Effect of 360° Titanium Core Strength Exercise© on Pain Intensity and Trunk Extensor Performance Amongst Chronic Non-Specific Low Back Pain in Malaysian Government Sector Workers

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Abstract

This preliminary study aimed to assess the effectiveness of the 360° TitaniUM Core Strength Exercise© on both pain intensity and trunk extensor performance amongst chronic non-specific low back pain (NSLBP) in Malaysian government sector workers. Participants with chronic NSLBP were randomly assigned into either the interventions or control group. Participants in the intervention groups received a 12-week program of the 360° TitaniUM Core Strength Exercise© with progressively increased on the frequency, intensity, or duration of training, while the control group received no treatment. Pain intensity and trunk extensor performance were assessed at pre-intervention and post-intervention. The results showed a significant improvement in pain intensity and trunk extensor performance in all intervention groups compared to the control group, with the intervention duration group and intervention intensity group indicated a superior improvement, respectively. Although the intervention groups experienced a great reduction in pain intensity, no statistically significant difference was observed between all groups. Whereas there was a significant interaction between time and groups on trunk extensor performance between all the interventions and control group. These findings suggest that the 360° TitaniUM Core Strength Exercise© with appropriate dosage of exercise is an effective core exercise program for managing chronic NSLBP.

Keywords: 360° TitaniUM Core Strength Exercise©, chronic non-specific low back pain, Malaysian government sector workers

1. Introduction

Low back pain (LBP) is a prevalent and debilitating condition that affects a large portion of the global population. It is estimated that up to 80% of adults will experience LBP at some point in their lifetime, making it one of the leading causes of disability and missed work days (Chou et al., 2007). The economic burden of LBP is significant, with the direct and indirect costs of LBP estimated to be billions of dollars each year (Yelin, 2003).

The etiology of LBP is complex and multifactorial, with risk factors including poor posture, prolonged sitting, physical inactivity, obesity, aging, muscle imbalance, and occupational demands (Hoy et al., 2014). Despite being a prevalent condition, the specific cause of LBP often remains unclear, and it is commonly referred as non-specific. The occurrences of LBP can be attributed to a range of musculoskeletal conditions such as herniated discs, spinal stenosis, and degenerative disc disease, as well as other conditions such as osteoarthritis, fibromyalgia, and spinal tumors (Srinivas, Deyo, & Berger, 2012).

The impact of non-specific low back pain (NSLBP) can be disturbing, with chronic NSLBP having a significant impact on an individual's quality of life and ability to perform daily activities (Maher, Underwood, & Buchbinder, 2017). Unlike acute NSLBP, chronic NSLBP is classified as back pain that persists for more than three months and presents a significant challenge to manage due to its prolonged non-specific nature and the lack of clear treatment guidelines. Although a comprehensive and multidisciplinary approach including pharmacological, physical therapy, and non-invasive therapy has been widely recommended for the management of chronic NSLBP, the effectiveness of these interventions may vary on the individual’s unique circumstances (Chou et al., 2017; Kamper et al., 2014; Maher et al., 2017).

Exercise, in particular, has been shown to be an effective strategy for the management of chronic NSLBP, with numerous studies demonstrating the benefits of core strengthening exercises (Akhtar, Karimi, & Gilani, 2017; Cho, Kim, & Kim, 2014; Hayden, Ellis, Ogilvie, Malmivaara, & van Tulder, 2021; Kumar, Kumar, Nezamuddin, & Sharma, 2015; Narouei et al., 2020). These studies highlight the significance of core strengthening exercises in reducing pain and improving physical function of individuals with chronic NSLBP, compared to those who only received conventional treatment. Despite the promising results, there remain a large degree of inconsistency and discordance in the recommendations for the best core exercise program for chronic NSLBP. These studies shown a diverse of core training approaches although they all share a common goal with mutual targeted core muscles such as transversus abdominis (TrA), multifidus (MF), paraspinal, abdominal, diaphragmatic, and pelvic musculature in order to improve the neuromuscular control, endurance, and strength of central muscles to maintain a dynamic spinal stability of individuals with chronic NSLBP (Akhtar et al., 2017; Amit, Manish, & Taruna, 2013; Cho et al., 2014; Inani & Selkar, 2013; Kumar et al., 2015; Nadler et al., 2002; Narouei et al., 2020; You, Kim, Oh, & Chon, 2014).

