internal organs. (2) Base for Attachment: for Ligaments, Tendons, and Muscles. (3) Structural Support for Head, shoulders and chest: Connects upper and lower body, and also balance and weight distribution. (4) Flexibility and mobility which include: flexion (forward bending), extension (backward bending), side bending (left and right), rotation (left and right), and combination of above. (5) Other functions include production of red blood cells in the bones and Mineral storage (Bridwell, 2005).

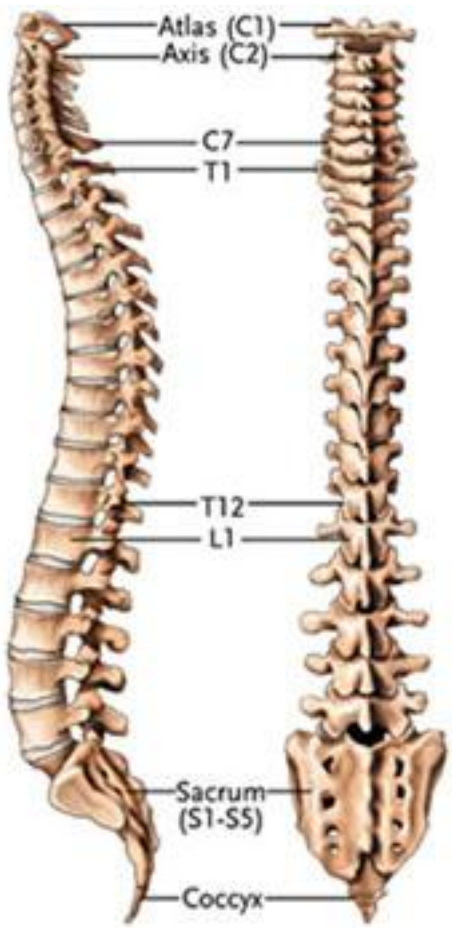

Figure 2: Diagram of the Spinal Column

(Reproduced from Back.com, 2003)

2.3.2 Muscles of the back

There are three groups of muscles in the back - viz are the superficial, intermediate, and deep groups. The superficial and intermediate groups are extrinsic back muscles that are concerned with limb movements and respiration respectively. The deep group constitutes the intrinsic back muscles that are concerned with movements of the vertebral column. The extrinsic muscles are superficial to the intrinsic muscles (Moore, 1992).

The intrinsic or deep muscles of the back (e.g. the erector spinae) are concerned with the maintenance of posture and movement of the vertebral column and head. The muscles are named according to their relationship to the surface: (1) Superficial layer e.g. splenius muscles, (2) an intermediate layer e.g. erector spinae muscles, and (3) a deep layer e.g. semispinalis, multifidus and rotatores. Rasch and Burke (1978) explained that the muscles producing spinal movement exist in bilateral pairs, the members of which can and often do contract independently. Anterior spinal muscles frequently do not attach directly to the vertebrae. For example, the rectus abdominis muscle connects the lower ribs and the pubes of the pelvis. When the rectus abdominis shortens, the spine is pulled into flexion by the displacement of the rib cage and/or the pelvis. Except for the quadratus lumborum, all spinal muscles are movers for either flexion or extension. The flexors comprise the abdominal group, the prevertebral group and the psoas. The extensors comprise the deep posterior spinal group, the semispinalis group, the erector spinae group and the suboccipital group.

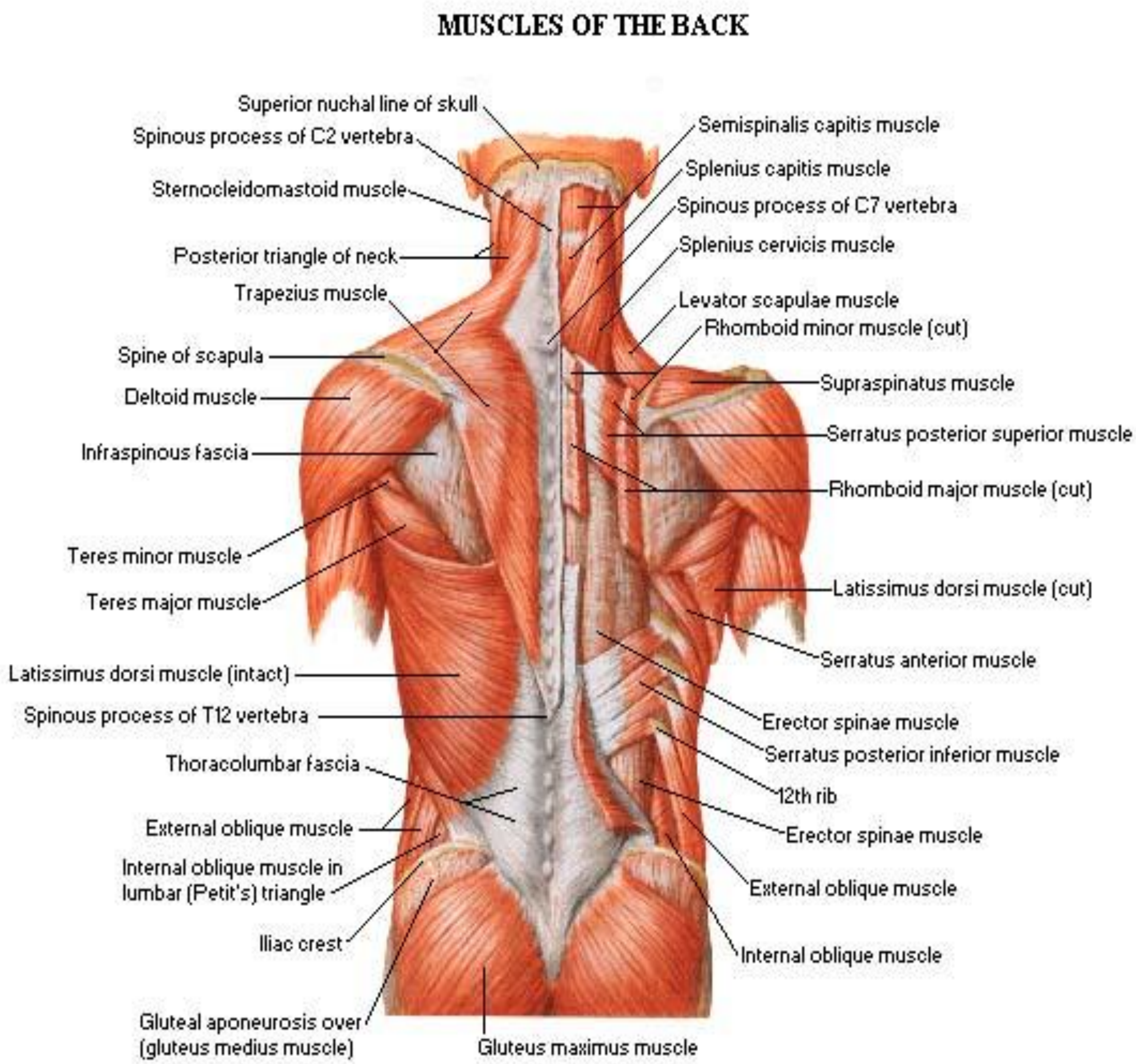

Figure 3: Muscles of the back
(Reproduced from Atlas of Interactive Anatomy Netter, F.H and Dalley A.F. 1998)

2.4.0 OUTCOME MEASURES IN LONG-TERM LOW-BACK PAIN

The restoration of normal function is considered a key outcome of physiotherapy treatment for low-back problems (Delitto, 1994; Beattie and Maher, 1997). Physiotherapists have traditionally tended to focus on the assessment and treatment of impairments. Physiotherapists therefore need measurement tools that can accurately assess function and monitor change in function over time. Impairments of body function, such as spinal range of movement and straight leg-raise, can be observed directly by the therapist in the clinical setting. In contrast, the performance of many daily activities cannot be directly observed in the clinical setting and clinicians typically collect this information by direct questioning during the assessment process (Davidson, 2003). It is now widely acknowledged that activity limitations need to be evaluated in addition to impairments, and that treatment goals should focus on restoring normal function because these are the outcomes of greatest interest to patients (Delitto, 1994; Fitzgerald et al., 1994; Fitzgerald, McClure, Jette and Jette, 1996; Beattie and Maher, 1997; Deyo et al., 1998). The use of standardised self-report questionnaires could provide a more convenient and reliable method of measuring activity limitations associated with low-back problems, and of monitoring response to treatment (Davidson, 2003).

The number of competing questionnaires has been identified as one of the barriers to the widespread clinical use of such questionnaires (Deyo and Patrick, 1989; Beattie and Maher, 1997). It is not clear which tool or tools (if any) are best suited for use in a general, ambulatory clinical population. Following a proliferation of new questionnaires, few of which have been fully evaluated, there has been a call for better development and use of existing instruments (Bombardier, 2000).

Current recommendations suggest that a low-back specific and a general health status questionnaire are required for comprehensive assessment of the impact of LBP (Davidson, 2003). There are many standardized self-reported questionnaires for measuring activity limitation and participation restriction in long-term LBP (Davidson, 2003). These include- the Oswestry Disability Questionnaire, the Quebec Back Pain Disability Scale, the Roland - Morris Low-Back Pain and Disability Questionnaire (RMLDQ) and the Waddell Index among several others. The Oswestry and Roland-Morris were the most widely used low-back questionnaires with many studies reporting on their clinimetric properties (Davidson, 2003) and have been increasingly recommended for use in the assessment of activity limitation and participation restriction respectively following low-back problems (Deyo et al., 1998; Bombardier, 2000). The RMLDQ and the Oswestry Low-Back Pain Disability Questionnaire (OLBPDQ) are the most commonly used disability scales for people with LBP (Beurskens et al., 1995). The measurement properties of both of these scales have been studied extensively, and a report of the International Forum for Primary Care Research in LBP contended that both scales are acceptable for measuring disability related to LBP (Deyo et al., 1998).

Roland and Morris (1983a) developed their 24-item questionnaire in the early 1980s to measure self-rated disability due to back pain in clinical trials. The RMLDQ is derived from the Sickness Impact Profile (SIP), a general health questionnaire (Bergner et al., 1981). Some authors have concluded that the psychometric properties of the Roland are similar to those of the entire SIP (Deyo and Centor, 1986; Jensen et al., 1992). The 18 – item RMLDQ was found to meet the reliability and validity criteria as the 24 – Item RMLDQ in an experimental design, and has 62% sensitivity and 87% specificity

(Stratford and Binkley, 1997). It allows for easy scoring as one simply totals the sum of the circled items and this represents the final score (Von and Saunders, 1996). The RMLDQ takes five minutes to complete and less than a minute to score. Davidson (2003) summarized that the reported floor and ceiling effects are within the 15% criterion limit. Evidence for internal consistency is somewhat conflicting; although Cronbach's alpha values in the recommended range suggest the items overall form an internally consistent scale. Test-retest reliability coefficients are generally high, and the MDC is estimated to be between 4 and 5 points. There is considerable evidence for the convergent validity of the scale and it appears to be responsive to change over time despite the dichotomous scaling method. The RMLDQ appears to be suitable for use in clinical settings to evaluate change in physical functioning in subjects with LBP (Davidson, 2003). Von and Saunders (1996) submitted that a cut-point of 14 or greater on the RMLDQ represents a significant disability associated with unfavourable outcomes which they felt was too high to identify all patients functioning poorly.

The Oswestry Low-Back Pain Disability Questionnaire was developed in the late 1970s at the Robert Jones and Agnes Hunt Orthopaedic Hospital in Oswestry, Shropshire (U.K.) as a clinical assessment tool that would provide an estimate of disability expressed as a percentage score (Fairbank et al., 1980). OLBPDQ was originally described in 1980 (Fairbank et al., 1980). Individual items included in the OLBPDQ were selected based on the experience of the scale's developers and were pilot tested in a sample of 25 patients. Disability was defined by the authors as "the limitations of a patient's performance compared with that of a fit person" (Fairbank et al., 1980). The questionnaire covers 10 domains including pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life and traveling, for the situation 'today' (Fairbank et al., 1980). For each domain there is a scale of six statements, where zero is the ability to perform the activity without pain and five is inability to perform the activity because of pain. Higher score means high degree of activity limitation (score 0-5). A sum score can be calculated: total score/total possible score*100 (Fairbank et al., 1980). Its internal consistency, structure, reliability and validity have been reported in previous studies (Kopec et al., 1995; Fischer and Johnston, 1997; Tibbles et al., 1998). Davidson (2003) summarized that the OLBPDQ fulfils the criteria of being a brief self-administered tool that is easy to complete and score. Data quality appears acceptable with minimal floor and no ceiling effects. There is a body of evidence that the OLBPDQ is a valid measurement tool for detecting activity limitation in people with LBP and that the Oswestry is responsive to change (Davidson, 2003).

Assessment of general health status has been recommended in low-back pain management (Davidson, 2003). Several different instruments are readily available to choose from within the general health status category. Some of these instruments include the Health Status Questionnaire Short Form (SF-36), the Sickness Index Profile and the Quality of Well-being Scale among others. The Health Status Questionnaire has been recommended in the assessment of patients with long-term LBP (Bombardier, 2000; Davidson, 2003; Kuijer, 2006). The Short Form *-36* (SF-36) Health Status Questionnaire is a generic health survey assessment tool developed by Ware et al., in the USA (Ware et al., 2000). The SF-36 is a generic questionnaire, not designed for any special patient category, but it is recommended in the studies of back pain (Bombardier, 2000). It consists of 36 items grouped under 8 questions. The domains include physical functioning, role limitations due to physical problems, bodily pain, general health perceptions, vitality, social functioning, role limitation due to emotional problems and general mental health. The raw scores for each domain are transformed to a 0–100-point scale such that 0 represents the poorest health and 100 the best health.

Many instruments abound in literature for the measurement of pain severity in patients with long-term LBP. The Visual Analogue Scales (VASs) have become very popular in pain research and in the clinical assessment of pain. Reliability and validity have been reported (Jensen and Karoly, 1993) and several distinct advantages over other measurement methods have been published (Scott and Huskisson, 1976; Price et al., 1994). Another specific application of the VAS is called the Quadruple visual analog scale (Von Korff et al., 1993). The scale assesses pain intensity under four categories, as pain right now, typical or average pain, pain level at its best and pain level at its worst respectively. For patients with long-term LBP, the average pain grade is often used. The patient will be asked to circle his /her level of pain on the scale line marked 0 – 10. Mark 10 stands for most severe pain while mark 0 stands for no pain. The ability of this scale to assess pain under the four different factors gives it an advantage over the other pain tools.

Actual performance of patients with long-term mechanical LBP during a physical performance tests may depend on several factors. Seen from the bio-psychosocial model, a patient's performance during a physical performance test may depend on biological, psychological and social factors (Reneman et al., 2008). These psychological factors are numerous and include self-efficacy expectations, self-esteem, fear-avoidance behaviour etc. Self-efficacy expectations refer to an individual's beliefs in one's competence or ability (Lackner and Carosella, 1999). Geffen (2003) opined that patients with long-term

LBP respond to their situation with lowered self-esteem. The pain self Efficacy Questionnaire (PSEQ) is often used to assess self-efficacy in the patients with long-term LBP. The 10 items scale was developed by Nicholas (1989). It covers a range of functions, including household chores, socializing, work as well as coping with pain without medications. It takes two minutes to complete, has a high completion rate, is available at no charge, and can be used in assessment, treatment planning, and outcome evaluation (Nicholas 2007). Clients are asked to rate how confidently they can perform the activities described, at present, despite their pain. They answer by circling a number on a 7-point Likert scale under each item, where 0 = not at all confident and 6= completely confident. A total score, ranging from 0 to 60, is calculated by adding the scores for each item. Higher score on the scale reflects a stronger self-efficacy belief (Nicholas, 1989). Low scores (< 20) indicate the client is more focused on the pain. Unless this belief is addressed it is likely to limit willingness to exercise independently. High scores (> 40) indicate the client is likely to respond well to an exercise program (Frost et al., 1995). Tonkin (2008) summarized that the PSEQ internal consistency is excellent (0.92 Cronbach's a) and test-retest reliability is high over a 3-month period (Asghari and Nicholas 2001). Validity is reflected in high correlations with measures of pain- related disability, different coping strategies, and another more activity-specific measure of self-efficacy beliefs, the Self-Efficacy Scale (Kaivanto et al., 1995). The evidence from studies with the PSEQ is that once clients with persisting pain reach scores over 40 they are likely to sustain, or build on, their functional gains (Nicholas, 2007).

Beliefs and attitude about the nature of pain, and its treatment influence patients' compliance with long-term pain management (William and Keefe, 1991; William et al., 1994). With recent research, long-term LBP is considered to be a patho-anatomical disorder (Bernard and Kirkaldy-Willis, 1987), in addition to a multifactorial biopsychosocial problem such as fear of movement, anxiety, a faulty coping strategy which has an impact on social life and thus require a multi-dimensional approach based on biopsychosocial model in its assessment and treatment (Haggman et al., 2004; Woby et al., 2004; Weiner, 2008). Fear and avoidance belief are often assessed in patients with long-term LBP. Fear-Avoidance Beliefs Questionnaire measures pain-related fear of physical activity that causes avoidance of activity and increased disability. This instrument was developed by Waddell et al., (1993) can help measure how much fear and avoidance are affecting a patient with LBP. It has an internal consistency of 0.88. It has a minimum score of 0 and a maximum score of 42 fro the 7-items scale. The higher the scale scores the greater the degree of fear and avoidance beliefs shown by the patient. Similarly, Back Belief Questionnaire is used to assess people's belief about low-back trouble (Symonds et al., 1995). This tool assesses belief about pain and its consequences regardless of whether back pain had been previously experienced. The questionnaire has been reported to have good internal consistency (Cronbach: 0.7) and test-retest reliability (ICC: 0.87) (Symonds et al., 1995). The questionnaire consists of 14 statements to which the respondent indicates their level of agreement on a 5 point scale. A score of 1 indicates complete disagreement and a score of 5 complete agreement. As 5 of the 14 statements are distractors, the scores of the 9 remaining statements are reversed and then summed to provide a total score ranging from 9 to 45. A lower score indicates the respondent has more negative beliefs about back pain.

The Borg scale was used for grading perceived rate of exertion (Borg, 2004). The scale is a popular method of assessing exertion in exercise prescription and rehabilitation. According to the 6-20 Borg scale, levels of exertion were rated as follows: No exertion at all (6-7), extremely light (8), very light (9-10), light (11-12), somewhat hard (13-14), hard (15-16), very hard (17-18), extremely hard (19) and maximum exertion (20).

