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Original Research Article

EFFECT OF TREADMILL WALKING VERSUS STATIONARY CYCLING ON PAIN, TRANSVERSUS ABDOMINIS ENDURANCE, DISABILITY & QUALITY OF LIFE IN NON-SPECIFIC CHRONIC LOW BACK PAIN: A QUASI EXPERIMENTAL STUDY

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ABSTRACT

Background: Diminished muscular performance & greater functional impairment leads to restricted quality of life in chronic low back pain (CLBP) patients. The transverses abdominis (TrA) has been implicated as part of the cause of LBP. The purpose of the study was to compare the effects of treadmill walking and stationary cycling in subjects with non-specific CLBP.

Methodology: A quasi-experimental study was conducted with 30 subjects divided into 2 groups. Group A consisted of treadmill walking & group B of cycling. Subjects aged 18 to 45 years with chronic LBP without radiating pain with absence of any cardiac & pulmonary conditions were included. Moderate intensity aerobic exercise for 10-20 minutes, 5 days/week based on FITT principle was given. Outcome measures were pain, TrA endurance, disability & quality of life.

Results: Statistically significant difference (p<0.001) was noted for all outcome measures in both groups A & B with non-significant difference (p>0.05) between groups. For Group A, NRS (Numerical Rating Scale) at rest (95% CI 2.182 to 3.685), NRS on activity (95% CI 3.056 to 4.410), TrA endurance (95% CI -3.61 to -2.79), MODI (Modified Oswestry Disability Index) (95% CI 20.05 to 29.01), physical health (95% CI -18.80 to -9.33) & overall QOL of WHOQOL (95% CI -2.06 to -1.26). For Group B, NRS at rest (95% CI 2.034 to 3.699), NRS on activity (95% CI 2.214 to 4.186) & TrA endurance (95% CI -4.78 to -2.01), MODI (95% CI 21.75 to 31.04), physical health (95% CI -23.36 to -10.77) & overall QOL of WHOQOL (95% CI -2.32 to -1.27).

Conclusion: Treadmill walking & stationary cycling were equally effective in improving pain, TrA endurance, disability & quality of life in subjects with non-specific CLBP.

Clinical Implication: Aerobic exercise such as walking & cycling at moderate intensity can be used to reduce pain & disability & increase core muscle (transversus abdominis) endurance thereby improving quality of life in patients with CLBP.

KEY WORDS: Transversus Abdominis (TrA) endurance, non-specific chronic low back pain, treadmill walking, stationary cycling, quality of life.

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INTRODUCTION

Low back pain (LBP) is a common symptom, affecting more than 80% of the general population in the industrialized world [1]. LBP is defined as pain and discomfort localized below the costal margin and above the inferior gluteal folds, with or without leg pain [2]. Chronic low back pain is defined as low back pain persisting for 12 weeks or more [2]. It never leaves completely, although the severity, duration, & region of pain may vary.

Non-specific low-back pain is defined as "tension, soreness and/or stiffness in the lower back region for which it is not possible to identify a specific cause of the pain [3,4]. Nearly, 90% of the patients have a non-specific cause for low back pain as stated by world health organization (WHO) in 2003 [5]. Its worldwide prevalence is estimated to be about 13–44%, which results in most individuals taking leave for about a week from work [6]. Nearly 60 per cent of the people in India have significant back pain at some time or the other in their lives [7].

Back pain has multifactorial cause including functional instability; deconditioning; abnormal posture; poor muscle recruitment; emotional stress; and associated with aging and injury such as disk degeneration, arthritis, and ligamentous hypertrophy [8,9]. Risk factors for nonspecific low back pain include heavy physical work; frequent bending, twisting, and lifting; and prolonged static postures [10,11].

