ORIGINAL RESEARCH

Interventions for chronic low back pain: whole body vibration and spinal stabilisation

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Abstract

Objectives. This study explored, described and compared the effects of whole body vibration (WBV) therapy and conventional spinal stabilisation exercises in persons with chronic low back pain (CLBP).

Design. A non-randomised sampling technique was used to delineate the base of volunteers gathered by a combination of accidental and snowball sampling methods. Twenty subjects were randomly assigned into either a WBV or a spinal stabilisation (SS) group. The dependent variables were perception of pain and general functionality, abdominal muscular endurance, spinal muscular endurance and hamstring flexibility. These were measured at the pre-, mid- and post-test assessments. During the 8-week intervention, both groups performed the same spinal stabilisation exercises 3 sessions per week, the difference being the dynamic performance of the conventional land-based SS group compared with the static, isometric performance on the vibration platform. Analysis of variance (ANOVA) determined differences between groups at the pre-, mid- and post-test. Dependent sample *t*-tests were computed to determine whether the increases/decreases over time were significant within each group. Cohen's d was used to determine the practical significance of results.

Results. There were significant decreases in perception of pain and enhanced performance of functional activity of daily living, increases in abdominal and hamstring flexibility midway through and after the intervention period for both groups. Neither of the two methods of rehabilitation was significantly superior except for spinal muscular endurance in the WBV group after the 8-week intervention. WBV could be considered as an alternative method of exercise intervention for the rehabilitation of CLBP.

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Introduction

A range of exercise modalities is used in the rehabilitation of individuals with chronic lower back pain (CLBP), the most current being whole body vibration (WBV) training. WBV training is a novel neuromuscular mode of exercise that has recently received awareness as both a medium for improving speed-strength performance in elite athletes, but also as an alternative or complementary training modality to existing exercise programmes in most biokinetics practices and health and fitness centres.[1]

According to conventional exercise programme guidelines, a WBV training programme should prove to be an ideal form of exercise for the person with CLBP as it incorporates the use of large-muscle activities, increases spinal stabilisation and flexibility, while providing a basis for improving balance and neuromuscular control through the disruptions it produces in stability. The notion that WBV exploits the neuromuscular system's ability to respond to disruptions in stability in order to stimulate and enhance muscle strength and performance has been proposed.[2] It does this by provoking an energy transfer within the body by means of vibrations that result in a stretch reflex.

Sedentary adults need to be persuaded to increase physical activity levels to an activity target level of moderate intensity instead of the traditional high intensity.[3] WBV training provides a means by which this requirement can be met as it provides health-related fitness benefits while reducing the non-compliance often encountered due to weather conditions, lack of motivation and work obligations.[4] This finding was substantiated in a statement that a short-term, supervised exercise protocol where the exercise scientist, health care professional or trainer has more or less direct influence and control over the intervention process, provided there is a fairly good adherence rate to the exercise programme.[5]

CLBP has been defined as persistent or recurrent back pain experienced by an individual for a period longer than 3 months. Nociceptors in the lumbar spine and numerous psychological risk factors, such as stress, anxiety and depression could be associated with work-related CLBP.[6] Training on a three-dimensional vibration platform positively influences a host of psychological, physiological and health-related physical fitness parameters.[7]

CLBP is listed among the most common and widely experienced health-related problems. It affects up to 85% of the population at some time.[6] The prevalence and exponential increase in the occurrence of CLBP has been extensively published and dates back to the initial works of Hult in 1945. CLBP has been reported to be the most common disability in those under the age of 45, posing the most expensive health care challenge in those between the ages of 20 and 50.[6] The World Health Organization report reiterated that the burden of this disability is continuing to grow and is being rapidly

TABLE I. Programme progression strategy

	WBV			SS		
Week	Time per exercise (sec)	Intensity (Hz)	Total time (mins)	Sets	Reps	Total time (mins)
1 - 2	30	30	20	1	8	20
3 - 4	30	35	25	2	8	25
5 - 6	30	40	30	3	8	30
7 - 8	30	50	35	4	12	35

fed by the globalisation and westernisation of developing countries.[8] Between 50% and 80% of the population in South Africa suffer from CLBP at least once in their lives.[9]