2.5 JUSTIFICATION FOR THE STUDY

Long-term mechanical LBP results in both physical and psychological deconditioning that traps the patient in a vicious circle characterized by exacerbated nociceptive sensations, decreased physical performance, depression, impaired social functioning and work disability (Demoulin et al., 2006). The McKenzie protocol is a popular treatment for mechanical LBP among physical therapists (Battie et al., 1994; Foster et al., 1999). Nonetheless, there is limited evidence for the use of McKenzie method in long-term LBP (Machado et al., 2006). On the other hand, back endurance exercise is believed to enhance muscle reactivation and reconditioning (Biering-Sorensen, 1984; Risch et al., 1993; Luoto et al., 1996; Mayer et al., 2008; Liddle et al., 2010). However, clinical trials on the effect of endurance exercise training of the back extensor muscles in well defined populations of patients with LBP are scarce. Furthermore, there appears to be a paucity of studies that have investigated the effects of addition of endurance exercise of the back extensor muscles to the McKenzie protocol in patients with LBP. The motivation for this study was based on the afore-mentioned gaps identified in literature on the physical therapy management of patients with long-term mechanical LBP.

In designing exercise programme, a group of back pain researchers recommended standardized use of outcome measures in back pain research, suggesting a minimum of pain, functional status, and general health measures (Deyo et al., 1998). In addition, the Paris task force on back pain provided a framework linking International Classification for Functioning, Health and Disability (ICF) and back pain for clinical and research purposes (Abenhaim et al., 2000). The ICF uses the bio-psychosocial model which currently is the state of the art in rehabilitation and disability perspectives (WHO-ICF, 2001) with the overall aim to provide a unified and standard language and framework for the description and classification of health and health related states (WHO-ICF, 2001; Elfving, 2002). However, there appears to be a dearth of studies in this environment that have adopted the ICF framework (bio-psychosocial model) in conducting LBP research. This study aimed to evaluate whether the addition of static or dynamic back extensor endurance exercise as adjunct treatment to the McKenzie protocol will be efficacious in the management of patients with long-term LBP in terms of pain, muscle endurance, activity limitation, disability, fear of movement, self-efficacy belief, belief of consequence of back pain and general health status using this ICF frame work. Table 1 shows the ICF classification considered in the choice of the parameters investigated and the assessment methods in this study.

Table 1: ICF classification used for the study

ICF domains	Assessment method
Impairments	
Static muscle endurance	BSME (secs)
Dynamic muscle endurance	RAUT (reps)
Muscle fatigue (RPE)	Borg scale (6-20)
Pain	QVAS
Activity limitation	
Physical activities	RMLDQ
Activity limitation and participation restriction	
Disability	OLBPDQ
Physical activities and health	SF - 36
Psychosocial factors	
Self-efficacy belief	Pain self efficacy questionnaire
Fear-avoidance behaviour	FABQ
Belief of consequence of back pain	Back belief questionnaire
General health status	SF - 36

Key:
BSME - Biering-Sørensen test of Static Muscular Endurance
RAUT - Repetitive Arch-Up Test (RAUT) OLBPDQ
OLBPDQ - Oswestry Low-Back Pain Disability Questionnaire
QVAS – Quadruple Visual Analogue Scale
RMLDQ - Low-Back Pain and Disability Questionnaire
FABQ-W = Fear-Avoidance Beliefs Questionnaire
SF-36 – Short-Form 36

Table 2: Summary table for previous studies that employed some form of back extensors exercise in patients with low-back pain

No.	Author and Year	Sample size and Sample characteristics	Outcome measures	Physiological measures	Methods	Purpose of study	Conclusion
1	Kopp et al., 1986	67 patients with herniated nucleus pulposus.		-Lumbar extension ROM	35 of the 67patients were treated with lumbar extension only. 32 of the patients underwent laminotomy and discectomy because they failed to improve with conservative measures.	The study examined the response of patients with acute herniated nucleus pulposus to lumbar extension.	Some of the patients responded so dramatically to extension therapy that the use of extension exercises as a therapeutic modality is recommended.
2	Manniche et al., 1988	105 patients with chronic LBP.		-Pain	Group A: - 30 sessions of intensive dynamic back extensor exercises over 3 months. Group B - one-fifth the exercise intensity of group A. Group C - one month of thermo-therapy, massage and mild exercises.	Clinical trial of an intensive muscle training for chronic LBP.	The results consistently favoured intensive exercise, which had no adverse effects.

No.	Author and Year	Sample size and Sample characteristics	Outcome measures	Physiological measures	Methods	Purpose of study	Conclusion
3	Risch et al., 1993	54 patients with chronic LBP	- Psycho-social dysfunction scale - Mental health inventory.	- Pain -Isometric strength	Group A (n=31) 10 weeks isolated lumbar extensors strengthening exercise. Group B (n=23) Waiting list control group	To determine the effects of exercise for isolated lumbar extensor muscles.	Lumbar extension exercise is beneficial for strengthening the lumbar extensors and results in decreased pain and improved perception of physical and psychological functioning in chronic LBP patients.
4	Spratt et al., 1993	56 LBP patients with radiographic evidence of retrodisplacement, spondylolisthesis, or normal sagittal translation.	-15-item pain inferential VAS	-Pain - Trunk strength - ROM	Group A: Bracing, education and flexion exercise. Group B: Bracing, education and McKenzie-type extension exercise. Group C: Placebo (Walking only). Duration: 1 month follow-up.	The study determined the efficacy of treatment involving bracing, exercise, and education controlling either flexion or extension postures in LBP patients with retrodisplacement, spondylolisthesis, or normal sagittal translation.	Improvement in extension treatment, regardless of the type of radiographic abnormality, suggests that the treating clinician might consider extension treatment for chronic low-back pain patients.

No.	Author and Year	Sample size and Sample characteristics	Outcome measures	Physiological measures	Methods	Purpose of study	Conclusion
5	Erhard et al., 1994	27 patients with sub-acute LBP. 3 patients dropped out of the study.	-OLBPDQ		Group A (n=12): Extension programme Group B (n=12): Program of manipulation followed by hand-heel rocks (flexion and extension). Duration: 1-week period.	The study examined the relative effectiveness of an extension program and a manipulation program with flexion and extension exercises in patients with low back syndrome.	The use of manipulation as an adjunct to an ongoing exercise program appears to be warranted in the category of patients with sub-acute LBP.
6	Nelson et al., 1995	895 patients with chronic LBP		- Isometric and dynamic strength - ROM	627 patients completed an intensive, specific exercise using firm pelvic stabilization to isolate and rehabilitate the lumbar spine musculature	The study aimed to test the hypothesis that chronic LBP could be treated effectively using intensive specific exercise.	76% of patients completing the program had excellent or good results. 94% of patients with good or excellent results maintained their improvement at 1-year follow-up.

No.	Author and Year	Sample size and Sample characteristics	Outcome measures	Physiological measures	Methods	Purpose of study	Conclusion
7	Holmes et al., 1996	38 subjects for fitness rehabilitation.	- VAS	- Pain - Strength - ROM	Group A - 20 healthy adults for community fitness programmes for 6 month. Group B 18 patients for active rehabilitation programme for 97 days and 20 visits.	Comparison of lumbar-extension strength between healthy asymptomatic and symptomatic geriatric females seeking medical attention for chronic LBP.	The study confirms the notion that many back pain sufferers have weaker lumbar-extension strength and some geriatric women can increase strength with progressive resistance exercise, which leads to a decrease in LBP.
8	Bentsen et al., 1997	74 women who were 57-year-old women with chronic LBP.			Group A - Dynamic strength back exercises. Group B - Home training program. Duration - First 3 months. Groups A & B continued home training program for 3 to 12 months.	To compare the effect of dynamic strength back muscle training with that of a home training program in patients with chronic LBP.	The home training program was as effective as the supervised dynamic strength muscle training programme.

No.	Author and Year	Sample size and Sample characteristics	Outcome measures	Physiological measures	Methods	Purpose of study	Conclusion
9	Nelson et al., 1998	46 Patient recommended for spinal surgery.		- Static strength - Dynamic endurance - ROM	Progressive resistance dynamic exercise of 21 visits for 10 weeks.	The study determined if patients recommended for spinal surgery can avoid surgery through an aggressive strengthening programme.	A large number of the patients were able to avoid surgery in the short-term by aggressive exercise.
10	Chok et al., 1999	54 subjects with sub-acute LBP.	- VAS - PRI - MPQ - RMLDQ	- Static endurance (BSME).	Control group - Back care advice - Hot packs Experimental group - Back care advice - Hot packs - Trunk extensors endurance exercise Duration 3 times weekly for 6 weeks.	To evaluate the effectiveness of trunk extensor endurance training in reducing pain and decreasing disability in subjects with sub-acute LBP.	Trunk extensor endurance training reduced pain and improved function at 3 weeks but resulted in no improvement at 6 weeks when compared with the control group.

No.	Author and Year	Sample size and Sample characteristics	Outcome measures	Physiological measures	Methods	Purpose of study	Conclusion
11	Mannion et al., 2001	148 patientswith chronic LBP.		- Strength - ROM - Fatigue (EMG) -endurance (BSME) - Dynamic tests	Group A - Active physiotherapy Group B - Muscle reconditioning on devices Group C - Low-impact aerobics Duration: 3 months	The study quantified the effects of 3 months active therapy on strength, endurance, activation, and fatigability of the back extensor muscles.	Significant changes in muscle performance were observed in all three active therapy groups post-therapy, which appeared to be mainly due to changes in neural activation of the lumbar muscles and psychological changes.
12	Petersen et al., 2002	260 consecutive patients with sub-acute or chronic LBP	-MLBPRS		Group A (n=132) - McKenzie therapy only Group B (n=128) Intensive dynamic strengthening training Duration 15 treatments for 8weeks	To compare the effect of McKenzie treatment method with that of intensive dynamic strengthening training in patients with sub-acute or chronic LBP.	McKenzie method and intensive dynamic strengthening training seem to be equally effective in patients with sub-acute or chronic LBP.
13	Sinaki et al., 2002	50 healthy white postmenopausal women, aged 58-75 years			Group A (n=27) - Progressive, resistive back-strengthening exercises for 2 years Group B (n=23) Controls.	The study determined the long-term protective effect of stronger back muscles on the spine.	The relative risk for compression fracture was 2.7 times greater in the control group than in the back exercise group.

No.	Author and Year	Sample size and Sample characteristics	Outcome measures	Physiological measures	Methods	Purpose of study	Conclusion
14	Udermann et al., 2004	I8 subjects with Chronic LBP	- SF-36	- Strength - endurance - ROM (Dynamo-metry)	Group A (n=9) - McKenzie therapy only Group B (n=9) - McKenzie therapy - Resistance training Duration 2 times weekly for 4 weeks	The purpose of the study was to evaluate the effect of the McKenzie therapy combined with the resistance training for the lumbar extensors on pain, disability and psychosocial functioning in patients with chronic LBP	McKenzie therapy is effective at improving physiological as well as psychosocial variables in Chronic LBP patients, and the addition of resistance training for the lumbar extensors, at the level prescribed for this investigation, provided no added benefit.
15	Browder et al., 2007	48 patients with LBP	- OLBPDQ -NPRS	- Pain -Strength	Group A (n=26): - An extension-oriented treatment approach Group B (n=22) strengthening exercise program Duration: 8 clinic sessions plus a home exercise program with follow-up up to 6 weeks.	The clinical trial examined the effectiveness of an extension-oriented treatment approach compared with a lumbar spine strengthening exercise program in a subgroup of subjects with (LBP).	An extension-oriented treatment approach was more effective than trunk strengthening exercise in a subgroup of subjects hypothesized to benefit from this treatment approach.

Key: MPQ - McGill Pain Questionnaire; PRI – Pain Rating Index; VAS – Visual Analogue Scale; RMLBPQ; Roland-Morris Low Back Pain Questionnaire; MLBPRS: Manniche Low-Back Pain Rating Scale; OLBPDQ – Oswestry Low-Back Pain Disability Questionnaire.

CHAPTER THREE

MATERIALS AND METHODS

3.0 MATERIALS

3.1.1 Participants

Ninety one (49 male and 42 female) consecutive patients attending the Out-patient Physiotherapy Department of the of the Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC); and the Department of Medical Rehabilitation, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Osun state, Nigeria were invited into the study. However, two of these patients declined participation while five were excluded for not satisfying inclusion criteria. Eighty four participants met the inclusion criteria and were randomly assigned to one of three treatment groups; the McKenzie Protocol (MP) Group (MPG) (n=29), MP plus Static Back Endurance Exercise Group (MPSBEEG) (n=27) and MP plus Dynamic Back Endurance Exercise Group (MPDBEEG) (n=28).

Sixty seven participants comprising 32 males (47.8%) and 35 females (52.2%) completed the 8 week study. Twenty five participants completed the study in McKenzie Protocol Group (MPG), 22 in McKenzie Protocol plus Static Back Endurance Exercise Group (MPSBEEG) and 20 in McKenzie Protocol plus Dynamic Back Endurance Exercise Group (MPDBEEG). A total drop-out rate of 20.2% was observed in the study. 13.8% of participants in MPG were lost to follow-up. 18.5% of the participants in MPSBEEG dropped-out (40% were lost to follow-up while 60% absconded due to improvement in their health condition) even as 28.6% of the participants in MPDBEEG dropped-out (37.5% were lost to follow-up while 62.5% absconded due to improvement in their health condition). The flow diagram showing the progression of patients through the study is presented in Appendix A.

3.1.1.1 Inclusion Criteria

The following categories of patients were recruited into the study:

1. Individuals diagnosed with mechanical LBP of not less than 3 months and referred for physiotherapy by a general practitioner or an orthopaedist.

2. Self-referred individuals assessed as having long-term mechanical LBP by the researcher.

3. Individuals without any obvious deformities affecting the trunk or upper and lower extremities.

3.1.1.2 Exclusion Criteria

Exclusion criteria for this study were:

1. Red flags indicative of serious spinal pathology with signs and symptoms of nerve root compromise (with at least two of these signs: dermatomal sensory loss, myotomal muscle weakness, reduced lower limb reflexes) (Waddell 2004).
2. Any obvious spinal deformity or neurological disease.
3. A reported history of cardiovascular diseases contraindicated to exercise; or individuals who were with elevated blood pressure (>140/90mmHg),
4. Pregnancy or previous spinal surgery.
5. Previous experience of McKenzie method.
6. Having directional preference for flexion, lateral or no directional preference based on the McKenzie assessment.

7. Previous experience of static and dynamic endurance assessments and training.
8. Roland -Morris disability score less than four or greater than twenty.

3.1.2 Instruments

The following instruments were used in this study:

1). *Height meter*- A height meter (Seca 240 – made in the UK) calibrated from 60 – 210 cm was used to measure the height of each participant to the nearest 0.1cm.

2). *Weighing Scale*- A weighing scale (Hana weighing Scale – made in China) was used to measure the body weight of participants in kilograms to the nearest 1.0Kg. It is calibrated from 0 – 120kg.

3). *Metronome*- A metronome (Wittner Metronom system Maelzel, Made in Germany) was used to set the tempo for dynamic exercise.

4). *Stop watch*- A Quartz stop watch (Quartz USA) was used to determine the endurance time or the isometric holding time i.e. from the onset of the BSME to volitional fatigue. This was recorded in seconds (s).

5). *Plinth*- A plinth which could be inclined at angle 30^0, 45^0 and 60^0 respectively was constructed used for the purpose of conducting the modified BSME and RAUT.

6). *Straps*- Two non-elastic straps were used to ensure stability during the tests.

7). *Towel*- A towel was positioned beneath the ankle straps to reduce the strain on the distal aspect of the tendo calcaneus (Achilles tendon) and thereby ensure comfort of the participants during the tests.

8). A blood pressure monitor was used to assess the cardiovascular status of the participants (An Omron M2 Compact BP).

9). *Roland - Morris Low-Back Pain and Disability Questionnaire* (RMLDQ) was used to assess activity limitation in ADL among the participants in this study (Appendix B). A Yoruba translated version of the 24-item RMLDQ (Appendix C) was used for participants who preferred the Yoruba. The translation was done at the department of linguistics and African languages of Obafemi Awolowo University, Ile Ife. Pearson product moment correlation coefficient (r) of 0.82 was obtained for the criterion validity of the back translation of the Yoruba version.

10). *The Oswestry Low-Back Disability Questionnaire* (OLBPDQ) (Appendix D) was used to assess disability. A Yoruba translated version of the OLBPDQ (Appendix E) was used for participants who were literate in the Yoruba language and preferred the Yoruba version. The translation was done at the department of linguistics and African languages of Obafemi Awolowo University, Ile Ife. Pearson product moment correlation coefficient (r) of 0.86 was obtained for the criterion validity of the back translation of the Yoruba version.

11). *General Health Status Questionnaire - Short Form -36* (SF-36) (Appendix F) was used to assess the general health status of the participants. A Yoruba translated version of the Health Status Questionnaire (SF-36) (Appendix G) was used for participants who were literate in the Yoruba language and preferred the Yoruba version. The translation was done at the department of linguistics and African languages of Obafemi Awolowo University, Ile Ife. Pearson product moment correlation coefficient (r) of 0.88 was obtained for the criterion validity of the back translation of the Yoruba version.

12). *Quadruple Visual Analogue Scale* (QVAS) (Appendix H) was used to assess pain intensity experienced by the participants at the time of assessment, typical or average pain, pain at its best and pain at its worst respectively (Von Korff et al., 1993). A Yoruba translated version of the QVAS (Appendix I) was used for participants who were literate in the Yoruba language and prefers the Yoruba version. The translation was done at the department of linguistics and African languages of Obafemi Awolowo University, Ile Ife. Pearson product moment correlation coefficient (r) of 0.88 was obtained for the criterion validity of the back translation of the Yoruba version.

13). *The Borg scale of perceived exertion* (Borg, 1982; 2004) (Appendix J) was used to assess level of fatigue to both BSME and RAUT respectively. The scale was translated to the Yoruba language. The translation was done at the department of linguistics and African languages of Obafemi Awolowo University, Ile Ife. Pearson product moment correlation coefficient (r) of 0.84 was obtained for the criterion validity of the back translation of the Yoruba version.

14). *A pain self-efficacy questionnaire* (Appendix K) was used to assess the participants' self-efficacy beliefs specifically related to basic physical activities. A Yoruba translated version of the pain self-efficacy questionnaire (Appendix L) was used for participants who were literate in the Yoruba language and preferred the Yoruba version. The translation was done at the department of linguistics and African languages of Obafemi Awolowo University Ile Ife. Pearson product moment correlation coefficient (r) of 0.82 was obtained for the criterion validity of the back translation of the Yoruba version.

15). *Fear-Avoidance Beliefs Questionnaire* (FABQ) (Appendix M) was used to measure pain-related fear of physical activity that causes avoidance of activity and increased disability. A Yoruba translated version of the (FABQ) (Appendix N) was used for participants who were literate in the Yoruba language and prefers the Yoruba version.