Given the increasing emphasis on core exercises as a potential solution for chronic NSLBP, it is therefore important to determine the most effective and targeted approach of core exercise program in the management of chronic NSLBP. In this study, we introduce the 360° TitaniUM Core Strength Exercise©, a novel sequence of core exercises aimed to strengthen a comprehensive range of core muscles without the need of specific equipment and suitable for all populations (Lim, Teo, Nguyen, Pham Thanh, & Phan Danh, 2020). The purpose of this preliminary study was to examine the effectiveness of the 360° TitaniUM Core Strength Exercise© on pain intensity and trunk extensor performance amongst chronic NSLBP in Malaysian government sector workers.

2. Methods

This study was approved by the Ethics Committee for Research involving Human Subjects of Universiti Putra Malaysia (JKEUPM-2021-845). All participants were recruited from various government departments located in Negeri Sembilan. The inclusion criteria were: (1) Government related workers based in Negeri Sembilan, (2) Aged 18-60 years with suspected or with chronic NSLBP, and (3) Low active lifestyle. However, participants who were: (1) Pregnant or receiving other forms of treatment at the same time, (2) Had a history of spinal surgery, spinal fracture, systemic rheumatologic diseases, neurological disorders or osteoporosis, (3) Had physical disabilities that prevented physical activity, and/or (4) Unable to comply with exercise program and/or scheduled follow-up assessment were excluded.

All participants were interviewed by a research assistant who was blinded to the study to obtain a detailed history upon recruitment. Those who met the criteria of the study were invited and informed about the nature and objective of this study, followed by a written informed consent was obtained prior to inclusion as participant in this study.

Participants were then randomly assigned into two categories (intervention and control) consisting of four groups using a computer-generated block randomization list (Suresh, 2011). This approach ensures a balanced and representative sample, reducing the potential for bias and increasing the validity of results. Participants assigned to the intervention groups underwent a 12-week exercise program of 360° TitaniUM Core Strength Exercise©, which was further divided into groups with progressively increasing frequency, intensity, or duration of the exercise over the study period (Lim et al., 2020). Meanwhile, the control group did not receive any treatment.

All groups were evaluated before (pre) and after the intervention (post). Pain severity was measured using the Visual Analogue Scale (VAS) where participants were asked to mark their pain intensity on a scale ranging from 0 points (no pain) to 10 points (unbearable pain) (Strong, Ashton, & Chant, 1991). Trunk extensor performance was assessed using the prone double straight leg raise (PDSLR) test, a simple and effective tool that measures the isometric endurance of the lower spinal extensor muscles (Arab, Salavati, Ebrahimi, & Ebrahim Mousavi, 2007). Participants were instructed to lie-down in prone with hips extended and hands under the forehead, forearms perpendicular to the body, then raise both legs until knee clearance, and hold the position as long as possible.

The 360° TitaniUM Core Strength Exercise© was designed to strengthen up to 29 pairs of core muscles, including the frontal abdominal muscles (rectus and transverse abdominis, internal and external obliques, adductors), back muscles (paraspinals and gluteals), and deep abdominal muscles (iliopsoas, iliacus, quadratus lumborum). The core exercises included: (1) Both elbow prone bridge, (2) Right elbow lateral bridge, (3) Both legs supine bridge, (4) Left elbow lateral bridge, (5) Both hand prone bridge, (6) Right hand lateral bridge, (7) Left leg up supine bridge, (8) Right leg up supine bridge, (9) Left hand lateral bridge, (10) Alternate left hand and right leg, (11) Alternate right hand and left leg, and (12) Superman. These exercises were performed in sequence as illustrated in Figure 1.

1. Both Elbow Prone Bridge

Lie on your stomach. Raise your body up so that you are resting on your forearms and elbows. Allign your head and neck with your back and place your shoulders directly above your elbows. Tighten your abdominal muscles.

2. Right Elbow Lateral Bridge

Lie on your right side, raising your body resting onto your right elbow and forearm. Rest your right arm along the side of your body. Place your left shoulder and arm directly above your right elbow, keep your shoulders, arm, hips, and knees in allignment. Tighten your abdominal muscles.