The multi-dimensional nature of CLBP manifests as a syndrome with musculoskeletal, sensory, emotional, cognitive and behavioural components impacting on the inclination towards a lack for exercise.[6] CLBP has a tendency to recur and contributes to a large portion of work absenteeism, with a loss of productivity and employee inefficiency.[10] In 2002, the cost of CLBP to the economy of South Africa was estimated at approximately R6 billion.[11] The American College of Sports Medicine (ACSM) guidelines for exercise management for persons with chronic disease and disabilities postulate that the goals of exercise prescription should be to prevent the debilitation caused by inactivity and to improve exercise tolerance and muscular strength.[12]

The research reported herewith sets out to explore, describe and document the effectiveness of WBV and conventional spinal stabilisation (SS) exercise intervention for individuals with CLBP.

Methods

A quasi-experimental approach using a two-group comparison, pre-, mid- and post-test design, was utilised to gain insight into the differences between two experimental groups over the 8-week intervention period for the four selected variables of perception of pain and functionality, abdominal muscle endurance, spinal muscle endurance and hamstring flexibility. The exercise intervention occurred 3 times a week for 8 consecutive weeks. A non-randomised sampling technique was used where subjects were selected through a combination of accidental and snowball sampling[13] and randomly placed into either the WBV (N=10) or SS group (N=11). A total of 8 males and 13 females with a mean age of 52.9 years in the WBV group and 40.3 years in the SS group gave written informed consent to participate in the study. The mean age of the total group was 46.3 years. Ethical approval was given by the Nelson Mandela Metropolitan University (NMMU) Research Human Ethical Committee.

Data gathering techniques

Prospective subjects were informed of the study by electronic mail, highlighting the rationale of the study and specifying the inclusion criteria as the presentation of symptoms of nonspecific CLBP for a period of at least 3 months. All the NMMU staff were invited to participate in the study on a voluntary basis. The dependent variables included the perception of pain and functionality as measured by the revised Oswestry disability questionnaire; abdominal endurance as measured by the partial curl-up test; spinal muscle endurance as measured by the Roman Chair Back Extension test; and hamstring flexibility as assessed by the sit-and-reach test. All these are well-known standardised tests.

The following procedure was employed: obtaining written consent from each participant prior to the study; gathering clinical data; applying pre-test measurement of the four dependent variables; implementing the WBV or SS exercise programme for a 4-week duration; applying mid-test measurement; implementing progression of the WBV or SS exercise programme for a further 4 weeks; and applying post-test measurement.

Intervention programmes

Both the WBV and SS groups performed the same conventional SS exercise programme as proposed by Brukner and Khan and others as being specific for spinal stabilisation.[6,14] The WBV programme was performed using static isometric contractions, whereas the SS programme consisted of dynamic concentric contractions. Postural awareness and correct technique were of the essence during every exercise session. The principles of progression in both exercise programmes (Table I) were administered under the supervision of a qualified biokineticist.

Statistical analysis

The Statistica version 9.0 computer processing package (StatSoft, Inc, Tulsa, OK, USA) was used to analyse the data and the level of significance was set at p<0.05. For the comparisons involving the WBV and the SS group, descriptive measures of means and standard deviations were calculated and dependent t-tests were performed, while a one-way analysis of variance (ANOVA) was applied to determine statistically significant differences between the two groups at the pre-, mid- and post-tests. Cohen's d-values were calculated to express the levels of practical significance. The interpretation of Cohen's d-values is as follows: d=0.20, 0.50 and 0.80 respectively indicate small, moderate and large effects in practical significance.[15] Due to the relatively small sample size, non-parametric statistical analyses were performed additionally, utilising Mann-Whitney U tests by ranks to determine statistically significant differences between the two groups and furthermore, to ascertain whether the increases/decreases differed within the WBV and SS group. As both parametric and non-parametric statistical analyses yielded similar results and reiterate the significance of the findings, only the parametric analysis of the data will be reported.

Results

There were no differences between the WBV and SS groups for any of the four dependent variables prior to the intervention. Any significant changes could therefore be attributed to an effect of the intervention programme. Table II displays the means and standard deviations for the WBV, SS, and total group obtained throughout the 8-week intervention.