The translation was done at the department of linguistics and African languages of Obafemi Awolowo University, Ile Ife. Pearson product moment correlation coefficient (r) of 0.80 was obtained for the criterion validity of the back translation of the Yoruba version.

16). The Back Beliefs Questionnaire (BBQ) (Appendix O) was used to measure general beliefs about the inevitable consequences of future life with LBP. A Yoruba translated version of the BBQ (Appendix P) was used for participants who were literate in the Yoruba language and prefers the Yoruba version. The translation was done at the department of linguistics and African languages of Obafemi Awolowo University, Ile Ife. Pearson product moment correlation coefficient (r) of 0.79 was obtained for the criterion validity of the back translation of the Yoruba version.

17). *Instructional guide on back care education* was given as home exercise (prophylaxis) for all the participants. The back care education used in this study was described by Ayanniyi (2003) adopted from Cyriax, (1978), McKenzie, (1980 and 1981), and Jayson, (1984). The present study provided pictorial representation to the back care instructions described by Ayanniyi (2003). The back care illustration pamphlet is provided in Appendix Q. The following specific prophylactic instructions were taught and given to the participants orally and in the pamphlet form as take home prophylaxis guide –

i. Avoid prolonged sitting, bending, stooping and squarting;

ii. Interrupt static posture every thirty minutes before developing any discomfort;

iii. Maintain lumbar lordosis (hollow in the low-Back) in sitting and other postures;

iv. Use supportive roll/cushion placed in the hollow of the back in sitting position;

v. Avoid sitting on low chairs, stool and soft couch with deep seat as much as possible;

vi. Use a firm, high chair with a good comfortable back support;

vii. Consciously control and maintain good upright posture when sitting on a seat without back rest or support;

viii. Avoid lifting of heavy loads as much as possible - when you have to lift, carry only a moderate load;

ix. Carry out your back exercises daily - bend backward five times with hands placed in the hollow of your back; every two hours (Ayanniyi, 2003)

3.2 METHODS

3.2.1 Sampling technique

Consecutive sampling technique was used to recruit patients into the study. The McKenzie Institute Lumbar Spine Assessment Format was used to ensure homogeneity of sample.

3.2.2 Sample size determination

Sample size for this study was obtained from the sample size table according to Cohen et al., (1988). Alpha level was 0.05, degree of freedom 2, effect size was 0.25, and power 80, hence N was found to be 52.

3.2.3 Research Design

This study was a pretest-posttest experimental study.

3.2.4 Procedures

Ethical approval for the study was obtained from the joint UI/UCH Ethical Review Committee (Ref no.: UI/UC/10/0194) (Appendix R) and the Ethics and Research Committee of the Obafemi Awolowo University Teaching Hospitals Complex Ethical Committee ((Ref no.: ERC/2010/01/02) (Appendix S). The purpose of the research was explained to the individual consenting participants. An informed consent form (Appendix T) which was also translated by experts into the Yoruba language (Appendix U) was used in the recruitment for the study. Interpretation was provided for participants who were not literate in either English or Yoruba language.

Participants were consecutively recruited but randomly assigned to the 3 treatment groups until they have all completed the 8-week treatment programme. In order to introduce blinding and reduce bias, a research assistant recorded the number of patients who were invited to participate, the number who declined to participate, and the number of screened patients who were ineligible and their reasons for declining participation or ineligibility. Participants who volunteer to participate and satisfy the eligibility criteria were randomly allocated to the different treatment groups (A, B, or C) by the same assistant who was not involved in the assessment and treatment of the participants. In order to ensure equal-sized treatment groups, random permuted blocks was used (Pocock, 1979) and a block size of 6 was chosen (i.e. AABBCC, ABABCC and all the other possible restricted permutations). The block permutations were computer-generated using a factorial equation formula**:**

(6!) / ((2!)(2!)(2!)) = 90

All the block permutations generated is presented in Appendix V. The consecutive participants were randomized following the computer-generated block permutations. The printout of all the 90 restricted computer-generated block permutation sequence was sequentially numbered, cut and placed in sealed envelope. If the first consecutive participant, pick e.g. serial no 10 with the block sequence of ABBACC, that participant will be assigned to group A, the next consecutive participant will be assigned to group B until that block sequence is exhausted, then another draw is made of a new block permutation sequence and the randomization continues. A participant who was randomized to group A recieved the McKenzie Protocol (MP) only, a participant who was randomized to group B was to receive MP plus static back extensors endurance exercise while a participant who was randomized to group C was to receive MP plus dynamic back extensors endurance exercise. The process of drawing block permuted sequence and randomization was repeated as the participants were recruited.

3.2.4.1 Pre-treatment Screening

All the participants were screened for their eligibility to take part in the study by the researcher using the McKenzie Institute's Lumbar Spine Assessment Format (MILSAF) (Appendix W). The MILSAF is a well-defined algorithm that leads to the simple classification of spinal-related disorders. This is based on a consistent "cause and effect" relationship between historical pain behaviour as well as the pain response to repeated test movements, positions and activities during the assessment process.

The participants were assessed for directional preference. This involved repeated movements, between 5-10 sets of each movement and it included movements in standing and lying and in sagittal and frontal planes while the participants' symptomatic and mechanical responses were assessed. Following the repeated-movement testing, the participants returned to the same standing position and following standardized instructions in the MILSAF, they were asked whether pain was centralizing or peripheralizing during and after movements or there was no effect. The participants' mechanical response to repeated movements was used to establish their directional preference.

Flexion, lateral and no responders to repeated movements were excluded from the study. Only extension responders from the MILSAF assessment were eligible for the study. Information such as age, gender, educational level, occupation, marital status, onset of back pain, recurrence, duration of complaint, previous intervention were recorded for each participant accordingly.

3.2.4.2 Physical performance test

Consenting participants were admonished to dress in a light vest and a pair of shorts to allow for ease of carrying out assessments and treatments. The physical performance assessment for both static and dynamic back extensors endurance was conducted prior the commencement of treatment intervention and at the 4th and 8th week of treatment respectively. Physical performance tests used in this study included the modified Biering-Sørensen test of Static Muscular Endurance (BSME) and Repetitive Arch-Up Test (RAUT) for dynamic endurance respectively. Prior to the endurance tests, the participants were instructed in detail on the study procedures. The test were preceded by a low-intensity warm-up phase of five minutes that comprised stretches and strolling at a self-determined pace around the research venue. The modified BSME and RAUT were performed in random order among the participants with a 15-minute interval provided between both tests. The tests ended with a cool-down phase, comprising the same low-intensity stretches and strolling around the research venue for about five minutes.

3.2.4.2.1 Assessment of static back extensors' endurance

The Biering-Sørensen test of Static Muscular Endurance (BSME) was used to assess the static back endurance. During the test the participant laid on the plinth in the prone position with the upper edge of the iliac crests aligned with the edge of the plinth with their hands held by their sides. The lower body was fixed to the plinth by two non-elastic straps located around the pelvis and ankles. Horizontality in the test position was ensured by asking the participant to maintain contact between his/her back and a hanging weighted ball. Once a loss of contact for more than 10 seconds was noticed, the participant was encouraged once to immediately maintain contact again. Once the participant could not immediately correct or hold the position or claimed to be fatigued the test was terminated (Biering-Sorensen, 1984; Alaranta, 2000).

3.2.4.2.2 Assessment of dynamic back extensors' endurance

Repetitive Arch-Up Test (RAUT) was used to assess the static back endurance. During the test, the participant lay in a prone position on the plinth with the arms positioned along the sides. The iliac crest was positioned at the edge of the plinth. The lower body was fixed to the plinth by two non-elastic straps located around the pelvis and ankles. With the arms held along the sides touching the body, the subject was asked to flex the upper trunk downward to 45^0 as indicated by a board. The participant then raised the upper trunk upwards to the horizontal position followed by returning back downward to 45 degrees to complete a cycle. The repetition rate was one repetition per two to three seconds. The movement was repeated as many times as possible at a constant pace synchronous to a metronome count. Once the movement becomes jerky or non-synchronous, or did not reach the horizontal level, the subject was encouraged once to immediately correct the motion again. The test was terminated once the participant could not go on with the tempo of the motion or reported fatigue or exhaustion (Alaranta, 2000).

3.3.0 INTERVENTION

Treatment for the different groups - McKenzie protocol Group (MPG), McKenzie protocol plus Static Back Endurance Exercise Group (MPSBEEG) and McKenzie protocol plus Dynamic Back Endurance Exercise Group (MPDBEEG)) comprised three phases including warm up, main exercise and cool down. Prior to treatment, the participants were instructed in details on the study procedures. This was followed by a low intensity warm-up phase of five minutes duration comprising stretches and strolling at self-determined pace around the research venue. Treatment also ended with a cool-down phase comprising of the same low intensity exercise as the warm-up for about five minutes (Chok et al., 1999; Johnson, 2010). Each participant received treatment thrice weekly for 8 weeks. The detail of the treatment protocols is provided below.

3.3.1 The McKenzie Protocol

The McKenzie protocol is a classification-treatment based method. Directional preference for extension was first assessed among the participants. This involved a course of specific lumbosacral repeated movements in extension that cause the symptoms to centralize, decrease or abolish. The determination of the direction preference for extension was followed by the main MP activities including:

1. Extension Lying Prone - The participant lay prone, with elbows placed under the shoulders so that he/she could lean on the forearms; and stayed in this position for five minutes. The movement was repeated up to ten times.

2. Extension In Prone - The participant remained in the prone position, placed his/her hands under his/her shoulders in the press – up position. The participant then straightened his/her elbows and pushed the top half of his/her body up as far as their pain permitted. He/she maintained the position for at least one second but not more than 2 seconds. The movement was repeated up to ten times.

3. Extension In Standing - The participant stood upright with the feet slightly apart and placed his/her hands in the small of his/her back with the fingers pointing backwards. He/she then stretched the trunk backwards at the waist level as far as he/she can, using the hands as a fulcrum while keeping the knees straight. The movement was repeated up to ten times.

The McKenzie protocol also included a set of back care education instructions which comprised a 9 item instructional guide on standing, sitting, lifting and other activities of daily living for home exercise for all the participants. However, adherence to the home exercise was not measured (McKenzie, 1990).

3.3.2 Static Back Extensors Endurance Exercise

In addition to completing the McKenzie protocol (i.e. back extension exercises plus the back care education), static back extensors endurance exercise included five different exercises of increasing level of difficulty where the positions of the upper and lower limbs were altered (Moffroid et al., 1993). The participants began the exercise training programme with the first exercise position, but progressed to the next exercises at their own pace when they could hold a given position for 10 seconds. On reaching the fifth progression, they continued with the fifth progression until the end of the exercise programme (Moffroid et al., 1993; Adegoke and Babatunde, 2007). The following were the five exercise progressions:

1. Participant lay in prone position with both arms by the sides of the body and lifting the head and trunk off the plinth from neutral to extension.
2. Participant lay in prone position with the hands interlocked at the occiput so that shoulders were abducted to 90° and the elbows flexed, and lifting the head and trunk off the plinth from neutral to extension.
3. Participant lay in prone position with both arms elevated forwards, and lifting the head, trunk and elevated arms off the plinth from neutral to extension.
4. Participant lay in prone position and lifting the head, trunk and contralateral arm and leg off the plinth from neutral to extension.
5. Participant lay in prone position with both shoulders abducted and elbows flexed to 90°, and lifting the head, trunk and both legs (with knees extended) off the plinth.

If pain was aggravated during the exercise, the participant was asked to stop. If the pain diminished within 5 minutes after the exercise, he/she was asked to continue the exercise but to hold the exercise position for only 5 seconds. The participant was asked to progress to 10 seconds if there was no adverse response. Each exercise was repeated 9 times. After 10 repetitions, the participant was instructed to rest for between 30 seconds to 1 minute. Static holding time in the exercise position was gradually increased to 20 seconds to provide a greater training stimulus (Petrofsky et al., 1975; Bonde-Petersen et al., 1975). The dosage of series of 10 repetitions was adopted from a previous protocol for participants with sub-acute LBP (Chok et al., 1999). The exercise period will range from 30 to 45 minutes.

3.3.3 Dynamic Back Extensors Endurance Exercise

In addition to completing the McKenzie protocol, dynamic back extensors endurance exercise included five different exercises. The dynamic back endurance exercise was an exact replica of the static back extensors endurance exercise protocol in terms of exercise positions, progressions and duration. However, instead of static posturing of the trunk in the prone lying position and holding the positions of the upper and lower limbs suspended in the air during all the five exercise progressions for the 10 seconds, the participant was asked to move the trunk and the suspended limbs 10 times.

If pain was aggravated during the exercise, participant was asked to stop. If the pain diminished within 5 minutes after the exercise, the participant was asked to continue the exercise but to carry out only 5 movements in the exercise position. The participant was asked to progress to 10 movements if there is no adverse response. Each exercise was repeated 9 times. After 10 repetitions, the participants were instructed to rest for between 30 seconds to 1 minute. The number of movements of the trunk in the exercise position was gradually increased to 20 seconds to provide a greater training stimulus. The exercise period will range from 30 to 45 minutes.

Irrespective of participants' treatment group, at the end of the session, the participants were instructed on back education for standing, sitting, lifting and other activities of daily living using the McKenzie back care education provided in the form of a pamphlet as take home and it also served as reminder on back care for the participants. Participants were reminded not to seek treatment from other health care professionals or other form of self therapy for their LBP. They were advised to telephone the researcher in case there was any aggravation of their condition during the study period. Participants who missed an appointment were contacted by telephone and offered another appointment. Those who declined another appointment were asked for their reasons and were considered to have dropped out from the study.

Following the initial assessment for all participants carried out at inclusion into the study, two additional assessments were made. The reassessments were scheduled at the 4 and 8th week after entry into the study. During these reassessment sessions, participants completed all the outcome measure questionnaires and also performed the modified BSME and RAUT respectively.

3.4 DATA ANALYSES

1. Descriptive statistics of mean, standard deviation, percentages and bar charts were used to summarize all data obtained from the participants.
2. Analysis of Variance (ANOVA) was used to:
   (i) Compare demographic and the continuous variables such as the QVAS, RMLDQ, Static Back Endurance, Dynamic Back Endurance and Borg Scale scores at baseline in the different treatment groups.
   (ii) Compare the effects of the different treatment regimens on the continuous variables. Least significant difference (LSD) post-hoc multiple comparisons was used to further test for any significant difference found in the ANOVA F-ratios.
3. Repeated measures ANOVA was used for within group comparison of the effects of the different treatment regimen on the continuous variables. LSD post-hoc multiple comparisons analysis was used to test for any significant difference found in the F-ratios.
4. Kruskal Wallis test was used to:
   (i) Compare the categorical variables such as OLBPDQ, BBQ, PSEQ, FABQ and SF-36 scores at baseline in the different treatment groups.
   (ii) Compare the effects of the different treatment regimens on categorical variables. Tukey multiple comparisons was used for post-hoc test analysis.

5. Friedman's ANOVA- (a non-parametric equivalent of the repeated measures ANOVA) was used for within group comparison of the effects of the different treatment regimen on the categorical variables. Wilcoxon signed ranked test was

used as the post-hoc multiple comparisons to test for any significant difference found in the Friedman's F-ratios.

Alpha level was set at 0.05.

The data analyses were carried out using SPSS 13.0 version software (SPSS Inc., Chicago, Illinois, USA).

Plate 1: The modified Biering-Sorensen test of static muscular endurance position