Panjabi reported evidences of lumbar instability, low muscular strength and endurance among subjects with LBP [12]. The TrA had insufficient control and speed of muscle contraction delayed in individuals with CLBP [13,14]. Subjects with chronic LBP do not pre-activate TrA prior to rapid upper and lower limb tasks [15]. Since TrA is the chief abdominal stabilizer of the spine, prevention and rehabilitation of LBP should target transversus abdominis [16].

Chronic low back pain has a major impact on health and health-related QOL, diminishing the capacity for standing, walking and sitting [17,18]. In CLBP, the reduction in quality of life could be attributed to sleep disturbances, fatigue, medication abuse [19], functional disability [20] and stress. Among younger adults, chronic back pain is associated with disability, unemployment and lost productivity [10,21,22].

Improved understanding of psychological factors associated with pain has given rise to the belief that any form of moderate-to-vigorous physical activity may be sufficient for LBP rehabilitation [23-26]. Physiotherapy management of long term low back pain favors active treatment programs involving improving aerobic fitness [27].

Aerobic exercise can play a critical role in maintaining spine health and ensuring progress in recovery from back pain.

Moderate-intensity aerobic exercise are not so exploited in the current available literature for the treatment of CLBP. No particular type of aerobic activity has been found to be more effective than another for gaining fitness or decreasing pain & disability for patients with back pain [9]. Therefore there was a need to study & compare their effects. The research question is:

1. Is treadmill walking and stationary cycling effective in reducing pain & disability & improving TrA endurance & quality of life in subjects with non-specific CLBP? Are both aerobic exercises equally effective?

METHODOLOGY

Ethics approval: The study was reviewed & approved by Ethics committee of Institutional Review Board, S.B.B College of Physiotherapy, Ahmedabad. Reference number is PTC/IEC/36/2013-14. All participants gave written informed consent before data collection began.

Design: A quasi experimental study using convenience sampling design was conducted for a period of 1 year.

30 subjects were selected from the Out-patient department of S.B.B college of Physiotherapy, V.S General Hospital, Ahmedabad. They were divided into 2 groups, each having 15 subjects. Group A consisted of Treadmill walking & Group B of Stationary cycling. Males & females aged 18-45 years with diagnosis of non-specific low back pain since 12 weeks or more without radiating pain with absence of any cardiac & pulmonary conditions were included. Subjects with medical history of serious injury to back, constant or persistent severe pain, previous

spinal surgery, acute disc prolapse, current nerve root entrapment accompanied by neurological deficit, degenerative and structural changes in spine, fracture, metabolic bone disease, inflammatory conditions, spinal infections, spinal tumor's, pregnancy were excluded. Subjects with Slump test & Straight leg raise test positive were excluded.

Procedure:

Subjects were selected according to inclusion & exclusion criteria. Nature and purpose of the study was explained. Baseline assessment of outcome measures was done prior to giving intervention. Training program was based on FITT principle.

Frequency-5 days/week (once in a day)

Intensity-13-14 RPE (Rate of Perceived Exertion) on 6-20 Borg Scale of Perceived Exertion

Time-20 minutes/day for 4 weeks

Type-Treadmill walking (Group A) or stationary cycling (Group B)

Exercise program was scheduled as follows: 5 minutes of warm up exercise (consisted of general free exercises of the arms, legs & trunk) followed by 20 minutes of aerobic exercise (treadmill walking or cycling) as mentioned in Table-1 & finally 5 minutes of cool down exercise (consisted of stretching of major muscles of lower limbs & back). Progression of exercise is shown in Table-1.

Subjects were also given isometric back and abdominal exercise & hot-packs to back (for 10 minutes) in addition to aerobic exercise. They were not restricted in any of their activities. All subjects were given similar back care advice.