Perception of pain and general functionality (PP)

There was a mean decrease in PP from the pre-test (30.0 arbitrary units (AU)) to the mid-test (21.0 AU) and then to the post-test (17.6 AU) for the WBV group. A similar trend was revealed in the SS group, where a mean decrease in PP occurred from a value of 34.9 (pre-test) to 26.0 AU (mid- test) and then to 23.4 AU (post- test).

TABLE II. Means and standard deviations for the groups

Group measure	WBV (N=10) Mean ± SD	SS (N=11) Mean ± SD	Total (N=21) Mean ± SD
(Repetitions)			
MS1 (pre)	36.4 ± 20.9	27.9 ± 25.2	31.8 ± 22.9
MS2 (mid)	39.3 ± 19.6	34.6 ± 24.5	36.9 ± 21.6
MS3 (post)	41.5 ± 22.6	33.8 ± 25.8	37.6 ± 23.8
(Repetitions)			
BE1 (pre)	20.7 ± 09.8	15.6 ± 08.5	18.4 ± 09.3
BE2 (mid)	23.2 ± 12.8	15.9 ± 08.2	19.9 ± 11.3
BE3 (post)	24.9 ± 12.8	18.5 ± 08.9	22.0 ± 11.4
(mm)			
SR1 (pre)	247.1 ± 88.5	208.2 ± 89.5	224.5 ± 88.8
SR2 (mid)	271.3 ± 85.2	230.0 ± 90.1	247.3 ± 88.1
SR3 (post)	276.3 ± 99.4	245.5 ± 91.1	258.4 ± 93.2
(Score)			
PP1 (pre)	30.0 ± 08.7	34.9 ± 16.8	32.5 ± 13.5
PP2 (mid)	21.0 ± 10.8	26.0 ± 13.7	23.6 ± 12.3
PP3 (post)	17.6 ± 13.2	23.5 ± 14.9	20.6 ± 14.1

WBV = whole body vibration; SS = spinal stabilisation exercises; MS = modified sit-ups; BE = back extension; SR = sit and reach; PP = perception of pain and general functionality.

Statistically significant decreases pertaining to the changes in the PP-scores from the pre- to the mid-test (t=-4.21, p=0.002) and from the pre- to the post-test (t=-4.94, p=0.0007) occurred for the WBV group, as displayed in Table III. Both aforementioned intra-group differences were practically significant with a *large effect* as indicated by Cohen's d (d=1.33 and d=1.56 respectively). Table III displays similar differences for PP in the SS group, where a statistical significance was indicated from the pre- to the mid-test (t=-4.43, p=0.001) and from the pre- to the post-test (t=-4.50, p=0.001). A large effect was found based on practical significance (d=1.34 and d=1.36 respectively). Intergroup differences were examined by an ANOVA analysis and revealed no significant differences between the WBV and SS group for perception of pain and general functionality at any one of the testing stages.

Abdominal muscular endurance (MS)

Results obtained for MS as measured by the modified sit-up test revealed a mean increase of eight repetitions from the pre- to the post-test in the WBV group while the mean score of the SS group increased by four repetitions. The MS scores of the SS group increased from the pre- to the mid-test (5 repetitions, mean score of 27.8 - 34.6 repetitions), but decreased slightly from the mid- to the post-test (34.6 - 33.7 repetitions).

Intra-group differences in MS of the WBV group were statistically significant, as indicated in Table III where the values increased from the pre- to the mid-test (t=3.40, p=0.01) and from the pre- to the post-test (t=2.70, p=0.03). Both aforementioned increases were practically significant with a *large effect* as indicated by Cohen's d (d=1.29 and d=0.91 respectively). Table III displays similar increases for MS in the SS group. Here the difference only approached significance from the pre- to the mid-test (t=2.24, p=0.059), yet the difference was statistically significant from the pre-test to the post-test (t=2.56, p=0.03). Practical significance of a *moderate effect* was achieved by Cohen's d (d=0.79) for the pre- to mid-test, while practical significance with a *large effect* was indicated from the pre- to post-test (d=0.91). No significant intergroup differences were found between the WBV and SS group for abdominal muscle endurance at any one of the testing stages.