Plate 2: Horizontal phase of the Repetitive Arch-Up Test

Plate 3: Downward phase of the Repetitive Arch-Up Test

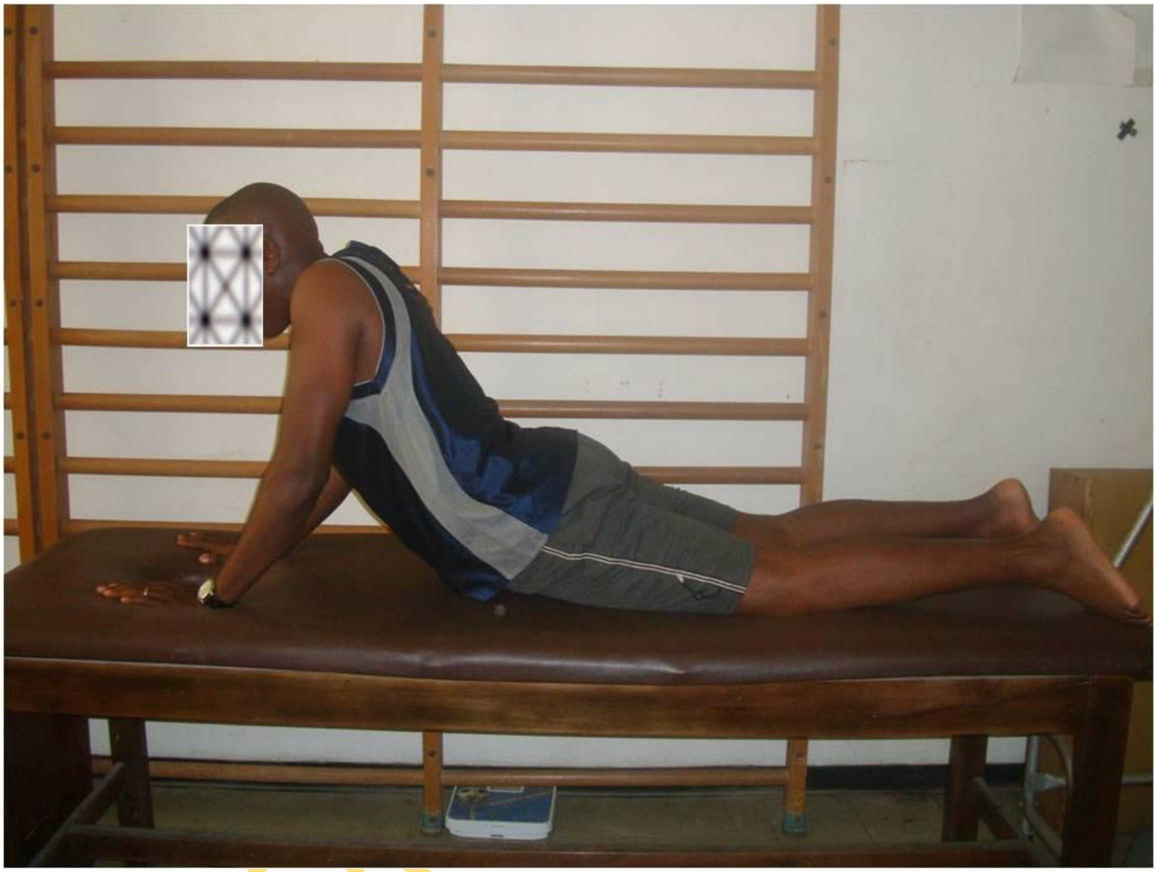

Plate 4: McKenzie Extension Exercise Posture in Lying

Plate 5: McKenzie Extension Exercise Posture in Standing

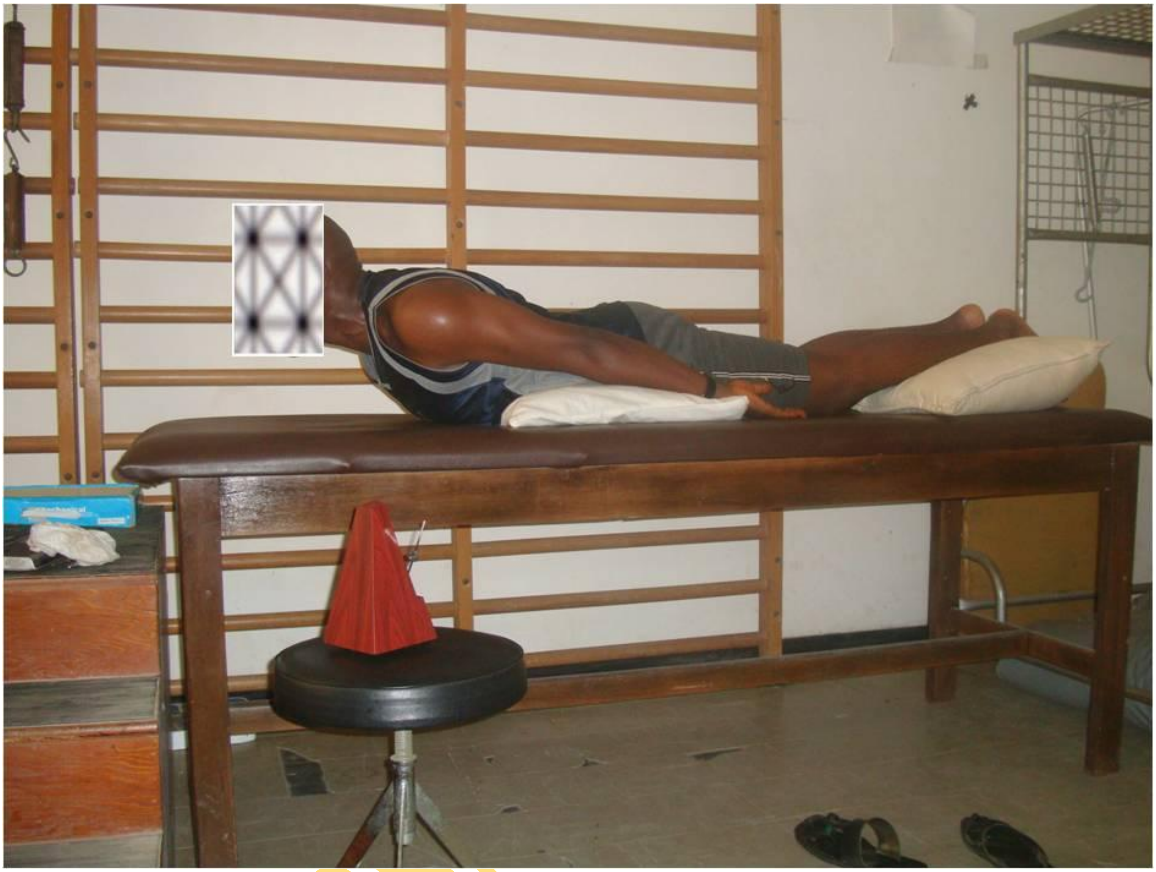

Plate 6: Exercise Position 1: Prone position with arms by the sides of the body, and head and trunk lifted off the plinth from neutral to extension for static and dynamic back extensors endurance exercise

Plate 7: Exercise Position 2: Prone position with hands interlocked at occiput so shoulders are abducted to 90^0 and elbows flexed, and head and trunk lifted off the plinth from neutral to extension for static and dynamic back extensors endurance exercise

Plate 8: Exercise Position 3: Prone position with both arms elevated forwards, and head and trunk lifted off the plinth from neutral to extension for static and dynamic back extensors endurance exercise

Plate 9: Exercise Position 4: Prone position and head, trunk and contralateral arm and leg lifted off the plinth from neutral to extension for static and dynamic back extensors endurance exercise

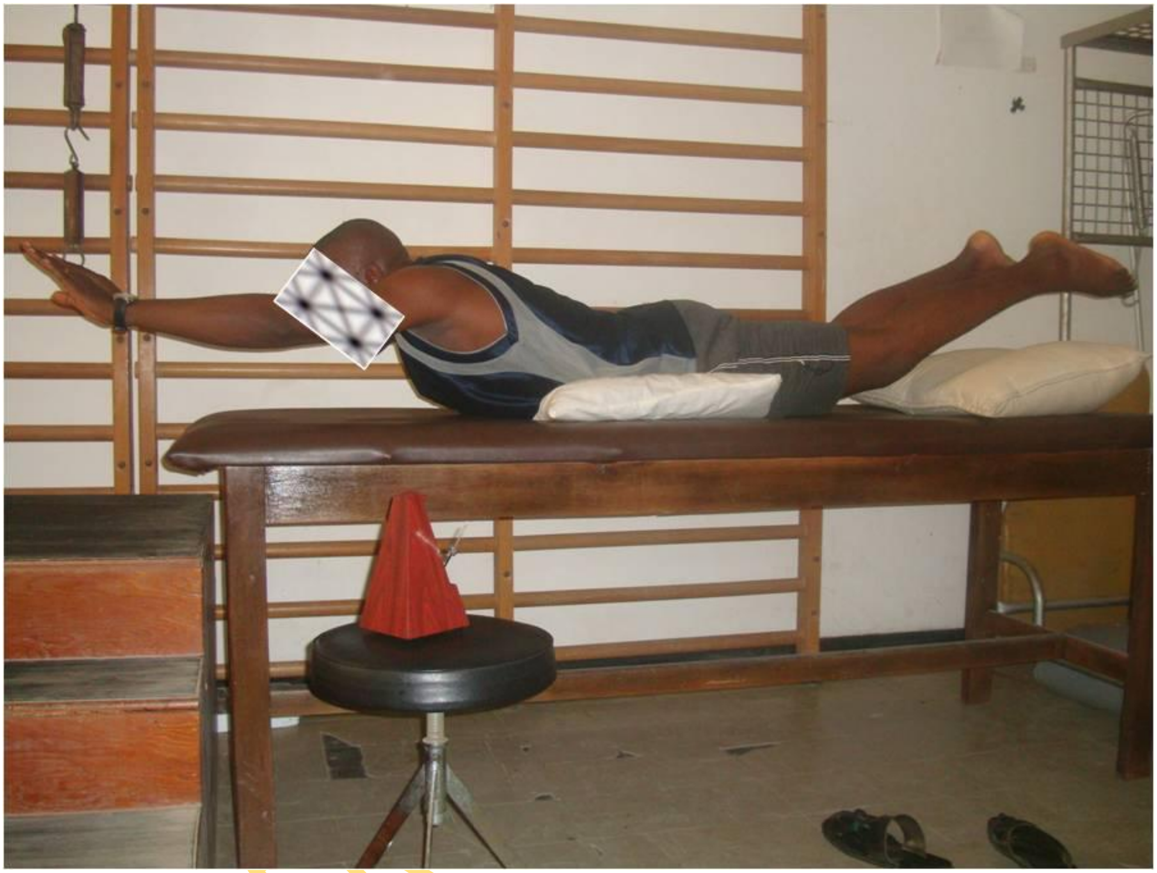

Plate 10: Exercise Position 5: Prone position with both arms elevated forwards and both legs (with knees extended) lifted off the plinth from neutral to extension for static and dynamic back extensors endurance exercise

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Participants' profile

The mean age, height, weight and BMI of all the participants was 51.8 ± 7.35 years (yr), 1.66 ± 0.04m, 76.2±11.2 Kg and 27.2 ± 4.43 kg/m^2 respectively. Comparison of the participants' general characteristics by treatment groups revealed that the participants in the different groups were comparable in their general characteristics ($p>0.05$) (table 3). A quarter of the participants who reported mechanical stresses due to job activities were civil servants (25.4%), about 15% were teachers and 13.4% were nurses (table 4). About a third of the participants reported no stress from leisure activities. However, 26.9% reported mechanical stresses from cooking, 13.4% from sex and 10.4% from gardening. Functional limitations reported by the participants included difficulty with sitting (47.8%), bending (22.4%) and driving (17.9%) (table 4). The mean functional disability and pain intensity scores reported by the participants were 5.43 ± 1.44 and 6.55 ± 1.75 (VAS) respectively (table 4). Majority (68.7%) of the participants has been off work because of the current episode of the LBP (table 4).

None of the participants reported positively to the specific questions in the algorithm indicative of red flags. None of the participants reported a current episode of constant symptoms of LBP. All participants have had a previous history of LBP and the duration of the current episode ranged between 4 and 12 months with a mean duration of 6.82 ± 1.96 months. Majority of the participants reported that the symptoms at onset affected the back mostly (53.7%), bending made the pain worst (53.7%), affected sleep (45.3%) and symptoms was often better when lying (68.7%) (table 5).

Among all the participants, test movements in flexion both standing and lying produced pain, while repeated movements in flexion increased pain in either standing or lying. On the other hand, test movements and repeated movements in extension both standing and lying decreased and/or centralized pain among the participants. Fifty six (83.5%) of the participants had posterior derangement syndrome, 5 (7.5%) had dysfunction syndrome and 6 (9.0%) had postural syndrome (table 6).

Table 3: One-way ANOVA comparison of the participants' general characteristics by treatment groups

Variable	MPG (n = 25) x̄ ± SD	MPSBEEG (n = 22) x̄ ± SD	MPDBEEG (n = 20) x̄ ± SD	F-ratio	p-value
Age (yr)	50.6 ± 7.57	51.2 ± 7.50	53.8 ± 6.83	1.106	0.339
Height (m)	1.67 ± 0.04	1.66 ± 0.04	1.68 ± 0.04	2.185	0.331
Weight (Kg)	76.3 ± 9.95	75.2 ± 13.2	77.2 ± 10.8	0.156	0.856
BMI (Kg/m^2)	27.5 ± 4.20	27.3 ± 5.25	26.9 ± 3.89	0.093	0.912

Alpha level was set at p <0.05

Key:
MPG = McKenzie Protocol Group
MPSBEEG = McKenzie Protocol plus Static Back Endurance Exercise Group
MPDBEEG = McKenzie Protocol plus Dynamic Back Endurance Exercise Group
x̄ = Mean
SD = Standard deviation

Table 4: Participants' profile using the McKenzie Institute Lumbar Spine Assessment Format

Characteristic	Number (%)	Mean
Sex		
Male	32 (47.8)	
Female	35 (52.2)	
Referral		
General practitioner	28(41.8)	
Orthopaedic surgeon	17(25.4)	
Self	22(32.8)	
Mechanical stresses due to work		
Civil servant	17(25.4)	
Teacher	10(14.9)	
Nurse	9(13.4)	
Business person	8(11.9)	
Seamstress	8(11.9)	
Retiree	7(10.5)	
Bricklayer	4 (6.0)	
Driver	4(6.0)	
Mechanical stresses due to leisure		
Nil	21(31.3)	
Cooking	18 (26.9)	
Sex	9(13.4)	
Gardening	7(10.4)	
Sports	6(9.0)	
Visiting	6(9.0)	
Present functional disability		
Sitting	32(47.8)	
Bending	15(22.4)	
Driving	12(17.9)	
Walking	8(11.9)	
Functional disability score (0-10)		5.43 ± 1.44
VAS score (0-10)		6.55 ± 1.75

Key:
VAS = Visual Analogue Scale
% = Percentage

Table 5: Clinical profile of the participants using the McKenzie Institute Lumbar Spine Assessment Format

Characteristic	Number (%)
Symptom at onset	
Back	36(53.7)
Thigh	13(19.4)
Back and thigh	18(26.9)
Intermittent symptom	
Back	52(77.6)
Back and thigh	15(22.4)
Activities that make pain worse	
Bending	36(53.7)
Sitting/rising	12(17.9)
Standing	10(14.9)
Walking	9(13.4)
Activities that make pain better	
Lying	46(68.7)
A.m. / as the day progresses	21(31.3)
Pain disturbing sleep	
Yes	31 (45.3)
No	36(53.7)
Previous episode	
1-5 months	18(26.9)
6-10 months	16(23.9)
11+ months	33(49.2)
Previous treatment	
Traditional care	19(28.4)
Drug therapy	18(26.9)
Physiotherapy	12(17.9)
No treatment	11(16.4)
Rest	7(10.4)
Medications	
NSAIDs and Analgesics	18(26.9)
Others	49(73.1)

Table 6: Participants' posture, movements and syndrome classifications profile using the McKenzie Institute Lumbar Spine Assessment Format

Characteristic	Number (%)
Sitting	
Good	36(53.7)
Fair	31(45.3)
Standing	
Good	46(68.7)
Fair	21(31.3)
Lordosis	
Reduced	27(40.3)
Accentuated	31(46.3)
Normal	9(13.4)
Posture correction	
Better	57(85.1)
No effect	10(14.9)
Posture correction	
Yes	57(85.1)
No	10 (14.9)
Flexion movement	
Major	47(70.1)
Moderate	10(14.9)
Minimal	10(14.9)
Extension movement	
Moderate	15(22.4)
Minimal	43(64.2)
Nil	9(13.4)
Provisional classification	
Posterior derangement	56(83.5)
Dysfunction	5(7.5)
Postural	6(9.0)

4.1.2 Comparison of participants' baseline parameters

Table 7 shows the comparison of the participants' baseline measures across the MPG, MPSBEEG and MPDBEEG for the continuous variables. Quadruple Visual Analogue Scale (QVAS), Roland Morris Disability Questionnaire (RMLDQ), static back endurance, dynamic back endurance and Borg scale scores were comparable ($p>0.05$). Table 8 shows the comparison of the participants' baseline measures for the categorical variables across the MPG, MPSBEEG and MPDBEEG for categorical variables. Oswestry Low-Back Pain Disability Questionnaire (OLBPDQ), Back Belief questionnaire (BBQ), Pain Self Efficacy Questionnaire (PSEQ), Fear-Avoidance Beliefs Questionnaire (FABQ) and SF-36 scores were comparable ($p>0.05$).

4.1.3 Within-group comparison of participants in MPG, MPSBEEG and MPDBEEG across the 3 time points of the study

The outcome parameters of participants in the different groups were compared across baseline, fourth and eighth week of the study and are presented in Tables 9-14. Results among the different groups showed that there were significant differences ($p<0.05$) in the participants' outcome parameters across the 3 time points of the study.

Table 7: One-way ANOVA comparison of the participants' baseline parameters for the continuous variables

Outcome	MPG (n=25) x̄±SD	MPSBEEG (n=22) x̄±SD	MPDBEEG (n=20) x̄±SD	F-ratio	p-value
VAS now	6.56 ± 1.83	6.50 ± 1.71	6.60 ± 1.79	0.017	0.983
VAS average	6.04 ± 1.83	6.54 ± 1.71	6.10 ± 1.79	1.203	0.307
VAS best	4.08 ± 1.12	4.50 ± 1.14	4.00 ± 1.21	1.117	0.315
VAS worst	8.20 ± 1.00	8.09 ± 1.02	8.20 ± 1.00	0.087	0.917
QVAS	69.3 ± 9.91	70.2 ± 10.9	69.7 ± 10.2	0.037	0.964
RMLDQ	9.28 ± 0.68	9.18 ± 0.85	9.20 ± 0.77	0.110	0.896
SE	36.7 ± 11.8	37.3 ± 13.4	39.2 ± 18.6	0.162	0.851
DE	11.7 ± 2.63	11.3 ± 2.10	11.3 ± 4.27	0.129	0.879
SRPE	13.5 ± 2.12	12.5 ± 2.01	12.2 ± 1.73	2.870	0.064
DRPE	14.1 ± 2.55	14.1 ± 2.16	13.4 ± 1.05	0.986	0.380

Alpha level was set at $p < 0.05$

Key:
x̄ = Mean
SD = Standard Deviation
VAS = Visual Analogue Scale
QVAS = Quadruple Visual Analogue Scale (Total score – 100)
RMLDQ = Roland Morris Disability Questionnaire
SE = Static Endurance
DE = Dynamic Endurance
SRPE = Static rate of perceived exertion
DRPE = Dynamic rate of perceived exertion

Table 8: Kruskal Wallis test comparison of the participants' baseline parameters for the categorical variables

Outcome	MPG (n=25) Mean rank	MPSBEEG (n=22) Mean rank	MPDBEEG (n=20) Mean rank	H	p-value
OLBPDQ	45.2	41.5	45.3	0.365	0.574
BBQ	28.1	35.1	40.3	4.788	0.091
PSEQ	32.8	33.4	36.3	0.408	0.815
FABQ-P	33.8	35.2	32.9	0.166	0.920
FABQ-W	30.2	35.2	37.5	1.840	0.399
HSQ					
HP	33.3	32.9	36.2	0.364	0.839
PF	33.0	36.3	32.8	0.442	0.802
RP	35.9	32.3	33.0	0.387	0.824
RE	34.2	34.7	33.0	0.083	0.960
SF	33.4	36.0	32.6	0.351	0.839
MH	32.5	35.2	34.5	0.246	0.884
BP	36.7	31.6	33.2	0.867	0.648
EF	31.7	35.6	35.1	0.597	0.742

Alpha level was set at $p < 0.05$
The test statistic for the Kruskal-Wallis test is H.

Key:
OLBPDQ = Oswestry Low-Back Pain Disability Questionnaire
BBQ = Back belief questionnaire
PSEQ = Pain self efficacy questionnaire
FABQ-P = Fear-Avoidance Beliefs Questionnaire – (Physical)
FABQ-W = Fear-Avoidance Beliefs Questionnaire (Work)
HSQ = Health status questionnaire; HP = Health perception; PF = Physical function; RP = Role physical; RE = Role emotional; SF = Social functioning; MH = Mental health; BP = Bodily pain; EF = Energy fatigue.