3. Both Legs Supine Bridge

Lie on your back with your knees bent (45° off ground). Keep your back in a neutral position, not arched and not pressed on the ground. Avoid lifting your hips. Straighten your hands on the ground pointing away from your head. Slowly raise your hips off the ground until your hips are aligned with your knees and shoulders. Tighten your abdominal muscles.

4. Left Elbow Lateral Bridge

Lie on your left side, raising your body resting onto your left elbow and forearm. Rest your left arm along the side of your body. Place your right shoulder and arm directly above your left elbow, keep your shoulders, arm, hips, and knees in allignment. Tighten your abdominal muscles.

5. Both Hand Prone Bridge

Lie on your stomach. Raise your body up so that you are resting on your palms. Allign your head and neck with your back and place your shoulders directly above your palms. Tighten your abdominal muscles.

6. Right Hand Lateral Bridge

Lie on your right side. Then, slowly raise and balance yourself supported by your right forearm and arm. Place your left shoulder and arm directly above your right forearm, keeping your left shoulder, arm, hips, and knees in allignment. Tighten your abdominal muscles.

7. Left Leg Up Supine Bridge

Lie on your back with your knees bent (45° off ground). Keep your back in a neutral position, not arched and not pressed on the ground. Avoid lifting your hips. Straighten your hands on the ground pointing away from your head. Slowly raise your hips off the ground until your hips are aligned with your knees and shoulders. Tighten your abdominal muscles. Then raise your left leg off the ground in alignment with your head, chest, and hip.

8. Right Leg Up Supine Bridge

Lie on your back with your knees bent (45° off ground). Keep your back in a neutral position, not arched and not pressed on the ground. Avoid lifting your hips. Straighten your hands on the ground pointing away from your head. Slowly raise your hips off the ground until your hips are aligned with your knees and shoulders. Tighten your abdominal muscles. Then raise your right leg off the ground in alignment with your head, chest, and hip.

9. Left Hand Lateral Bridge

Lie on your left side. Then, slowly raise and balance yourself supported by your left forearm and arm. Place your right shoulder and arm directly above your left forearm, keeping your right shoulder, arm, hips, and knees in allignment. Tighten your abdominal muscles.

10. Alternate Left Hand and Right Leg

Start on your hands and knees on the ground. Place your right hand directly below your shoulder and align your head and neck with your back. Raise your right leg off the ground then slowly raise your left arm. Tighten your abdominal muscles.

11. Alternate Right Hand and Left Leg

Start on your hands and knees on the ground. Place your left hand directly below your shoulder and align your head and neck with your back. Raise your left leg off the ground then slowly raise your right arm. Tighten your abdominal muscles.

12. Superman

Lie on your stomach. Raise all your limbs i.e., your arms and legs off the floor. Tighten your abdominal muscles.

Figure 1: Sequence of performing the 360° TitaniUM Core Strength Exercise©.

In the initial session of the 360° TitaniUM Core Strength Exercise© training program, participants in the intervention groups were briefed with some detailed instructions on proper exercise strategies and safety considerations (i.e., wearing suitable sport attire, performing a warm-up and cool-down, and exercising at least three hours after a meal), followed by a guided training session conducted by researcher. The remaining training sessions were conducted as home-based exercise program. A research assistant was assigned to ensure the progress and adherence of the participants through weekly phone and video calls. In addition, a written exercise program along with accompanying images, a logbook, and a demo video on YouTube were also provided to the participants to facilitate their home-based training program. The 360° TitaniUM Core Strength Exercise© program was carried out for three months and was performed according to the schedule of outlined in Table 1.