Spinal muscular endurance (BE)

Results obtained for spinal muscle endurance as measured by the back extension (BE) test revealed an increase in BE from a mean pre-test value of 20.6 repetitions to a mid-test mean value of 23.3 repetitions and then to a post-test mean value of 24.9 repetitions for the WBV group. The BE for the SS group increased from a mean score of 15.5 to 15.8 repetitions and then to 18.5 repetitions. There was a statistically significant increase for BE from the pre- to post-test in the WBV group (t=2.62, p=0.03) with a *large effect* for practical significance of Cohen's d (d=0.87) as tabulated in Table III. However, the increase in BE for the SS group approached significance for the mid- to post-test result only (t=2.25, p=0.058) where a practical significance with a *large effect* (d=0.80) was designated, as shown in Table III. Once again the WBV and SS group revealed no significant intergroup differences for spinal muscle endurance at any one of the testing stages.

Hamstring flexibility (SR)

Results for SR as measured by the sit-and-reach test indicated that the WBV group achieved an increase from a mean value of 247.1

TABLE III. Difference between three testing sessions for each measure within each group

	WBV Gr (*N*=10)				SS Gr (*N*=11)			
Measure	**MD±SD**	***t***	***p***	**d**	**MD±SD**	***t***	***p***	**d**
Units: score								
PP: pre - mid	-9±7	4.43	0.001	1.34	-9±7	-4.43	0.001	1.34
PP: mid - post	-3±4	2.35	0.040	0.40	-3±4	-2.35	0.040	0.71
PP: pre - post	-12±8	4.94	0.010	1.56	-11±8	-4.50	0.001	1.36
Units: repetitions								
MS: pre - mid	5±4	3.40	0.010	1.29	7±9	2.24	0.050	0.79
MS: mid - post	2±6	1.04	0.320	0.37	-1±5	-0.50	0.620	0.18
MS: pre - post	8±8	2.70	0.030	1.02	6±6	2.56	0.030	0.91
Units: repetitions								
BE: pre - mid	4±10	1.20	0.260	0.40	1±4	0.50	0.620	0.19
BE: mid - post	2±6	0.97	0.030	0.87	6±7	2.62	0.350	0.87
BE: pre - post	6±7	2.62	0.030	0.87	6±7	2.62	0.030	0.87
Units: mm								
SR: pre - mid	24±15	4.70	0.002	1.66	22±26	2.74	0.020	0.83
SR: mid - post	25±19	0.76	0.460	0.27	15±16	3.13	0.010	0.95
SR: pre - post	29±25	3.29	0.010	1.17	37±32	3.86	0.003	1.17

WBV = whole body vibration; SS = spinal stabilisation exercises; MS = modified sit-ups; BE = back extension; SR = sit and reach; PP = perception of pain and general functionality.

mm (pre-test) to 271.2 mm (mid-test) and then to 276.2 mm (post-test), while the SS obtained an increase from 208.1 to 230.0 mm and then to 245.4 mm over the same 8-week intervention period.

A statistically significant increase in SR from the pre- to mid -test was revealed for the WBV group (t=4.70, p=0.002) with a *large effect* based on practical significance (d=1.66) as seen in Table III. Furthermore, from the pre- to post-test a statistical significant increase was attained by the WBV group (t=3.29, p=0.01) with a *large effect* in practical significance (d=1.17). Table III reveals a statistically significant increase in BE for the SS group with practical significant large effects for all three assessments, namely: from the pre- to mid-test (t=2.74, p=0.02, d=0.83), the mid- to post- test (t=3.13, d=0.01, d=0.95), and the pre- to post-test (t=3.86, p=0.003, d=1.17). The SS group, however, initially had a lower score and therefore had more scope for increasing hamstring flexibility. No significant intergroup differences were indicated between the WBV and SS group for hamstring flexibility at any one of the testing stages.