Table 9: Repeated measures ANOVA and LSD post-hoc multiple comparisons of continuous treatment outcomes among participants in MPG across the 3 time points of the study (n=25)

Outcome	Baseline x̄±SD	4th week x̄±SD	8th week x̄±SD	F-ratio	p-value
VAS now	6.56 ± 1.83[a]	3.76 ± 1.67[b]	2.04 ± 1.24[c]	51.005	0.001
VAS average	6.04 ± 0.84[a]	2.84 ± 0.74[b]	0.96 ± 0.68[c]	287.651	0.001
VAS best	4.08 ± 1.12[a]	2.04 ± 1.14[b]	0.64 ± 0.70[c]	74.236	0.001
VAS worst	8.20 ± 1.00[a]	4.44 ± 0.96[b]	2.00 ± 1.00[c]	250.276	0.001
QVAS	69.3 ± 9.91[a]	36.8 ± 8.90[b]	16.7 ± 7.64[c]	224.799	0.001
RMLDQ	9.28 ± 0.68[a]	5.92 ± 1.04[b]	3.52 ± 0.92[c]	263.798	0.001
SE	36.7 ± 11.8[a]	51.4 ± 10.2[b]	66.4 ± 10.2[c]	47.402	0.001
DE	11.2 ± 2.63[a]	14.6 ± 2.52[b]	20.0 ± 2.92[c]	62.126	0.001
SRPE	13.4 ± 2.12[a]	12.6 ± 2.16[a]	9.06 ± 2.16[b]	22.419	0.025
DRPE	14.1 ± 2.55[a]	13.7 ± 2.11[a]	10.7 ± 2.11[b]	16.767	0.001

Alpha level was set at $p < 0.05$.

Superscripts (^{a,b,c}).
For a particular variable, mean values with different superscript are significantly ($p<0.05$) different. Mean values with same superscripts are not significantly ($p>0.05$) different. The pair of cell means that is significant has different superscripts.

Key:
x̄ = Mean
SD = Standard deviation
VAS = Visual Analogue Scale
QVAS = Quadruple Visual Analogue Scale (Total score – 100)
RMLDQ = Roland Morris Disability Questionnaire
SE = Static Endurance
DE = Dynamic Endurance
SRPE = Static rate of perceived exertion
DRPE = Dynamic rate of perceived exertion

Table 10: Friedman's ANOVA and Wilcoxon signed ranked test multiple comparisons of the categorical treatment outcomes among participants in the MPG across the 3 time points of the study (n=25)

Outcome	Baseline Mean rank	4th week Mean rank	8th week Mean rank	$\chi 2$	p-value
OLBPDQ	45.2[a]	20.3[b]	17.2[c]	50.000	0.001
BBQ	28.1[a]	34.4[b]	36.4[b]	49.238	0.001
PSEQ	32.8[a]	44.7[b]	47.1[b]	45.632	0.001
FABQ-P	33.8[a]	14.7[b]	11.1[b]	50.210	0.001
FABQ-W	30.2[a]	24.2[b]	19.3[c]	48.980	0.001
HSQ					
HP	33.3[a]	59.3[b]	69.2[c]	50.000	0.001
PF	33.0[a]	57.8[b]	66.8[c]	48.080	0.001
RP	35.9[a]	38.5[b]	48.4[c]	45.960	0.001
RE	34.2[a]	43.8[b]	52.7[c]	40.735	0.001
SF	33.4[a]	64.8[b]	72.6[c]	48.910	0.001
MH	32.5[a]	56.4[b]	63.1[b]	47.446	0.001
BP	36.7[a]	54.4[b]	66.2[c]	52.108	0.001
EF	31.7[a]	57.7[b]	64.8[c]	47.265	0.001

Alpha level was set at $p < 0.05$.
Wilcoxon signed ranked test was used to specify the groups difference obtained from the Friedman's Chi-square.
Superscripts (a,b,c).
For a particular variable, mean values with different superscript are significantly ($p<0.05$) different. Mean values with same superscripts are not significantly ($p>0.05$) different. The pair of cell means that is significant has different superscripts.

Key:
OLBPDQ = Oswestry Low-Back Pain Disability Questionnaire
BBQ = Back belief questionnaire
PSEQ = Pain self efficacy questionnaire
FABQ-P = Fear-Avoidance Beliefs Questionnaire – (Physical)
FABQ-W = Fear-Avoidance Beliefs Questionnaire (Work)
HSQ = Health status questionnaire; HP = Health perception; PF = Physical function; RP = Role physical; RE = Role emotional; SF = Social functioning; MH = Mental health; BP = Bodily pain; EF = Energy fatigue.

Table 11: Repeated measures ANOVA and LSD post-hoc multiple comparisons of continuous treatment outcomes among participants in MPSBEEG across the 3 time points of the study (n=22)

Outcome	Baseline x̄±SD	4th week x̄±SD	8th week x̄±SD	F-ratio	p-value
VAS now	6.50 ± 1.71[a]	3.64 ± 1.59[b]	1.77 ± 1.41[c]	50.230	0.001
VAS average	6.46 ± 1.01[a]	3.46 ± 0.94[b]	1.32 ± 0.84[c]	171.50	0.001
VAS best	4.50 ± 1.14[a]	2.27 ± 0.94[b]	0.77 ± 0.87[c]	78.974	0.001
VAS worst	8.09 ± 1.01[a]	4.18 ± 1.14[b]	2.09 ± 0.97[c]	186.562	0.001
QVAS	70.1 ± 10.9[a]	36.5 ± 9.57[b]	17.3 ± 9.23[c]	159.791	0.001
RMLDQ	9.18 ± 0.85[a]	5.46 ± 1.30[b]	3.50 ± 1.14[c]	147.635	0.001
SE	37.3 ± 13.4[a]	83.1 ± 10.9[b]	98.1 ± 10.1[c]	159.362	0.001
DE	11.3 ± 2.10[a]	24.2 ± 10.0[b]	29.4 ± 8.93[c]	13.981	0.001
SRPE	12.5 ± 2.02[a]	10.5 ± 2.08[b]	7.05 ± 2.08[c]	38.069	0.001
DRPE	14.2 ± 2.16[a]	12.7 ± 1.91[b]	9.68 ± 1.91[c]	29.448	0.001

Alpha level was set at $p < 0.05$.

Superscripts ([a,b,c]).
For a particular variable, mean values with different superscript are significantly ($p<0.05$) different. Mean values with same superscripts are not significantly ($p>0.05$) different. The pair of cell means that is significant has different superscripts.

Key:
x̄ = Mean
SD = Standard deviation
VAS = Visual Analogue Scale
QVAS = Quadruple Visual Analogue Scale (Total score – 100)
RMLDQ = Roland Morris Disability Questionnaire
SE = Static Endurance
DE = Dynamic Endurance
SRPE = Static rate of perceived exertion
DRPE = Dynamic rate of perceived exertion

Table 12: Friedman's ANOVA and Wilcoxon signed ranked test multiple comparisons of the categorical treatment outcomes among participants in MPSBEEG across the 3 time points of the study (n=22)

Outcome	Baseline Mean rank	4th week Mean rank	8th week Mean rank	χ2	p-value
OLBPDQ	41.5[a]	19.3[b]	16.0[b]	44.000	0.001
BBQ	35.1[a]	36.5[b]	38.1[b]	37.904	0.001
PSEQ	33.4[a]	45.5[b]	47.6[b]	41.302	0.001
FABQ-P	35.2[a]	14.6[b]	11.0[b]	40.000	0.001
FABQ-W	35.2[a]	25.7[b]	21.2[b]	44.000	0.001
HSQ					
HP	32.9[a]	64.4[b]	72.5[c]	42.340	0.001
PF	36.3[a]	65.0[b]	74.0[c]	44.500	0.001
RP	32.3[a]	48.4[b]	59.2[c]	41.400	0.001
RE	34.7[a]	49.6[b]	57.3[c]	39.321	0.001
SF	36.0[a]	72.3[b]	81.2[c]	43.517	0.001
MH	35.2[a]	59.9[b]	68.1[c]	42.091	0.001
BP	31.6[a]	61.3[b]	70.2[c]	44.120	0.001
EF	35.6[a]	60.7[b]	71.2[c]	38.273	0.001

Alpha level was set at $p < 0.05$.
Wilcoxon signed ranked test was used to specify the groups difference obtained from the Friedman's Chi-square.

Superscripts (a,b,c).
For a particular variable, mean values with different superscript are significantly ($p<0.05$) different. Mean values with same superscripts are not significantly ($p>0.05$) different. The pair of cell means that is significant has different superscripts.

Key:
OLBPDQ = Oswestry Low-Back Pain Disability Questionnaire
BBQ = Back belief questionnaire
PSEQ = Pain self efficacy questionnaire
FABQ-P = Fear-Avoidance Beliefs Questionnaire – (Physical)
FABQ-W = Fear-Avoidance Beliefs Questionnaire (Work)
HSQ = Health status questionnaire; HP = Health perception; PF = Physical function; RP = Role physical; RE = Role emotional; SF = Social functioning; MH = Mental health; BP = Bodily pain; EF = Energy fatigue.

Table 13: Repeated measures ANOVA and LSD post-hoc multiple comparisons of continuous treatment outcomes among participants in MPDBEEG across the 3 time points of the study (n=20)

Outcome	Baseline $\bar{x}$±SD	4^{th} week $\bar{x}$±SD	8^{th} week $\bar{x}$±SD	F-ratio	p-value
VAS now	6.60 ± 1.79^{a}	3.70 ± 1.66^{b}	1.20 ± 1.30^{c}	42.534	0.001
VAS average	6.10 ± 1.07^{a}	2.90 ± 0.85^{b}	1.01 ± 0.92^{c}	146.771	0.001
VAS best	4.01 ± 1.21^{a}	1.90 ± 1.07^{b}	0.65 ± 0.81^{c}	52.399	0.001
VAS worst	8.20 ± 1.01^{a}	4.35 ± 0.88^{b}	2.20 ± 0.95^{c}	206.763	0.001
QVAS	69.7 ± 10.2^{a}	36.5 ± 7.98^{b}	17.3 ± 7.77^{c}	184.448	0.001
RMDQ	9.20 ± 0.77^{a}	5.00 ± 0.73^{b}	3.20 ± 0.77^{c}	333.556	0.001
SE	39.2 ± 18.6^{a}	56.2 ± 18.5^{b}	75.2 ± 18.5^{c}	15.011	0.001
DE	11.3 ± 4.27^{a}	22.0 ± 8.45^{b}	27.9 ± 8.27^{c}	26.890	0.001
SRPE	12.2 ± 1.73^{a}	10.8 ± 2.19^{b}	7.80 ± 2.19^{c}	23.652	0.001
DRPE	13.4 ± 1.05^{a}	9.35 ± 1.35^{b}	6.35 ± 1.35^{c}	158.731	0.001

Alpha level was set at $p < 0.05$.

Superscripts (^{a,b,c}).

For a particular variable, mean values with different superscript are significantly ($p<0.05$) different. Mean values with same superscripts are not significantly ($p>0.05$) different. The pair of cell means that is significant has different superscripts.

Key:

$\bar{x}$ = Mean

SD = Standard deviation

VAS = Visual Analogue Scale

QVAS = Quadruple Visual Analogue Scale (Total score – 100)

RMLDQ = Roland Morris Disability Questionnaire

SE = Static Endurance

DE = Dynamic Endurance

SRPE = Static rate of perceived exertion

DRPE = Dynamic rate of perceived exertion

Table 14: Friedman's ANOVA and Wilcoxon signed ranked test multiple comparisons of the continuous treatment outcomes among participants in the MPDBEEG across the 3 time points of the study (n=20)

Outcome	Baseline Mean rank	4th week Mean rank	8th week Mean rank	χ2	p-value
OLBPDQ	45.3[a]	20.6[b]	17.1[c]	41.000	0.001
BBQ	40.3[a]	38.4[b]	39.8[c]	35.096	0.001
PSEQ	36.3[a]	47.6[b]	50.5[c]	38.100	0.001
FABQ-P	32.9[a]	14.8[b]	11.1[c]	39.980	0.001
FABQ-W	37.5[a]	26.8[b]	22.2[c]	40.000	0.001
HSQ					
HP	36.2[a]	67.6[b]	77.4[c]	38.400	0.001
PF	32.8[a]	72.8[b]	80.4[c]	40.220	0.001
RP	33.0[a]	55.2[b]	65.0[c]	44.110	0.001
RE	33.0[a]	53.4[b]	62.1[c]	42.340	0.001
SF	32.6[a]	72.7[b]	81.6[c]	39.519	0.001
MH	34.5[a]	67.5[b]	76.4[c]	43.124	0.001
BP	33.2[a]	65.0[b]	71.2[c]	42.645	0.001
EF	35.1[a]	66.2[b]	78.4[c]	45.600	0.001

Alpha level was set at $p < 0.05$.
Wilcoxon signed ranked test was used to specify the groups difference obtained from the Friedman's Chi-square.
Superscripts ([a,b,c]).
For a particular variable, mean values with different superscript are significantly ($p<0.05$) different. Mean values with same superscripts are not significantly ($p>0.05$) different. The pair of cell means that is significant has different superscripts.

Key:
OLBPDQ = Oswestry Low-Back Pain Disability Questionnaire
BBQ = Back belief questionnaire
PSEQ = Pain self efficacy questionnaire
FABQ-P = Fear-Avoidance Beliefs Questionnaire – (Physical)
FABQ-W = Fear-Avoidance Beliefs Questionnaire (Work)
HSQ = Health status questionnaire; HP = Health perception; PF = Physical function; RP = Role physical; RE = Role emotional; SF = Social functioning; MH = Mental health; BP = Bodily pain; EF = Energy fatigue.

4.1.4 Comparison of treatment outcomes (mean change) at week four of the study

The results showed that there were no significant differences in the mean change pain intensity ($p>0.05$) across the groups at the end of the 4th week of the study (table 15). However, there were significant differences in mean change of RMLDQ score, static and dynamic endurance and rate of perceived exertion across the group ($p<0.05$) at the end of the 4th week of the study. The Least significant difference (LSD) post hoc analysis was used to elucidate where the differences within between groups lie.

There were no significant differences ($p>0.05$) in mean change of OLBPDQ, BBQ and FABQ scores across the groups at the end of the 4th week of the study. However, there were significant differences in mean change of PSEQ and SF-36 scores across the group ($p<0.05$) at the end of the 4th week of the study.

Table 15: One-way ANOVA and Least Significant Difference Post-Hoc Multiple Comparison of the participants' treatment outcomes (mean change) for the continous variables at week four of the study

Outcome	MPG (n=25) x̄±SD	MPSBEEG (n=22) x̄±SD	MPDBEEG (n=20) x̄±SD	F-ratio	p-value
VAS now	2.80 ± 0.65^{a}	2.86 ± 0.47^{a}	2.90 ± 0.64^{a}	0.167	0.847
VAS average	3.20 ± 0.40^{a}	3.31 ± 0.72^{a}	3.20 ± 0.41^{a}	0.367	0.694
VAS best	1.24 ± 0.78^{a}	1.36 ± 1.00^{a}	1.00 ± 1.07^{a}	0.491	0.614
VAS worst	4.44 ± 0.96^{a}	4.18 ± 1.14^{a}	4.35 ± 0.79^{a}	0.341	0.712
QVAS	32.5 ± 3.09^{a}	33.6 ± 3.97^{a}	33.1 ± 3.82^{a}	0.522	0.579
RMLDQ	3.36 ± 0.76^{a}	3.72 ± 0.70	4.20 ± 0.52^{b}	8.556	0.001
SE	14.6 ± 8.44^{a}	45.7 ± 17.0^{b}	17.1 ± 10.2^{a}	43.703	0.001
DE	2.88 ± 1.88^{a}	12.9 ± 11.1^{b}	10.7 ± 6.51^{b}	12.088	0.001
SRPE	12.6 ± 2.16^{a}	10.1 ± 2.08^{b}	10.8 ± 2.19^{b}	3.916	0.025
DRPE	13.7 ± 2.11^{a}	12.7 ± 1.91^{a}	9.35 ± 1.35^{b}	60.250	0.001

Alpha level was set at $p < 0.05$.

Superscripts (^{a,b,c}).

For a particular variable, mean values with different superscript are significantly ($p<0.05$) different. Mean values with same superscripts are not significantly ($p>0.05$) different. The pair of cell means that is significant has different superscripts.

Key:

x̄ = Mean

SD = Standard deviation

VAS = Visual Analogue Scale

QVAS = Quadruple Visual Analogue Scale (Total score – 100)

RMLDQ = Roland Morris Disability Questionnaire

SE = Static Endurance

DE = Dynamic Endurance

SRPE = Static rate of perceived exertion

DRPE = Dynamic rate of perceived exertion

Table 16: Kruskal Wallis test comparison of the participants' treatment outcomes (mean change) for categorical variables at week four of the study

Outcome	MPG (n=25) Mean rank	MPSBEEG (n=22) Mean rank	MPDBEEG (n=20) Mean rank	H	p-value
OLBDDQ	32.8	36.5	32.7	0.562	0.755
BBQ	29.0	35.8	38.3	3.479	0.176
PSEQ	26.6^{a}	36.5^{b}	40.5^{b}	8.020	0.018
FABQ-P	36.2	31.2	34.3	0.933	0.627
FABQ-W	35.7	27.2	39.4	5.142	0.077
HSQ					
HP	19.0^{a}	41.7^{b}	44.3^{b}	24.060	0.001
PF	18.1^{a}	37.1^{b}	50.5^{c}	31.887	0.001
RP	14.8^{a}	40.1^{b}	51.3^{c}	42.277	0.001
RE	22.5^{a}	36.7^{b}	45.4^{c}	16.702	0.001
SF	22.4^{a}	39.5^{b}	42.4^{c}	14.397	0.001
MH	21.7^{a}	30.5^{b}	53.3^{c}	30.639	0.001
BP	18.9^{a}	38.4^{b}	48.1^{c}	26.813	0.001
EF	23.4^{a}	36.0^{b}	45.1^{b}	14.193	0.001

Alpha level was set at $p < 0.05$.
The Tukey multiple comparisons test was used to specify which groups differ.
Superscripts (^{a,b,c}).
For a particular variable, mean values with different superscript are significantly ($p<0.05$) different. Mean values with same superscripts are not significantly ($p>0.05$) different. The pair of cell means that is significant has different superscripts.

Key:
OLBPDQ = Oswestry Low-Back Pain Disability Questionnaire
BBQ = Back belief questionnaire
PSEQ = Pain self efficacy questionnaire
FABQ-P = Fear-Avoidance Beliefs Questionnaire – (Physical)
FABQ-W = Fear-Avoidance Beliefs Questionnaire (Work)
HSQ = Health status questionnaire; HP = Health perception; PF = Physical function; RP = Role physical; RE = Role emotional; SF = Social functioning; MH = Mental health; BP = Bodily pain; EF = Energy fatigue.

4.1.5 Comparison of treatment outcomes (mean change) at week eight of the study

The treatment outcomes of the participants in the three groups were compared at the end of the 8th week of the study. The results showed that there were significant differences in static and dynamic endurance and rate of perceived exertion across the group ($p>0.05$) at the end of the 8th week of the study. The LSD post-hoc analysis was used to elucidate where the differences within between groups lie (Table 17).