Outcome measures:

Outcome measures were pain measured using numerical rating scale (NRS) & transversus abdominis (TrA) endurance (i.e. holding or tonic capacity of TrA) measured by the number of 10-second holds (up to 10) using pressure bio-feedback in prone position [28]. A pressure biofeedback unit is a reliable and valid clinical instrument for assessing deep abdominal muscle function, and has been used to develop a method for the careful monitoring of lumbar stabilization [29]. NRS has excellent test-retest reliability (r = 0.79 – 0.92) & internal consistency (Coefficient alpha = 0.89 –0.98) in cases of chronic pain [30]. NRS has large effect size at 1 week and 4 weeks (ES = 0.95-1.2) in patients receiving physical therapy for low back pain [31].

Disability was measured using modified oswestry disability index (MODI) & quality of life was measured using WHO quality of life (QOL) - BREF. The MODI is a disease-specific disability measure used to establish a level of disability, stage a patient's acuity status [32], and monitor change over time. The measurement characteristics of the MODI are good to excellent. Test-retest ICC is 0.83 - 0.94 for (1-14 days) [33] and 0.90 over 4 weeks in a group of patients judged stable [34]. WHOQOL-BREF provides a measure of an individual's perception of quality of life for the four domains: physical health, psychological health, social relationships and environmental health. WHOQOL-BREF is an abbreviated version of the WHOQOL-100 quality of life assessment. Internal consistency of WHOQOL-BREF ranged from 0.66-0.87 (Cronbach's alpha co-efficient). It has good discriminant validity & test retest reliability [35].

Data analysis: Power analysis was based on the study by Murtezani A et al. [36] Sample size (N) estimated with α = 0.05 and 1- β = 0.95 was found to be 30 (n = sample size required in each group = 15.4 ~ 15). Data was analyzed using Statistical Package for Social Sciences (SPSS) version 20. Within group analysis of mean difference pre and post intervention was performed using one-Sample t-test. Between-group comparison post intervention was performed using Independent samples t-test. Level of significance was considered as $p<0.05$ & 95% confidence interval (CI).

RESULTS

Flow of participants through the study: 65 subjects having chronic low back pain were screened. 38 fulfilled the inclusion criteria and were recruited for the study. 6 subjects found the department too far from their residence & other 2 went out of town in the middle of treatment. Thus 8 dropped out from the study & remaining 30 completed the treatment protocol. 11 (37%) participants were men. 19 (63%) participants were women. There was no significant difference between the groups (p= 0.75) with respect to age. Baseline outcome measures were checked for normal distribution. Independent samples t-test was applied between the groups & there was no statistically significant difference in all baseline outcome measures except TrA endurance & physical health domain of WHOQOL-BREF as shown in Table-2. One-sample t-test was used to compare means pre & post treatment within the groups. Independent samples t-test was used to compare mean difference between the groups. Mean difference between pre & post scores of WHOQOL-Domain 3 in both the groups was 0, so t-test could not be computed. Results are shown in Table 3 & 4.

Table 1: Exercise progression.

Weeks	Frequency	Time
1st week	5 days/week	
	1st day	5 minutes
	2nd & 3rd day	10 minutes
	4rth & 5th day	15 minutes
2nd – 4rth week	5 days/week	20 minutes

Table 2: Baseline outcome measures in each group.

Outcome measure	Group A (Mean + SD)	Group B (Mean + SD)	p-value
NRS AT REST	3.67+1.23	4.13+1.18	0.3
NRS ON ACTIVITY	6.73+0.96	7.07+1.28	0.42
TrA endurance	0	1.2 + 1.23	0.01
MODI	45.6+11.29	53.07+12.46	0.09
WHOQOL-BREF (Domain 1)	61.07+11.13	50.27+11.04	0.01
WHOQOL-BREF (Domain 2)	64.33+10.14	65.13+8.76	0.81
WHOQOL-BREF (Domain 3)	82.93+10.46	80.80+15.25	0.65
WHOQOL-BREF (Domain 4)	68.6+14.5	63.8+12.88	0.34
Overall QOL & general health	6.6+0.98	5.87+0.99	0.052