Discussion

The results of this study indicated that both the WBV and SS exercises relieved pain and improved pain-related limitations in the performance of activities of daily living for individuals with CLBP. The mechanism of proprioceptive feedback and potentiation of inhibition of pain whereby an individual's pain threshold increased, could have contributed to both experimental groups' decrease in the perception of pain and enhanced general functionality.[6]

This finding that vibration therapy alleviated perception of pain and daily functionality is in contrast to literature where industrial and non-industrial circumstances have been regarded as predisposing risk factors in the aetiology of CLBP. However, differentiation between industrial and therapeutic WBV therapy on variables have been made such as the method of the vibratory application, the individual's posture, the frequency of the application and the duration of exposure to the vibration, as well as the resulting fatigue.[7]

The findings regarding abdominal muscle endurance correspond with unpublished research[16] and published work[17] where the study revealed an improvement in abdominal endurance after a 12-week WBV therapy programme in previously sedentary individuals. The latter reported that vibratory waves irritated the primary endings of the muscle spindle that activated a larger fraction of the motor neuron pool and recruited previously inactive motor units into contraction. This resulted in a more efficient use of the force production potential of the muscle groups involved. This mechanism of motor neuron pool activation was further reinforced during WBV by the recruitment of previously inactive motor neurons, together with their activity synchronisation, and increased discharge of the neural drive, which led to greater improvements in neuromotor control during voluntary muscle contraction as evaluated in the modified sit-up analyses. Could aforementioned theory substantiate the finding of a significant maintenance of increased abdominal muscle endurance throughout the 8-week intervention for the WBV group, while the SS group decreased in MS after the mid-test assessment? Increased spinal muscular endurance after completing a 12-week WBV exercise programme has been reported.[7] The findings of the present study support the findings of the aforementioned research. The rationale stated for the increased abdominal musculature endurance also applies to results obtained for this variable, namely that the muscle spindles activated a larger fraction of the motor neuron pool and recruited previously inactive motor units into contraction, thus resulting in a more efficient use of the force production potential of the muscle groups involved.[17]

The use of hamstring flexibility exercises during the 8-week intervention period had a positive effect on the range of motion around the posterior compartment of the hip joint and pelvis for both WBV and SS experimental groups. However, the SS group in comparison increased more significantly in hamstring flexibility in the mid- test and could be ascribed to the lower score obtained for SR at the onset of the study. It could be reasoned that subjects in the SS group had a greater scope of improving the hamstring flexibility due to the exercise stimulus. These findings support the results reported of a significant increase in hamstring flexibility after a 12-week intervention period utilising static stretching to enhance hamstring flexibility.[18]

The improvement in hamstring flexibility in both experimental groups could be explained within a physiological paradigm according to the involvement of two possible mechanisms. Firstly, the enhanced local blood flow through the muscles generated additional heat, thereby enhancing muscle elasticity and facilitating an increase in range of motion in the hamstring muscles.[19,20] The second mechanism proposed is neurophysiological in nature as the vibration training elicited a tonic vibration reflex that activated the muscle spindles and led to the advancement of the stretch-reflex loop.

Based on the findings for all the selected relevant dependent variables, the proposal can be made that WBV be considered by the health care professional as a means to decrease the perception of pain and increase the selected health-related variables in individuals with CLBP.

Conclusion

CLBP is internationally a major concern in the field of rehabilitation due to the high incidence rates and the high rate of re-occurrence. Individuals suffering from CLBP often experience a cycle of pain, disuse, further pain and less usage. They become debilitated and suffer from a decrease in strength, endurance and flexibility. Although a myriad range of exercise techniques are used in the rehabilitation of individuals with CLBP, health care professionals realise the essence of postural awareness, strengthening the core abdominal and lumbar stabilising musculature and re-education as composites of any intervention programme.

Although the study was conducted on a relatively small sample group over a period of 8 weeks only, it provides useful information that indicates alternative options for the treatment of CLBP. Both WBV and SS showed improvements in the dependent variables of pain perception and general functionality, abdominal and spinal muscular endurance and hamstring flexibility after participating in the 8-week WBV and SS intervention programmes. The findings indicated that both WBV and conventional SS were effective exercise regimes for individuals with CLBP. Neither of the two methods of intervention was superior in producing more significant results and supported previous studies in the literature reporting positive results.

WBV therapy appears to be a safe, rehabilitative exercise modality that improves lower back and hamstring flexibility, increases relative back strength and increases abdominal muscular endurance. However, further research is needed to replicate these results on the long-term effects of WBV in CLBP. Future research is required to ascertain what the re-occurrence rate is for individuals with CLBP who followed vibration therapy as opposed to conventional modes of intervention programme prescription. Vibration therapy in the form of WBV could be considered as an alternative method of exercise intervention for the rehabilitation of CLBP, if designed, presented and supervised by a specialist health professional.

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