There were significant differences in PSEQ and SF-36 scores across the group ($p>0.05$) at the end of the 8th week of the study. The Tukey multiple comparisons analysis was used to elucidate where the differences within between groups lie (Table 18).

Table 17: One-way ANOVA and LSD post-hoc multiple comparison of the participants' treatment outcomes (mean change) for the continuous variables at week eight of the study

Outcome	MPG (n=25) x̄±SD	MPSBEEG (n=22) x̄±SD	MPDBEEG (n=20) x̄±SD	F-ratio	p-value
VAS now	4.52 ± 0.87[a]	4.73 ± 0.70 [a]	4.60 ± 0.80 [a]	0.392	0.678
VAS average	5.08 ± 0.28[a]	5.14 ± 0.35[a]	5.10 ± 0.31[a]	0.194	0.824
VAS best	3.44 ± 0.71[a]	3.73 ± 0.55[a]	3.35 ± 0.75[a]	1.841	0.167
VAS worst	6.20 ± 0.41[a]	6.00 ± 0.31[a]	6.00 ± 0.56[a]	1.672	0.196
QVAS	52.7 ± 3.73[a]	52.9 ± 3.30 [a]	52.3 ± 3.60[a]	0.125	0.883
RMDQ	5.76 ± 0.60[a]	5.68 ± 0.65[a]	6.00 ± 0.01[a]	2.114	0.129
SE	29.6 ± 8.44[a]	60.7 ± 17.1[b]	32.1 ± 10.2[a]	41.620	0.001
DE	8.36 ± 2.22[a]	18.1 ± 10.1[b]	16.6 ± 6.24[b]	13.981	0.001
SRPE	3.88 ± 1.67[a]	5.41 ± 2.32[b]	4.35 ± 1.63[b]	5.616	0.012
DRPE	3.40 ± 1.00[a]	4.55 ± 1.30[a]	7.05 ± 1.05[b]	60.210	0.001

Alpha level was set at $p < 0.05$.

Superscripts (a,b,c).

For a particular variable, mean values with different superscript are significantly ($p<0.05$) different. Mean values with same superscripts are not significantly ($p>0.05$) different. The pair of cell means that is significant has different superscripts.

Key:

x̄ = Mean

SD = Standard deviation

VAS = Visual Analogue Scale

QVAS = Quadruple Visual Analogue Scale (Total score – 100)

RMLDQ = Roland Morris Disability Questionnaire

SE = Static Endurance

DE = Dynamic Endurance

SRPE = Static rate of perceived exertion

DRPE = Dynamic rate of perceived exertion

Table 18: Kruskal Wallis test comparison of the participants' treatment outcomes (mean change) for the categorical variables at week eight of the study

Outcome	MPG (n=25) Mean Rank	MPSBEEG (n=22) Mean Rank	MPDBEEG (n=20) Mean Rank	H	p-value
OLBDDQ	33.8	36.9	31.1	0.925	0.630
BBQ	34.4	34.9	32.5	0.202	0.904
PSEQ	25.5[a]	37.4[b]	43.5[c]	18.106	0.001
FABQ-P	35.4	31.9	34.6	0.484	0.785
FABQ-W	36.1	28.8	39.6	3.746	0.154
HSQ					
HP	22.1[a]	43.2[b]	44.1[b]	27.010	0.001
PF	19.2[a]	40.1[b]	52.3[b]	33.122	0.001
RP	16.4[a]	41.2[b]	51.7[c]	46.108	0.001
RE	23.7[a]	38.2[b]	46.3[c]	22.112	0.001
SF	24.2[a]	40.4[b]	44.0[c]	16.014	0.001
MH	23.4[a]	36.2[b]	53.1[c]	36.114	0.001
BP	21.3[a]	40.3[b]	49.2[c]	28.612	0.001
EF	24.7[a]	38.2[b]	47.0[b]	15.018	0.001

Alpha level was set at $p < 0.05$.
The Tukey multiple comparisons test were used to specify which groups differ.

Superscripts ([a,b,c]).
For a particular variable, mean values with different superscript are significantly ($p<0.05$) different. Mean values with same superscripts are not significantly ($p>0.05$) different. The pair of cell means that is significant has different superscripts.

Key:
OLBPDQ = Oswestry Low-Back Pain Disability Questionnaire
BBQ = Back belief questionnaire
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FABQ-P = Fear-Avoidance Beliefs Questionnaire – (Physical)
FABQ-W = Fear-Avoidance Beliefs Questionnaire (Work)
HSQ = Health status questionnaire; HP = Health perception; PF = Physical function; RP = Role physical; RE = Role emotional; SF = Social functioning; MH = Mental health; BP = Bodily pain; EF = Energy fatigue.

4.2 HYPOTHESES TESTING

1. Hypothesis 1: The hypothesis stated that there would be no significant difference in the pain intensity of participants in the McKenzie Protocol Group (MPG) across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

a. Observed F-ratio for present pain intensity = 51.005 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed F-ratio for average pain intensity = 287.651 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

c. Observed F-ratio for pain at its best = 74.236 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

d. Observed F-ratio for pain at its worst =250.276 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

e. Observed F-ratio for total pain intensity score = 224.799 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

2. Hypothesis 2: The hypothesis stated that there would be no significant difference in the static muscle endurance of participants in the MPG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

Observed F-ratio = 47.402 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

3. Hypothesis 3: The hypothesis stated there would be no significant difference in the dynamic muscle endurance of participants in the MPG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

Observed F-ratio = 62.126 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

4. Hypothesis 4: The hypothesis stated that there would be no significant difference in the muscle fatigue of participants in the MPG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

a. Observed F-ratio for muscle fatigue to static test = 22.419 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed F-ratio for muscle fatigue to dynamic test = 16.767 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

5. Hypothesis 5: The hypothesis stated there would be no significant difference in the activity limitation of participants in the MPG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

Observed F-ratio = 263.798 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

6. Hypothesis 6: The hypothesis stated there would be no significant difference in the disability of participants in the MPG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

Observed F-ratio = 50.000 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

7. Hypothesis 7: The hypothesis stated there would be no significant difference in the Fear-Avoidance Behaviour (FAB) of participants in the MPG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

a. Observed F-ratio for FAB (physical) = 50.210 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed F-ratio for FAB (work) = 48.980 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

8. Hypothesis 8: The hypothesis stated that there would be no significant difference in the pain self-efficacy belief of participants in the MPG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

Observed F-ratio = 45.632 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

9. Hypothesis 9: The hypothesis stated there would be no significant difference in the belief of the consequences of back pain of participants in the MPG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

Observed F-ratio = 49.238 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

10. Hypothesis 10: The hypothesis stated that there would be no significant difference

in the general health status of participants in the MPG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

a. Observed F-ratio for health perception of GHS = 50.000 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed F-ratio for physical function of GHS = 48.080 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

c. Observed F-ratio for role physical of GHS = 45.960 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

d. Observed F-ratio for role emotional of GHS = 40.735 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

e. Observed F-ratio for social functioning of GHS = 48.910 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

f. Observed F-ratio for mental health of GHS = 47.446 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

g. Observed F-ratio for bodily pain of GHS = 52.108 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

h. Observed F-ratio for energy fatigue of GHS = 47.265 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

11. Hypothesis 11: The hypothesis stated that there would be no significant difference in the pain intensity of participants in the McKenzie Protocol plus Static Back Endurance Exercise Group (MPSBEEG) across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

a. Observed F-ratio for present pain intensity = 50.230 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed F-ratio for average pain intensity = 171.50 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

c. Observed F-ratio for pain at its best: F-ratio = 78.974 p =0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

d. Observed F-ratio for pain at its worst =186.562 p =0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

e. Observed F-ratio for total pain intensity score = 159.791 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

12. Hypothesis 12: The hypothesis stated that there would be no significant difference in the static muscle endurance of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

Observed F-ratio = 159.362 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

13. Hypothesis 13: The hypothesis stated that there would be no significant difference in the dynamic muscle endurance of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

Observed F-ratio = 13.981 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

14. Hypothesis 14: The hypothesis stated there would be no significant difference in the muscle fatigue of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

a. Observed F-ratio for muscle fatigue to static test = 38.069 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed F-ratio for muscle fatigue to dynamic test = 29.448 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

15. Hypothesis 15: The hypothesis stated that there would be no significant difference in the activity limitation of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

Observed F-ratio = 147.635 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

16. Hypothesis 16: The hypothesis stated that there would be no significant difference in the disability of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

Observed X^2 = 44.000 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

17. Hypothesis 17: The hypothesis stated there would be no significant difference in the Fear-Avoidance Behaviour (FAB) of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

a. Observed X^2 for FAB (physical) = 40.000 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed X^2 for FAB (work) = 44.000 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

18. Hypothesis 18: The hypothesis stated there would be no significant difference in the pain self-efficacy belief of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

Observed X^2 = 41.302 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

19. Hypothesis 19: The hypothesis stated there would be no significant difference in the belief of the consequences of back pain of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

Observed $X^2 = 37.904$ $p = 0.001$

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

20. Hypothesis 20: The hypothesis stated there would be no significant difference in the general health status of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

a. Observed X^2 for health perception of GHS = 42.340 $p = 0.001$

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed X^2 for physical function of GHS = 44.500 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

c. Observed X^2 for role physical of GHS = 41.400 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

d. Observed X^2 for role emotional of GHS = 39.321 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

e. Observed X^2 for social functioning of GHS = 43.517 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

f. Observed X^2 for mental health of GHS = 42.091 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

g. Observed X^2 for bodily pain of GHS = 44.120 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

h. Observed X^2 for energy fatigue of GHS = 38.273 $p = 0.001$

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

21. Hypothesis 21: The hypothesis stated that there would be no significant difference in the pain intensity of participants in the McKenzie Protocol plus Dynamic Back Endurance Exercise Group (MPDBEEG) across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

a. Observed F-ratio for present pain intensity = 42.534 $p = 0.001$

$F\text{-critical}_{(2, 66)} = 3.14$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed F-ratio for average pain intensity = 146.771 $p = 0.001$

$F\text{-critical}_{(2, 66)} = 3.14$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

c. Observed value for pain at its best: F-ratio = 52.399 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

d. Observed F-ratio for pain at its worst =206.763 p =0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

e. Observed F-ratio for total pain intensity score = 184.448 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

22. Hypothesis 22: The hypothesis stated there would be no significant difference in the static muscle endurance of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

Observed F-ratio = 15.011 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

23. Hypothesis 23: The hypothesis stated there would be no significant difference in the dynamic muscle endurance of participants in the MPDBEEG across weeks 0, 4 and 8

of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

Observed F-ratio = 26.890 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

24. Hypothesis 24: The hypothesis stated there would be no significant difference in the muscle fatigue of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

a. Observed F-ratio for muscle fatigue to static test = 23.652 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed F-ratio for muscle fatigue to dynamic test = 158.731 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

25. Hypothesis 25: The hypothesis stated that there would be no significant difference in the activity limitation of participants in the MPDBEEG across weeks 0, 4 and 8 of the

study.

Alpha level: 0.05

Test statistics: Repeated measure ANOVA

Observed F-ratio = 333.556 p = 0.001

$F\text{-critical}_{(2, 66)} = 3.14$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

26. Hypothesis 26: The hypothesis that stated there would be no significant difference in the disability of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

Observed $X^2 = 41.000$ p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

27. Hypothesis 27: The hypothesis stated there would be no significant difference in the Fear-Avoidance Behaviour (FAB) of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

a. Observed X^2 for FAB (physical) = 39.980 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed X^2 for FAB (work) = 40.000 $p = 0.001$

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

28. Hypothesis 28: The hypothesis stated that there would be no significant difference in the pain self-efficacy belief of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

Observed X^2 = 38.100 $p = 0.001$

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

29. Hypothesis 29: The hypothesis stated there would be no significant difference in the belief of the consequences of back pain of participants in the MPSBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

Observed X^2= 35.096 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

30. Hypothesis 30: The hypothesis stated there would be no significant difference in the general health status of participants in the MPDBEEG across weeks 0, 4 and 8 of the study.

Alpha level: 0.05

Test statistics: Friedman's ANOVA

a. Observed X^2 for health perception of GHS = 38.400 p = 0.001

X^2critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed X^2 for physical function of GHS = 40.220 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

c. Observed X^2 for role physical of GHS = 44.110 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

d. Observed X^2 for role emotional of GHS = 42.340 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

e. Observed X^2 for social functioning of GHS = 39.519 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

f. Observed X^2 for mental health of GHS = 43.124 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

g. Observed X^2 for bodily pain of GHS = 42.645 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

h. Observed X^2 for energy fatigue of GHS = 45.600 p = 0.001

X^2 critical = 5.99

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

31. Hypothesis 31: The hypothesis stated that there would be no significant difference

in the effect of the three treatment regimens on pain intensity at week four of the study.

Alpha level: 0.05

Test statistics: One-way ANOVA

a. Observed F-ratio for present pain intensity = 0.167 p = 0.847

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

b. Observed F-ratio for average pain intensity = 0.367 p = 0.694

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

c. Observed F-ratio for pain at its best = 0.491 p =0.614

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

d. Observed F-ratio for pain at its worst =0.341 p =0.712

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

e. Observed F-ratio for total pain intensity score = 0.522 p = 0.579

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

32. Hypothesis 32: The hypothesis stated there would be no significant difference in the effect of the three treatment regimens on static muscle endurance at week four of the study.

Alpha level: 0.05

Test statistics: One-way ANOVA

Observed F-ratio = 43.703 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

33. Hypothesis 33: The hypothesis stated there would be no significant difference in the effect of the three treatment regimens on dynamic muscle endurance at week four of the study.

Alpha level: 0.05

Test statistics: One-way ANOVA

Observed F-ratio = 12.088 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

34. Hypothesis 34: The hypothesis stated that there would be no significant difference

in the effect of the three treatment regimens on muscle fatigue at week four of the study.

Alpha level: 0.05

Test statistics: One-way ANOVA

a. Observed F-ratio for muscle fatigue to static test = 3.916 p = 0.025

$F\text{-critical}_{(2, 66)} = 3.14$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed value for muscle fatigue to dynamic test: F-ratio = 60.250 p = 0.001

$F\text{-critical}_{(2, 66)} = 3.14$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

35. Hypothesis 35: The hypothesis stated there would be no significant difference in the effect of the three treatment regimens on activity limitation at week four of the study.

Alpha level: 0.05

Test statistics: One-way ANOVA

Observed F-ratio = 8.556 p = 0.001

$F\text{-critical}_{(2, 66)} = 3.14$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

36. Hypothesis 36: The hypothesis stated there would be no significant difference in the effect of the three treatment regimens on disabilty at week four of the study.

Alpha level: 0.05

Test statistics: Kruskal-Wallis test

Observed Critical H value = 0.562 p = 0.755

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

37. Hypothesis 37: The hypothesis stated that there would be no significant difference in the effect of the three treatment regimens on Fear-Avoidance Behaviour (FAB) at week four of the study.

Alpha level: 0.05

Test statistics: Kruskal-Wallis test

a. Observed H value for FAB (physical = 0.933 p = 0.627

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

b. Observed H value for FAB (work) = 5.142 p = 0.077

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

38. Hypothesis 38: The hypothesis stated that there would be no significant difference in the effect of the three treatment regimens on pain self-efficacy belief at week four of

the study.

Alpha level: 0.05

Test statistics: Kruskal-Wallis test.

Observed H value = 8.020 $p = 0.018$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

39. Hypothesis 39: The hypothesis stated that there would be no significant difference in the effect of the three treatment regimens on belief of consequences of back pain at week four of the study.

Alpha level: 0.05

Test statistics: Kruskal-Wallis test

Observed H value = 3.479 $p = 0.176$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

40. Hypothesis 40: The hypothesis stated that there would be no significant difference in the effect of the three treatment regimens on general health status (GHS) at week four of the study..

Alpha level: 0.05

Test statistics: Kruskal-Wallis test

a. Observed H value for health perception of GHS = 24.060 $p = 0.001$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed H value for physical function of GHS = 0.31.887 $p = 0.001$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

c. Observed H value for role physical of GHS = 42.277 $p = 0.001$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

d. Observed H value for role emotional of GHS = 16.702 $p = 0.001$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

e. Observed H value for social functioning of GHS = 14.397 $p = 0.001$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

f. Observed H value for mental health of GHS = 30.639 $p = 0.001$

Critical H $_{(2, 66)}$ = 5.805

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

g. Observed H value for bodily pain of GHS = 26.813 p = 0.001

Critical H $_{(2, 66)}$ = 5.805

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

h. Observed H value for energy fatigue of GHS = 14.193 p = 0.742

Critical H $_{(2, 66)}$ = 5.805

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

41. Hypothesis 41: The hypothesis stated that there would be no significant difference in the effect of the three treatment regimens on pain intensity at week eight of the study.

Alpha level: 0.05

Test statistics: One-way ANOVA

a. Observed F-ratio for present pain intensity = 0.392 p = 0.678

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

b. Observed F-ratio for average pain intensity = 0.194 p = 0.824

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

c. Observed F-ratio for pain at its best = 1.841 p =0.167

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

d. Observed F-ratio for pain at its worst =1.672 p =0.196

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

e. Observed F-ratio for total pain intensity score = 0.125 p = 0.883

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

42. Hypothesis 42: The hypothesis stated there would be no significant difference in the effect of the three treatment regimens on static muscle endurance at week eight of the study.

Alpha level: 0.05

Test statistics: One-way ANOVA

Observed value: F-ratio = 41.620 p = 0.001

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

43. Hypothesis 43: The hypothesis stated that there would be no significant difference in the effect of the three treatment regimens on dynamic muscle endurance at week eight of the study.

Alpha level: 0.05

Test statistics: One-way ANOVA

Observed F-ratio = 13.981 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

44. Hypothesis 44: The hypothesis stated that there would be no significant difference in the effect of the three treatment regimens on muscle fatigue at week eight of the study.

Alpha level: 0.05

Test statistics: One-way ANOVA

a. Observed F-ratio for muscle fatigue to static test = 5.616 $p = 0.012$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed F-ratio for muscle fatigue to dynamic test = 60.210 $p = 0.001$

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

45. Hypothesis 45: The hypothesis stated there would be no significant difference in the effect of the three treatment regimens on activity limitation at week eight of the study.

Alpha level: 0.05

Test statistics: One-way ANOVA

Observed F-ratio = 2.114 p = 0.129

F-critical $_{(2, 66)}$ = 3.14

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

46. Hypothesis 46: The hypothesis stated there would be no significant difference in the effect of the three treatment regimens on disability at week eight of the study.