Statistical analysis: Statistically significant difference (p<0.001) was noted for all outcome measures pre & post treatment in within group analysis as shown in Table-3. There was statistically non-significant difference (p>0.05) for all outcome measures in Between group analysis as shown in Table-4. For Group A, NRS (Numerical Rating Scale) at rest (95% CI 2.1 to 3.6), NRS on activity (95% CI 3.1 to 4.4), TrA endurance (95% CI -3.61 to -2.79), MODI (Modified Oswestry Disability Index) (95% CI 20 to 29), physical health (95% CI -18.80 to -9.33), psychological health (95% CI -8.33 to -0.74), environmental health (95% CI -11.84 to -3.75) & overall QOL & general health domain (95% CI -2.06 to -1.26). For Group B, NRS at rest (95% CI 2 to 3.7), NRS on activity (95% CI 2.2 to 4.2) & TrA endurance (95% CI -4.78 to -2.01), MODI (95% CI 21 to 31), physical health (95% CI -23.36 to -10.77), psychological health (95% CI -7.28 to -1.11), environmental health (95% CI -6.95 to -5.04) & overall QOL & general health domain (95% CI -2.32 to -1.27).

Table 3: Within group analysis Pre & Post treatment for all outcome measures.

Outcome Measure	Group	Pre- Treatment Mean	Pre- Treatment SD	Post- Treatment Mean	Post- Treatment SD	p-value	95% CI
NRS at rest	A	3.67	1.23	0.73	0.7	0.001	**2.182 to 3.685**
	B	4.13	1.18	1.27	1.03	<0.0001	**2.034 to 3.699**
NRS on activity	A	6.73	0.96	3	0.84	<0.0001	**3.056 to 4.410**
	B	7.07	1.28	3.87	1.35	<0.0001	**2.214 to 4.186**
TrA endurance	A	0	0	3.2	0.77	<0.0001	**-3.61 to -2.79**
	B	1.2	1.2	4.6	2.32	<0.0001	**-4.78 to -2.01**
MODI	A	45.6	11.29	21.07	7.4	<0.0001	**20.05 to 29.01**
	B	53.07	12.46	26.67	10.21	<0.0001	**21.75 to 31.04**
QOL D1: Physical health	A	61.07	11.13	75.13	7.06	0.001	**-18.80 to -9.33**
	B	50.27	11.04	67.33	5.9	0.001	**-23.36 to -10.77**
QOL D2: Psychological health	A	64.33	10.14	68.87	7.41	0.173	**-8.33 to -0.74**
	B	65.13	8.76	69.33	8.48	0.193	**-7.28 to -1.11**
QOL D3: Social relationships	A	82.93	10.46	82.93	10.46	1	——
	B	80.8	15.25	80.8	15.25	1	
QOL D4: Environmental health	A	68.6	14.5	76.4	10.43	0.102	**-11.84 to -3.75**
	B	63.8	12.88	69.8	12.64	0.209	**-6.95 to -5.04**
Overall QOL & general health	A	6.6	0.986	8.27	0.704	<0.0001	**-2.06 to -1.26**
	B	5.87	0.99	7.67	0.617	0.001	**-2.32 to -1.27**

Table 4: Between group analysis for all outcome measures.

Outcome Measure		Group A	Group B	p-value	95% CI
NRS at rest	Mean	2.93	2.87	0.83	-0.576 to 0.709
	SD	0.884	0.834		
NRS on activity	Mean	3.73	3.2	0.1	-0.120 to 1.186
	SD	0.884	0.862		
TrA endurance	Mean	3.2	3.43	0.56	-1.03 to 0.57
	SD	0.775	1.284		
MODI	Mean	24.53	26.4	0.54	-8.03 to 4.29
	SD	8.08	8.39		
QOL D1: Physical health	Mean	14	17	0.346	-10.54 to 4.54
	SD	9.99	9.99		
QOL D2: Psychological health	Mean	15.17	15.83	0.818	-4.33 to 5.00
	SD	6.12	6.12		
QOL D4: Environmental health	Mean	15.13	15.87	0.809	-2.31 to 5.91
	SD	5.29	5.29		
Overall QOL & general health	Mean	15.17	15.83	0.822	-0.76 to 0.49
	SD	0.82	0.82		

DISCUSSION

The study showed that treadmill walking & cycling were equally effective in improving pain, TrA endurance, disability & quality of life in subjects with non-specific chronic low back pain.