Alpha level: 0.05

Test statistics: Kruskal-Wallis test

Observed H value = 0.925 p = 0.630

Critical H $_{(2, 66)}$ = 5.805

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

47. Hypothesis 47: The hypothesis stated that there would be no significant difference in the effect of the three treatment regimens on Fear-Avoidance Behaviour (FAB) at

week eight of the study.

Alpha level: 0.05

Test statistics: Kruskal-Wallis test

a. Observed H value for FAB (physical) = 0.484 p = 0.785

Critical $H_{(2, 66)}$ = 5.805

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

b. Observed H value for FAB (work) = 3.746 p = 0.154

Critical $H_{(2, 66)}$ = 5.805

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

48. Hypothesis 48: The hypothesis stated that there would be no significant difference in the effect of the three treatment regimens on pain self-efficacy belief at week four of the study.

Alpha level: 0.05

Test statistics: Kruskal-Wallis test.

Observed H value = 18.106 p = 0.001

Critical $H_{(2, 66)}$ = 5.805

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

49. Hypothesis 49: The hypothesis stated that there would be no significant difference

in the effect of the three treatment regimens on belief of consequences of back pain at week four of the study.

Alpha level: 0.05

Test statistics: Kruskal-Wallis test

Observed H value = 0.202 p = 0.904

Critical $H_{(2, 66)}$ = 5.805

Since the observed p-value was higher than 0.05 Alpha level. The hypothesis was therefore NOT REJECTED.

50. Hypothesis 50: The hypothesis stated that there would be no significant difference in the effect of the three treatment regimens on general health status (GHS) at week eight of the study.

Alpha level: 0.05

Test statistics: Kruskal-Wallis test

a. Observed H value for health perception of GHS = 27.010 p = 0.001

Critical $H_{(2, 66)}$ = 5.805

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

b. Observed H value for physical function of GHS = 33.122 p = 0.001

Critical $H_{(2, 66)}$ = 5.805

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

c. Observed H value for role physical of GHS = 46.108 $p = 0.001$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

d. Observed H value for role emotional of GHS = 22.112 $p = 0.001$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

e. Observed H value for social functioning of GHS = 16.014 $p = 0.001$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

f. Observed H value for mental health of GHS = 36.114 $p = 0.001$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

g. Observed H value for bodily pain of GHS = 28.612 $p = 0.001$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

h. Observed H value for energy fatigue of GHS = 15.018 $p = 0.742$

Critical $H_{(2, 66)} = 5.805$

Since the observed p-value was lesser than 0.05 Alpha level. The hypothesis was therefore REJECTED.

4.3 DISCUSSION

4.3.1 Participants' socio-demograhic and clinical profile

This study investigated the effect of static or dynamic back extensors endurance exercise in combination with McKenzie Protocol on physiological and psychosocial variables in patients with long-term mechanical LBP. The age range of the participants in this study is between 38 and 62 years with a mean of 51.8 ± 7.35 years. The age range of the participants is within the age bracket during which LBP is reported to be a more common problem (Leboeuf-Yde and Kyvik, 1998).

The profile of syndromes of the participants in this study based on the centralization phenomenon and directional preference (McKenzie, 1981) showed that 83.5% of the participants had posterior derangement syndrome, 7.5% had dysfunction syndrome and 9.0% had postural syndrome. The distribution of syndromes of mechanical LBP observed in this study is similar to the trends reported by previous investigators among patients with mechanical LBP in the general population. Kilby et al., (1990) in a study among 41 patients found the prevalence of 42.7%, 22% and 2.4% for derangement, dysfunction and postural syndromes respectively. Riddle and Rothstein (1993) in a study among 363 patients found a prevalence of 52.9%, 34.7% and 9.6% for derangement, dysfunction and postural syndromes respectively. Razmjou et al., (2000) in a study among 45 patients found 86.7%, 4.4% and 2.2% for derangement, dysfunction and postural syndromes respectively, while Kilpikoski et al., (2002) in a study among 39 patients found 90% and 2% for derangement and dysfunction syndromes respectively. A common trend among all the cited studies is the preponderance of derangement syndrome in patients with mechanical LBP.

The profile of directions of preference of the participants in this study showed that 3.4% had direction preference for flexion, 94.4% had direction preference for extension while 2.3% had no direction preference at all. The pattern of direction preference found in this study is comparable to a study by Hefford (2008) who found 70% and 6% direction preference for extension and flexion respectively among 140 patients with mechanical LBP. Similarly, another study by Glover and May (2009) found extension as the most common directional preference (83%) among 28 patients who had mechanical assessment.

4.3.2 Drop-out rate among the participants

The total drop-out rate observed in this study was 20.2%. Varying drop-out rates from previous studies on physiotherapy for LBP from the developed countries have been reported. Torstensten et al., (1998) and Rittweger et al., (2002) reported 15% drop–out respectively in patients receiving treatment for LBP. Hurley et al., (2004) reported a 30% drop-out in a trial investigating physiotherapy for LBP. Similarly, Johnson et al., (2010) in a 8-week study that compared four physiotherapy regimens in the treatment of long-term mechanical LBP among Nigerian patients reported a 27.4 % drop-out. However, the observed drop-out rate in this study is less than the 30% benchmark for defining acceptable level of drop-out in studies involving patients with LBP.

Reasons for drop-out in clinical trials on physiotherapy for LBP seem to vary from one facility to another and from one geographical location to another. 47.1% of the patients who dropped out in this study discontinue with treatment because of the observed improvement in their health condition before the eight week that the study was supposed to last for each participants. Of the 47.1% drop-out to improvement, participants who had McKenzie Protocol plus Dynamic Back Endurance Exercise Group (MPDBEEG) had 62.5% while the patients that had McKenzie Protocol plus Static Back Endurance Exercise Group (MPSBEEG) had 37.5%.

Fifty two point nine of the other patients were lost to logistical problem such as inflexibility of time. The finding on the reason for drop-out in this study is consistent with the common anecdotal reports that patients usually discontinue with treatment once they think their improvement is good enough (Al-Eisa, 2010; Johnson, 2010).

4.3.3 Comparison of baseline parameters of participants in the three groups

From the result of this study, no significant difference in physical characteristics and baseline outcome parameters of the participants in the different treatment groups was observed. Baseline characteristics are believed to be predictors of response to treatment in clinical trials for LBP (Child et al., 2004; Hagen et al., 2005; Underwood et al., 2007). Comparability in baseline measure in clinical trials is reported to reduce the chances of co-founders other than the intervention in predicting outcomes. However, Friedman et al., (2010) submitted that for many measurements, baseline data may not reflect participant true condition at the time of baseline, because investigators perform baseline assessment close to the time of intervention. Nonetheless, from the result of this study, the groups were comparable in their general characteristics and baseline physiological and psychosocial parameters. Therefore, it is implied that the results obtained at different point in the course of the study could have been largely due to the effects of the various treatment regimens.

4.3.4 Effect of the McKenzie Protocol on physiological variables in mechanical long-term LBP

Within-group comparison across the 3 time-points (weeks 0-4, 4-8 and 0-8) of the study revealed that the McKenzie protocol (MP) had significant effects on the on pain, muscle fatigue and static and dynamic endurance respectively. These findings are consistent with previous reports that demonstrated evidence for use of the McKenzie protocol (Delitto et al., 1993; Schenk et al., 2003; Ponte et al., 1984; Nwuga and Nwuga, 1985; Stankovic and Johnell, 1990; Reddeck, 1997; Cherkin et al., 1998; Machado et al., 2006).

The mechanism by which the MP achieves its therapeutic effects is largely dependent on patients' differences and pathologic conditions as the type of McKenzie syndrome. For example derangement syndrome is believed to result in obstructed range of motion (McKenzie, 1990; Donelson et al., 1997; Ayanniyi et al, 2007). McKenzie postulated that spinal flexion causes a movement of the nucleus pulposus to a more posterior position due to increased mechanical compression on the anterior surface of the intervertebral disc (McKenzie, 1990). Therefore, extension in derangement syndrome is proposed to help alleviate stress on the posterior annulus, decreased nerve root compression and thereby relieve pain (Fennell et al., 1996; Ordway et al., 1999). Nuclear pressure is reduced when compressive force is transferred from the vertebral disc body unit to the apophyseal joints during extension exercise (Adams et al., 1980; Quinnell et al., 1983; Nachemson, 1992; Adams et al., 1994). Furthermore, Adams et al., (200) posited that the posterior anulus can be stress shielded by the neural arch in extended postures, and this may explain why extension exercises can relieve LBP in some patients.

Consequent on the foregoing, previous studies have shown that extension movements cause an anterior migration of nuclear tissue, which conversely displaces posteriorly during flexion (Vanharanta et al., 1987; Coppes et al., 1991; Schwarzer et al., 1995; Fennell et al., 1996). Therefore, the success of extension principle of the McKenzie method may be linked to the ability of the exercises to have an effect on internal displacements and also reduce posterior protrusions in some intervertebral discs (Kopp et al., 1986; Alexander et al., 1991).

Alternatively, extension movements may relieve pain by reducing the forces acting on pain-sensitive tissues (Adams et al., 2000). Extension movements are hypothesized to unload the entire disc as the vertebrae can pivot around the apophyseal joints during the manoeuvre (Adams et al., 2000). Similarly, within the disc itself, extension causes a transfer of load from the anterior anulus and nucleus to the posterior annulus (McNally et al., 1992; Adams et al., 1994) and the effect is magnified after creep-loading (Adams et al., 1996). Sustained and repeated extension movements have been shown in some studies to increase the height of the spine presumably by unloading the disc and permitting rehydration (Magnusson et al., 1996).

Studies on the effect of the MP on muscle fatigability and endurance (static or dynamic) seem not available in literature. However, this present study found that patients that were treated with the McKenzie protocol only had significantly decreased back muscles' fatigability and increased static and dynamic back extensor muscles' endurance respectively. It is opined that the effect of MP on muscle fatigue and endurance might be due to the relationship between pain and each of muscle fatigue and endurance. It is believed that chronic pain and fatigue often occur together in majority of individuals with musculoskeletal pain and that muscle pain and fatigue are not independent conditions, and may share a common pathway that is disrupted in chronic muscle pain conditions (UoI, 2008). Similarly, pain in itself has been reported to precipitate decreased muscle endurance resulting from increased muscle metabolite from prolonged muscle tension and spasm (Armstrong, 1984), muscle deconditioning (Roy and Oddsson, 1998) and inhibition of the paraspinal muscles (Roy and Oddsson, 1998). It is adduced that the MP may not have a direct effect on muscle fatigue and endurance but a consequence of its effect on pain. However, this speculation is open to empirical investigation.

4.3.4 Effect of the McKenzie Protocol on psychosocial variables in mechanical long-term LBP

Within-group comparison across the 3 time-points (weeks 0-4, 4-8 and 0-8) of the study revealed that the MP had significant effects on the psychosocial variables. The effect of the McKenzie protocol on the studied psychosocial variables was comparable with other treatment regimens that incorporated static or dynamic back endurance exercise except for activity limitation and pain self-efficacy belief where the addition of dynamic endurance exercise to the MP led to higher treatment effect. Previous studies have reported an association between LBP and psychosocial factors (Hill and Fritz, 2011; Main and George, 2011). Management of LBP is described as a continuum of physical and psychosocial factors, with varying amounts of each (Main and George, 2011). The traditional approach based on a biomedical model is centered on the treatment of physical factors, whereas the psychological model is based on psychosocial factors (Main and

George, 2011). It is widely accepted that LBP and disability can only be understood and managed in the light of a bio-psychosocial model (a model that includes physical, psychological and social elements), which describes the key psychological and behavioural factors that may help to understand current levels of pain and disability (Waddel 1987; Turk et al., 1988).

Evidence suggests that psychosocial factors have an influence on the outcome of physical therapy treatment and that the extent of their influence differs considerably among patients (Hill and Fritz, 2011). Increasing studies suggest that the psychosocial factors are likely to have important roles as prognostic factors and treatment effect-modifiers-or-mediators in patients with LBP (Jellema et al., 2005; 2006; Hill and Fritz, 2011). Prognostic factors are those characteristics that help to estimate a patient's likely outcome irrespective of the chosen management (Hill and Fritz, 2011), treatment effect modifiers are pre-randomized or baseline characteristics that may moderate or influence treatment outcomes (Dunn, 2007) while treatment effect mediators are factors that change during or as a consequence of treatment and correlate with a defined outcome (Hill and Fritz, 2011).

A previous study by Smeets and colleagues (2006) submitted that active physical therapy regimen primarily designed to improve physiological aspects of LBP such as aerobic fitness level, low back muscle strength and endurance can also reduce the impact of psychosocial factors such as pain catastrophizing that it did not deliberately target. In view of current evidence, Hill and Fritz (2011) suggested that it may not necessarily follow that a psychologist is better placed to improve treatment outcomes than a physical therapist, even when a goal of treatment is the mediation of a psychosocial factor such as pain catastrophizing. The authors (Hill and Fritz, 2011) further submitted that what is apparent is that such factors, which are broadly termed psychosocial factors, have a strong influence on the success of treatment for patients with back pain at a group level. Unfortunately, there is a dearth of studies on the effect of the MP on psychosocial variables in patients with long-term mechanical LBP. Further studies are necessary to corroborate the result of this study and to verify how the MP affects psychosocial variables of patients with long-term mechanical LBP.

4.3.5 Effect of McKenzie Protocol plus Static Back Endurance Exercise on the physiological variables

Within-group comparison across the 3 time-points (weeks 0-4, 4-8 and 0-8) of the study revealed that the McKenzie Protocol plus Static Back Endurance Exercise (MPSBEE) had significant effects on pain, muscle fatigue and static and dynamic endurance respectively. There seems to be a scarcity of similar studies to which the result obtained in this study can be compared directly. However, there are other reports that indicate that endurance training of the low back extensors can be effective in relieving LBP, elevate fatigue threshold and improve performance, thus reducing disability (Plum and Rehfeld, 1985; Manniche et al., 1988; Moffroid et al., 1993; Chok et al., 1999), and decrease work loss (Lindstrom et al., 1992; Gundewall et al., 1993; LeFort and Hannah, 1994).

Moffroid in 1997 submitted that research to determine how endurance training of trunk muscles in persons with long-term LBP affects performance and function is sparse. Since then, little research on endurance training of trunk muscles in persons with long-term LBP has been recorded (Chok et al., 1999; van der Velde and Mierau, 2000; Petersen et al., 2002; Udermann et al., 2004). Even though, it is suggested that muscular endurance training of the back extensors is believed to be more important in the treatment and prevention of LBP than muscular strength (Udermann et al., 2003). Furthermore, endurance training is believed to cause mechanical loading of the muscles (Moffroid, 1997) which in turn leads to tissue adaptation (Kjaer, 2004).

The orientation and posture for the static back extensor endurance exercise in this study was extension in sagittal plane while in prone-lying. It is believed that an increase in sagittal curvature and change in spinal shape may alter physiologic loading through the spine as a consequence of a shift in trunk mass (Pearsall and Reid, 1992). Also, it is adduced that the increased mechanical loading resulting from the change in spinal posture during a static hold or posturing in prone-extension may put a stress on the musculature of the back extensors. The above stated assertion is corroborated by studies that indicated that changes in spinal posture may lead to alterations in length-tension relationships and function of paraspinal musculature (O'Sullivan et al., 2002); moment arm lengths and force vector orientations (Tveit et al., 1994; McGill et al., 2000). In addition, increased mechanical loading may have a reactivating effect on the paraspinal musculature (Cook et al., 1990; McGill, 1991; Delitto and Rose, 1992) and this may account for one of the ways static back endurance exercise achieves it therapeutic effect. Conversely, mechanical loading that exceeds the fatigue threshold of the back muscles is deleterious (Kelsey et al., 1984; Adams et al., 1985; 1995; Kankaanpää et al., 1997). However, change in muscles properties in response to static contraction is proposed to be dependent on the relationship between motor unit activity and conduction velocity of the muscle fibre membrane (Krogh-Lund and Jorgensen, 1991; Crenshaw et al., 1997). Nonetheless, it is difficult to compare the result of this study directly with other previous findings without caution; this is because of the variability that exists in mode, load, frequency and volume of exercise training. Furthermore, some of the previous studies did not clearly delineate resistance training of the lumbar extensor as either strength or endurance, static or dynamic.

4.3.6 Effect of McKenzie Protocol plus Static Back Endurance Exercise on the psychosocial variables

Within-group comparison across the 3 time-points (weeks 0-4, 4-8 and 0-8) of the study showed significant differences in all the psychosocial variables in of the participants. It is implied that MPSBEE had effect on psychosocial variables in patients with long-term mechanical LBP. Literature suggests that exercise generally has a potential benefit on psychosocial aspect of patient with long-term LBP (Pollock et al., 1998b; Scully et al., 1998; Burton et al., 2004; Rainville et al., 2004). Long-term LBP leads to deconditioning (Verbunt et al., 2003; Duque et al., 2009) and many problems associated with deconditioning are believed to be reversible through general and specific exercise regimens (Harding and Watson, 1998). Harding and Watson (1998) submitted that improvement in overall physical function is linked with improvement in psychosocial function.

4.3.7 Effect of McKenzie Protocol plus Dynamic Back Endurance Exercise on the physiological variables

Within-group comparison across the 3 time-points (weeks 0-4, 4-8 and 0-8) of the study revealed that McKenzie Protocol plus Dynamic Back Endurance Exercise (MPDBEE) had significant effects on the on pain, muscle fatigue and static and dynamic endurance respectively. Over the past decades, different types of dynamic exercises have employed in the management of patients with LBP with varying reported successes (Manniche et al., 1991; Lee, 1994; Elia et al., 1996; Bentsen et al., 1997). Johannsen et al., (1995) found that dynamic endurance training improved isokinetic back muscle strength and endurance, while Arokoski et al., (1999) reported that they are effective in activating the paraspinal muscles.

The basis for dynamic exercises in low-back rehabilitation in most of the previous studies was due to the fact that in reality, some daily tasks involve dynamic movement and may require dynamic endurance more than static endurance (Leigh and Sheetz, 1989; McGill, 1999b; Zinzen et al., 2000). During dynamic tasks, it has shown that the force generation and muscle recruitment activities associated with twisting change significantly as a function of the trunk posture (Marras et al., 1998) and the activity of the trunk muscles can be used to speculate on the stress on the lumbar intervertebral joints (Seroussi and Pope, 1987; Cook et al., 1990; McGill, 1991; Delitto and Rose, 1992). Consequently, the dynamic tasks could possibly lead to LBP (Pinupong, 2005). Therefore, the concept of dynamic training for the trunk muscles to act in a synchronous manner to maintain stability (McGill, 199b) is supported by reported link between mechanical instability of the lumbar spine and LBP disorders (Cholewicki and McGill,

1996) and the association of LBP with muscle dysfunction (O'Sullivan et al., 1997). However, to the knowledge of the researcher, there seems to be an apparent dearth of studies that have examined the effects of combining the McKenzie protocol and dynamic endurance training of the back extensors.

4.3.8 Effect of McKenzie Protocol plus Dynamic Back Endurance Exercise on the psychosocial variables

Within-group comparison across the 3 time-points (weeks 0-4, 4-8 and 0-8) of the study showed significant differences in all the psychosocial variables of the participants. Similar to this study's result on MPSBEE on psychosocial variables, it was deduced that MPDBEE was effective in improving psychosocial variables in patients with long-term mechanical LBP. Unfortunately, there seems to be a dearth of studies involving dynamic endurance exercise of the back extensor muscles compared with a chronicle of few studies that have investigated the effect of static muscular endurance exercise training in patients with acute (Plum and Rehfeld, 1985), sub-acute (Chok et al., 1999) and long-term LBP (Thompson, 1992) respectively. Meanwhile, dynamic endurance may be needed more than static endurance as most of the daily tasks involve dynamic movement (Leigh and Sheetz, 1989; Burnett and Glenn, 1990).

4.3.9 Comparative efficacy of static and dynamic back extensor muscles endurance exercise in patients with long-term mechanical low-back pain treated with McKenzie protocol

McKenzie Protocol plus Static Back Endurance Exercise (MPSBEE) led to higher significant improvement on static and dynamic endurance and reduction in muscle fatiguability at week four and eight respectively. Meanwhile, McKenzie Protocol plus Dynamic Back Endurance Exercise (MPDBEE) led to higher effect on activity limitation at week four; and on pain self-efficacy belief and all domains of general health status at week four and eight respectively. Similar to the findings of this study, Petersen et al., (2002) in a study that compared the effect of the MP and resistance training of the lumbar extensor musculature in patients with chronic LBP (Petersen et al., 2002) concluded that the McKenzie protocol and resistance training of the lumbar extensor musculature were equally effective. Another study by Udermann et al., (2004) examined the effects of combining the McKenzie protocol and resistance training of the lumbar extensors and concluded that the McKenzie protocol was effective at improving both physiological and psychosocial variables and also that the addition of resistance training to the McKenzie protocol provided no additional benefit.

The observed efficacy of the MP, MPSBEE and MPDBEE in this study could be as a result of the fact that each of the regimen contained active exercise carried out in extension positions. Many studies have shown that exercises and postures in extension improve and resolve symptoms in patients with specific and nonspecific LBP **(**Ponte et al., 1984; Nwuga and Nwuga, 1985; Kopp et al., 1986; Alexander et al., 1991; Williams et al., 1991; Adams, 1993). Active exercise is described as functional exercise performed by the patient or client. Previous studies have shown that active exercise, irrespective of the type is more effective in the management of patients with long-term LBP than passive therapy (Frost et al., 1995; Kankaanpaa et al., 1999; Rainville et al., 2002). Active exercise in their different forms in long-term LBP are aimed at restoring back function by improving movement, strength, endurance and general fitness (Rainville et al., 2004). The McKenzie protocol utilizes a system of patient self generated force to mobilize or manipulate the spine through a series of active repeated movements or static positioning and it is based on the patient's pain response to certain movements and postures during assessment (McKenzie, 1981). Similarly, endurance exercises are active exercises that require static posturing or repeated movements in order to initiate overload stimuli on the musculature.

Movement is a major element of active exercise. The different treatment regimen in this study had movement components, either from the McKenzie protocol which is the baseline treatment for all the groups or from the back extensors endurance exercise protocols. Movement is reported to enhance healing in the musculoskeletal system by stretching muscles, tendons and ligaments, by increasing blood and nutrients supply to back extensor muscles, by mobilizing stiff joints, and by mechanically affecting disc pathology, or a combination of all the different effects (Mooney, 1995a, Mooney, 1995b; Nelson et al., 1999; Udermann et al., 2004).

Pain is the major impairment of long-term LBP and it results in deconditioning of the musculoskeletal system leading to loss of motion, stiffness, cartilage degeneration, fear-avoidance behaviour, iatrogenic muscular inhibition and muscle atrophy (Holmes et al., 1996; Nelson et al., 1999). Like a vicious cycle, the deconditioning syndrome may also precipitate and perpetuate pain which consequents in recurrent or acute-on-chronic LBP. Pain leads to muscle guarding or splinting of all movements in the affected region, splinting or disuse leads to muscular atrophy, which in turn results in weakness (Holmes et al., 1996). The weakness therefore, may be secondary to inhibition caused by the noxious stimuli caused by pain (Holmes et al., 1996). The movement component of treatment regimens as used in this study may have resulted in reconditioning of the patients by making them to expand the limits to their physical functioning, retard muscle atrophy, enhance their pain control ability and improve the psychosocial factors affected by LBP. This is in order to counteract the effect of long-term LBP which precipitates inhibition of movements and thus results in physical inactivity and consequent neurological and physiological changes of the paraspinal musculature resulting in back muscles' inhibition, selective loss of Type 2 muscle fibers, weakness and shortening (Ahern et al., 1990; Rainville et al., 1993; Rissanen et al., 1995; Rainville et al., 2002).

From this study, MPSBEE led to higher improvement on physiological variables of static back endurance, dynamic back endurance and fatigability of the back extensors of patients with long-term mechanical LBP. Previous studies indicated that static training programme was effective for increasing isometric (static) endurance of the trunk extensor muscles in healthy (Moffroid et al., 1993; Adegoke and Babatunde, 2007) and patient populations (Mayer et al., 1989; Kohles et al., 1990; Chok et al., 1999; Mannion et al., 2001; Petersen et al., 2002; Udermann et al., 2004) respectively. Another study among healthy male adults found that static training can increased both isometric and dynamic endurance while dynamic training can increased dynamic endurance only (Pinupong, 2005). The treatment methodology for the participants in this group involved both movement and mechanical loading components. The treatment regimen may have possible stimulating and reactivating effect on the inhibited muscles of the back extensors caused by long-term LBP. This is because skeletal muscle tissues adapts to higher level of stimulus. An overload stimulus is believed to improve neural control, muscle contractile protein size and muscular hypertrophy (Holmes et al., 1996). Addition of load to movement is reported to enhance predominantly fast motor unit recruitment (McArdle et al., 1996). The physiological principle on which static endurance training depends is the overload principle. This principle states simply that the strength, endurance and hypertrophy of a muscle will increase only when the muscle performs for a given period of time at its maximum strength and endurance capacity, i.e. against workloads that are above those normally encountered (Pinupong, 2005).

On the other hand, MPDBEE led to significantly higher positive effects on the psychosocial variables of activity limitation, pain self-efficacy belief and all domains of general health status at week 4, and in pain self-efficacy belief and all domains of general health status at week 8. A previous study by Manniche et al., (1991) found that intensive dynamic back extensor exercises was effective and without risk in patients with long-term LBP. Nelson et al., (1995) reported that lumbar extension exercise against dynamic resistance was effective in the management of patients with long-term LBP. Another study by Johannes et al., (1995) in a study which compared intensive training of muscle endurance with a protocol that emphasized coordination in the management of long-term LBP and concluded that subjects in the muscle endurance group improved in pain, disability, and spinal mobility. Conversely, Hansen et al., (1993) in a study compared intensive dynamic back exercise, standard physiotherapy and placebo and reported that all the groups were comparable in their effect on pain. Also, Bentsen et al., (1997) compared supervised intensive dynamic back exercise and home exercise and found no significant difference in their effect on functional ability.

It is adduced from the results of this study that the significant higher treatment outcome might be due to combine effects of movements and overload stimulus on the back extensor muscles. MPDBEE seems to contain movement ingredients from double font. Firstly, the MP which is a baseline treatment for this group involved a series of active repeated movements. Secondly, the dynamic back extensors endurance exercise also involved repeated movements of the trunk and limbs in the sagittal plane. Loss of movements to long-term LBP is often due to splinting or guarding resulting from pain. It seems that extension exercise with movement elements carried out in pattern similar to the daily tasks motions might help to improve psychosocial aspects of long-term LBP as observed in this study. The finding is in line with previous reports suggesting that patients with LBP whose treatment regimen do not avoid pain and movements have less disability (Rosentiel and Keefe, 1983; Estanlder and Harkapaa, 1989; Holmes and Stevenson, 1990; William and Keefe, 1991).

Generally, the findings of this study on the effect of static and dynamic back extensor muscles endurance exercise on physiological and psychosocial variables of patients with LMLBP treated with MP cannot be adequately compared with other studies. This is because most of the previous studies lacked randomized controls (Coxhead et al., 1981; Plum and Rehfeld, 1985), standardized and clearly defined exercise guidelines or protocols (Plum and Rehfeld, 1985; Manniche et al., 1988), common methodological approach and definition of construct/concept. In order, to minimize some of the shortcomings of previous studies, this study ensured homogeneity of sample by recruiting patients who had directional preference for extension only and all exercise were conducted in the sagittal plane.

In order to achieve adequate training effect based on recommendation of previous studies (Fox et al., 1988; Liddle et al., 2004), the frequency, intensity, type and time principle was applied in selecting dosage. This involved a 30 to 45 minute, thrice weekly and eight weeks exercise; and training load of 10 seconds static hold or 10 repetitions per exercise position. From the post-hoc results across the 3 time points of the study, it was observed that the different treatment regimens had significant effect at week four on all the physiological and psychosocial variables except for the effect on muscle fatigue of McKenzie protocol only that was only significant at the week eight. The effect of the different treatment regimens on the physiological and psychosocial variables were significantly higher at week eight of the study compared with week four. However, the effect of MP only on beliefs about the consequences of back pain, fear-avoidance behaviour (physical) and mental health domain of the general health status questionnaire were comparable at week four and eight of the study. Furthermore, the effect of MPSBEE on disability, beliefs about the consequences of back pain, pain-self efficacy belief, and fear-avoidance behaviour (physical and work) were comparable at week four and eight of the study. However, a lower or higher exercise dosage could yield different result. It was adduced that a four-week MP as well as the addition of static or dynamic back extensors endurance exercises are effective in improving physiological and psychosocial variables of patients with long-term mechanical LBP.

4.3.10 Clinical implications of the findings

The clinical implications of the findings were as follow:

- MP, MPSBEE and MPDBEE were comparable in their effect on pain, disability, beliefs about the consequences of back pain and fear-avoidance belief behaviour in patients with long-term mechanical LBP.

- MPSBEE may lead to significantly higher positive effect on physiological variables of static and dynamic back endurance and reduction in muscle fatigability of the back extensors in patients with long-term mechanical LBP within eight weeks of treatment.

- MPDBEE may lead to significantly higher positive effects on the psychosocial variables of activity limitation in patients with long-term mechanical LBP within four weeks of treatment.

- MPDBEE may lead to significantly higher positive effects on the psychosocial variables of pain self-efficacy belief and all domains of general health status in patients with long-term mechanical LBP within eight weeks of treatment.

- MP as well as the addition of static or dynamic back extensor muscles' endurance exercises was effective in improving physiological and psychosocial factors in patients with long-term mechanical LBP.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 SUMMARY

Long-Term Mechanical Low-Back Pain (LMLBP) is a growing public health concern characterized by exacerbated nociceptive sensations, decreased physical performance, impaired psychosocial functioning and work disability. LMLBP has maintained a deviant stance against most therapeutic approaches and constitutes a challenge to clinicians and researchers worldwide. McKenzie protocol is a common efficacious conservative therapy but its use in addressing back muscles inhibition accompanying LMLBP is doubtful. However, back endurance exercise is suggested to enhance muscle reactivation. This study investigated the effect of static or dynamic back extensors endurance exercise in combination with the McKenzie protocol on physiological and psychosocial variables in patients with LMLBP using the bio-psychosocial model.

The literature review for this study focused on the definition, classification, epidemiology, aetiology and risk factors for Low-Back Pain (LBP). The review examined the different management models in LBP with emphasis on the bio psychosocial model which currently is the state of the art in rehabilitation and disability perspectives. The conservative and non-conservative management of LBP were also studied. The non-conservative approach involving different types of exercise therapies were scrutinized. The McKenzie protocol was found to be a popular classification-based treatment method for LBP among physical therapists but evidence on its effect in addressing back muscles inhibition accompanying long-term mechanical LBP is sparse. On the other hand, emerging reports indicate that back endurance exercise enhance muscle reactivation and reconditioning. The review also looked at the International Classification of Functioning, Disability and Health (ICF) framework for conducting low back research which was based on the bio psychosocial model. The anatomy of the back was examined. Different physical assessment tests for low back research and management involving the Biering-Sorensen test of static muscular endurance and the Repetitive Arch-Up Test; and Selected outcome measures in long-term LBP involving the Quadruple Visual Analogue Scales (VASs) Oswestry Disability Questionnaire, Roland - Morris Low-Back Pain and Disability Questionnaire, The Short Form *-36* (SF-36), Borg scale (6-20), Pain self efficacy questionnaire, Fear-avoidance behaviour, Belief of consequence of back pain, and Back belief questionnaire were reviewed. The review considered previous studies that employed some form of back extensors exercise in the management of patients with LBP. The literature review was concluded with the justification for the study which was based on the recommendations and gaps identified in the previous studies.

A pretest-posttest single-blind controlled trial was carried out. Ethical approval for the study was obtained from the Ethics and Research Committee of the Obafemi Awolowo University Teaching Hospitals Complex (Reg no.: ERC/2010/01/02) and the joint University of Ibadan /University College Hospital Institutional Review Committee (Ref no.: UI/UC/10/0194) respectively. Informed consent of the participants was sought after the rationale and procedure of the study was duly explained. For the purpose of identifying a homogenous sub-group of patients from those diagnosed with LMLBP during the course of this study, eligibility was determined using the McKenzie algorithm. Eighty four consenting patients who demonstrated directional preference for extension were consecutively recruited from the Physiotherapy Department, Obafemi Awolowo University (OAU) Teaching Hospital and the Department of Medical Rehabilitation, College of Health Sciences, OAU Health Centre, Ile-Ife respectively. The participants were randomly assigned to one of three groups; the McKenzie protocol Group (MPG), McKenzie protocol and Static Endurance Exercise Group (MPSEEG) and McKenzie protocol and Dynamic Endurance Exercise Group (MPDEEG). Treatment was applied thrice weekly for eight weeks and outcomes were measured in terms of physiological variables of: pain intensity, static and dynamic muscle endurance, and muscle fatigue; and psychosocial variables of activity limitation, disability, fear-avoidance behaviour, pain self-efficacy belief, belief of consequence of back pain and general health status at the end of 4th and 8th week of study, using Quadruple Visual Analogue Scale (QVAS), Biering-Sorensen test, repetitive arch-up test, Borg scale, Roland – Morris Back Pain Questionnaire (RMBPQ), Oswestry Low-back Disability Questionnaire (OLBDQ), Fear-avoidance Beliefs Questionnaire (FABQ), Pain Self-Efficacy Questionnaire (PSEQ), Back Belief Questionnaire (BBQ) and SF-36 questionnaire. Data were analyzed using descriptive and inferential statistics of One-way analysis of variance (ANOVA), repeated measures of ANOVA, Friedman's ANOVA, Kruskal-Wallis test and multiple comparisons post-hoc tests at 0.05 alpha level.

The mean age of the participants was 51.8 ± 7.35 years. A drop-out rate of 20.2% was observed in the study. 25, 22 and 20 participants in MPG, MPSBEEG and MPDBEEG respectively completed the study. The groups were comparable in age, physical characteristics and baseline outcomes ($p>0.05$). Within-group comparison across the 3 time-points of the study revealed that the different regimens had significant effects on the physiological and psychological variables ($p < 0.05$). The different regimens were comparable in their mean change (MC) scores on QVAS, OLBDQ, BBQ and FABQ at week 4th and 8th respectively ($p > 0.05$). There were significant differences in groups mean change scores on static endurance (14.6±8.44, 45.7±17.0 and 17.1±10.2 sec), dynamic endurance (2.88±1.88, 12.9±11.1 and 10.7±6.51 rep), muscle fatigue (12.6±2.16, 10.1±2.08 and 10.8±2.19), RMBPQ (3.36±0.76, 3.72±0.70 and 4.20±0.52) and mean rank score on PSEQ (26.6, 36.5 and 40.5) at week 4; and static endurance (29.6±8.44, 60.7±17.1 and 32.1±10.2 sec), dynamic endurance (8.36±2.22, 18.1±10.1 and 16.6±6.24 reps), muscle fatigue (3.88±1.67, 5.41±2.32 and 4.35±1.63) and mean rank score on PSEQ (23.5, 37.4 and 43.5) at week 8 respectively. Post-hoc test showed that MPSBEEG had significantly higher mean change in static endurance, dynamic endurance and muscle fatigue scores at week 4 and 8 respectively. MPDBEEG had higher mean change in RMBPQ and PSEQ at week 4, and in PSEQ at week 8.

The results obtained were discussed by comparing and contrasting the findings of the study with those of related past studies. Literature were appropriately cited to corroborate the results obtained in this study. Reasons were adduced for the result obtained in the light of literature and clinical reasoning. It was concluded that combining static back endurance exercise with Mckenzie protocol led to higher improvement in physiological variables of muscle endurance and fatigue while the addition of dynamic back endurance exercise resulted in higher improvement in psychosocial variables of activity limitation, pain self-efficacy and general health status.

5.2 CONCLUSIONS

From the finding of this study, the following conclusions were drawn –

1. The McKenzie protocol alone, or in combination with static or dynamic back extensor muscles endurance exercise were comparable in their effect on pain, disability, beliefs about the consequences of back pain and fear-avoidance belief behaviour in patients with long-term mechanical LBP.
2. The addition of static endurance exercise to the McKenzie protocol led to significantly higher positive effect on physiological variables of static back endurance, dynamic back endurance and fatigability of the back extensors in patients with long-term mechanical LBP.
3. The addition of dynamic endurance exercise to the McKenzie protocol led to significantly higher positive effects on the psychosocial variables of activity limitation, pain self-efficacy belief and all domains of general health status in patients with long-term mechanical LBP.

5.3 RECOMMENDATIONS

The findings of this study gave rise to the following recommendations:

1. Combining static and dynamic back extensors endurance exercise with the McKenzie protocol is recommended in improving physiological and psychosocial factors in patients with long-term mechanical LBP.
2. Further studies should investigate the effects of combining static and dynamic back extensors endurance exercise with the McKenzie protocol in the management of other sub-groups of patients with long-term LBP.

3. Further studies should investigate the effects of combining static and dynamic back extensors endurance exercise with the McKenzie protocol in the management of patients with sub- acute LBP.

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