Effect of treadmill walking & stationary bicycling on pain: For Group A, statistically significant improvement in pain is in accordance with the study by Mirovskya Y et al [37] & for Group B, it is in accordance with the study by Hoffman MD et al [38], Smeets RJ et al [39] & Marshall PW et al [40]. Marshall et al concluded that 8 weeks of stationary cycling produced statistically significant improvements in pain ($p < 0.05$). Hoffman et al concluded that 25 minutes of cycling (single-session) significantly decreased pain ratings ($p < 0.05$) both 2 and 32 minutes post exercise.

The study showed a significant decrease in pain scores after 4 weeks in both the groups, which is in accordance with the study done by Sculco et al [41], Van der Velde et al [42] & Murtezani A et al [36]. All the authors employed treadmill walking or stationary bicycling as the main intervention, which meant that participants may have performed either as an intervention. Murtezani A et al concluded that treadmill walking or stationary bicycling was more effective than applied passive modalities in improving pain intensity ($p < 0.001$).

According to Childs et al [31], a difference of 2.2 points on the NRS represents a clinically meaningful change that exceeds the bounds of measurement error in subjects with CLBP at 4-weeks of therapy. The present study observed > 2.2 points (i.e. 30%) reduction in pain [Group A-2.94 points (i.e. 80%) at rest & 3.73 points (i.e. 55%) on activity & Group B-2.86 points (i.e. 70%) at rest & 3.2 points (i.e. 45%) on activity]. So there is also clinically meaningful improvement (CMI) in addition to being statistically significant.

A long-term pain-induced inhibition of physical activity like that induced by CLBP leads to deconditioning. This deconditioning can perpetuate the sensation of pain and create a vicious cycle from which the patient may never escape [43]. Aerobic exercises such as walking & cycling use continuous, rhythmic movement of large muscle groups to strengthen the cardiovascular system [44].

Pain reduction mechanism: Walking provides a low compression cyclical load and results in lower spine torques & muscle activity that may enhance disc nutrition [45] and the ability to adapt to spinal loading [46].

This increases the flow of blood and nutrients to back structures & support healing which in turn decreases the stiffness in the back and joints that lead to back pain [47].

Some exercise-associated analgesia is a result of direct activation of pain inhibiting brain substrates by type III and IV afferent nerves [48]. Increased secretion of β-endorphin by the pituitary gland and by the leukocytes and macrophages in injured tissues also contributes to exercise- induced analgesia [49].

Effect of treadmill walking & stationary bicycling on trunk muscle endurance: In a study by Shnayderman & Katz-Leurer (2012) [50], there was significant improvement in the trunk flexor & extensor endurance equally in both treadmill walking & strengthening group. Mannion AF et al [25] got significant improvement in muscle performance in terms of erector spinae activation & paraspinal (erector spinae) muscle cross-sectional area mainly due to changes in neural activation of the lumbar muscles and psychological changes concerning such as motivation. Individuals with greater levels of muscular strength and endurance tend to have fewer spinal problems [52]. Theoretically, better recruitment of transversus abdominis can be a precursor for long-term pain reduction in chronic non-specific LBP [52].

Aerobic fitness increases the strength and flexibility of the lumbar musculature, ensuring lumbar stability [27]. It is easier to control weight or lose weight, decreasing the stress placed on the spine structures and joints [47]. Large inter-individual differences in abdominal muscle activation [53] have been observed after supervised exercise for LBP. The amplitude of muscle activity is greater on treadmill walking compared to over-ground which indicates that more motor units are recruited during the contraction. This can be helpful in prescribing the appropriate type of exercise especially for patients with core muscle weakness [54].

Effect of treadmill walking & stationary bicycling on disability: Significant decrease in MODI score pre & post intervention for Group A is in accordance with the study by Shnayderman I and Katz-Leurer M & for Group B is in accordance with the study by Smeets et al. [39] & for both the groups is in accordance with the study done by Van der Velde et al, Mannion et al & Murtezani et al. They employed either treadmill walking or stationary cycling. According to Fritz & Irrgang [33], a difference of 6-13% point on the modified Oswestry represents a clinically meaningful change that exceeds the bounds of measurement error in subjects with CLBP at 4-weeks of therapy. The present study observed > 13 % points for reduction in disability (Group A-55% points & Group B-50% points). So there is also clinically meaningful improvement (CMI) in addition to being statistically significant. According to Saltin et al cycling activates large muscle groups that lead to a relatively steep rise in muscle temperature that reaches a plateau after 10-20 minutes [55]. Increased muscle temperature may increase muscle extensibility [56].

Effect of treadmill walking & stationary bicycling on quality of life: Quality of life depends on a patient’s physical, psychological and social responses to a disease and its treatment [57]. Statistically significant difference ($p \leq 0.001$) was found for physical health & overall QOL & general health domain for both Groups A & B. The other 3 domains i.e. psychological health, social relationships & environment showed statistically insignificant difference ($p>0.05$) within the groups as well as between the groups. Studies on QOL in chronic diseases including CLBP points to factors such as chronicity, seriousness of the episode, stress and depression that reduce the QOL [57].

Psychological factors such as anxiety & depression may have a larger impact on disability and quality of life than pain itself [17,18]. Chatzitheodorou et al (2007) [58] & Murtezani et al obtained statistically as well as clinically significant improvement ($p<0.001$) in psychological strain (anxiety & depression) which relates to overall QOL & general health. Mannion et al concluded that low-impact aerobic exercises significantly reduced fear avoidance belief score ($p=0.009$). Thus it can be postulated that exercise modifies psychological stress reactivity & reduces negative affective states [59].

The physiological effects of aerobic exercise are not only confined to musculoskeletal function. Aerobic exercise, acts on most body systems; therefore, being effective in changing clinical symptoms [58].

The present study also included stretching of leg & trunk muscles as part of cool down exercise. Stretching, strengthening and cardiovascular (aerobic) conditioning exercises are components of any good exercise session in the management of chronic pain. Patients report that introducing regular stretching is extremely helpful. Thus aerobic exercise and the promotion of an active lifestyle proved to be beneficial [60].

CONCLUSION

Treadmill walking & stationary cycling done at moderate intensity (13-14 RPE) for 4 weeks are equally effective in reducing pain & disability & improving Transversus Abdominis endurance & health-related quality of life in combination with isometric back & abdominal exercise & hot-packs in subjects with non-specific chronic low back pain.

Limitations: The study lasted 4 weeks. Possibly, a longer intervention could indicate significant difference in the effects of the two groups.

Future recommendations: Treadmill walking & stationary cycling offers a relatively cost-effective way to target back pain & decreased muscular endurance of the trunk muscles. The effects of treadmill walking & stationary cycling observed in non-specific CLBP can be further used to treat specific cases of LBP according to flexion or extension bias experienced by the subjects.

ABBREVIATIONS

CLBP - Chronic low back pain
TrA - Transversus Abdominis
FITT - Frequency, Intensity, Time, Type
NRS - Numerical Rating Scale
MODI - Modified Oswestry Disability Index
WHO-QOL - World Health Organization Quality of Life
RPE - Rate of Perceived Exertion
ES - Effect size
CMI - Clinically Meaningful Improvement

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Conflicts of interest: None

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