Table 1: Schedule of Performing the 360° TitaniUM Core Strength Exercise©

Month	Intervention (Frequency)	Intervention (Intensity)	Intervention (Duration)
First	2 sessions/week; 10 seconds/exercise; 2 sets	2 sessions/week; 10 seconds/exercise; 2 sets	2 sessions/week; 10 seconds/exercise; 3 sets
Second	3 sessions/week; 10 seconds/exercise; 2 sets	2 sessions/week; 10 seconds/exercise; 3 sets	2 sessions/week; 15 seconds/exercise; 3 sets
Third	4 sessions/week; 10 seconds/exercise; 2 sets	2 sessions/week; 10 seconds/exercise; 4 sets	2 sessions/week; 20 seconds/exercise; 3 sets

3. Statistical Analysis

A Split Plot Analysis of Variance (SPANOVA), also known as mixed design (within-group between-group ANOVA) were used to assess the collected data. All the data obtained from this study were analyzed by using the Statistical Package for Social Sciences version 26.0 (SPSS Inc, Chicago, IL, USA). The assumptions of normality, linearity, and homoscedasticity were assessed for all the data, along with the equality of variances was determined through spread-level plots and Levene's test. For multivariate tests, the Box's *M* statistic was used to show that inter-correlations were homogeneous. Bonferroni correction was also applied for multiple comparisons. The effect size of the differences was calculated using partial eta-squared (η_p^2). It was found that all the tests were two tailed, with an alpha significance level of .05. Data were presented as mean ± SD.

4. Results

In this study, a total of 52 participants met the inclusion criteria and participated. Of these groups, forty-eight participants completed the study, with a successful completion rate of 96%. Those who withdrew from the study included 3 participants from the intervention groups and 1 participant from the control group. Table 2 shows the demographic data of all participants.

Table 2: Demographic data of participants

Descriptions	***N=48***	**%**
Gender		
Male	12	25.00
Female	36	75.00
Ethnicity		
Malay	21	43.75
Chinese	25	52.08
Indian	2	4.17
Marital Status		
Single	14	29.17
Married	30	62.50

Widowed	1	2.08	
Divorce	3	6.25	
Residence			
Urban	31	64.58	
Rural	17	35.42	
Educational Level			
Primary	3	6.25	
Secondary	23	47.92	
Tertiary	22	45.83	
Descriptions	**Minimum**	**Maximum**	***Mean ± SD***
Age (years)	22	57	37.77 ± 9.93
Blood Pressure (mm/Hg)	92/51	181/103	127/80 ± 17.75/12.92
Heart Rate (bpm)	62	109	78.67 ± 10.72
Oxygen Saturation (%)	97	100	98.50 ± 0.88
Body Mass Index	16.22	38.17	26.54 ± 5.59
Habitual Physical Activity Index	2.25	6.75	4.22 ± 1.15

In this study, the level of pain was measured through a VAS, in which a higher score in scale showed that greater pain caused by chronic NSLBP. Table 3 shows the distribution of VAS in the study groups.

Table 3: The VAS mean scores of participants

Group	***n***	**Mean ± SD**	
		Pre-test	**Post-test**
Intervention (Frequency)	12	3.26 ±1.97	1.25±2.09
Intervention (Intensity)	12	4.06 ±2.51	1.00 ±1.15
Intervention (Duration)	12	4.34±2.31	0.58±0.85
Control	12	3.29±2.01	1.38 ±1.81
Total	48	3.74 ±2.19	1.05± 1.54

A SPANOVA was conducted to analyze the changes in mean of VAS between pre-test and post-test as well as the difference between intervention groups and control group. Table 4 shows the results of the analysis.

Table 4: The SPANOVA of VAS

Predictor	Wilks' lambda	*F*	*p*	Partial eta square
Time (pre-test vs. post-test)	0.36	76.99	< .001	0.64
Time*group (intervention vs. control)	0.88	2.08	.116	0.12

The changes between the level of pain in pre-test and post-test was significant, Wilks' lambda, Λ = 0.36, F (1, 44) = 76.99, $p < .001$, with a large effect size, $\eta_p^2 = 0.64$. Therefore, VAS was shown to be significantly improved within the groups. However, there was no significant interaction between time and groups (pre-test vs. post-test), Wilk's Lambda, Λ = 0.88, F (1, 44) = 2.08, $p = .116$, with a medium effect size, $\eta_p^2 = 0.11$. This indicated that the improvements of pre-test-post-test in the intervention groups were not significantly different from the control group. Multivariate between-group differences were also not significant, F (3, 44) = 0.73, $p = .974$, with an effect size, $\eta_p^2 = 0.05$, indicated that no mean differences were found between groups. Figure 2 shows the results of this analysis..

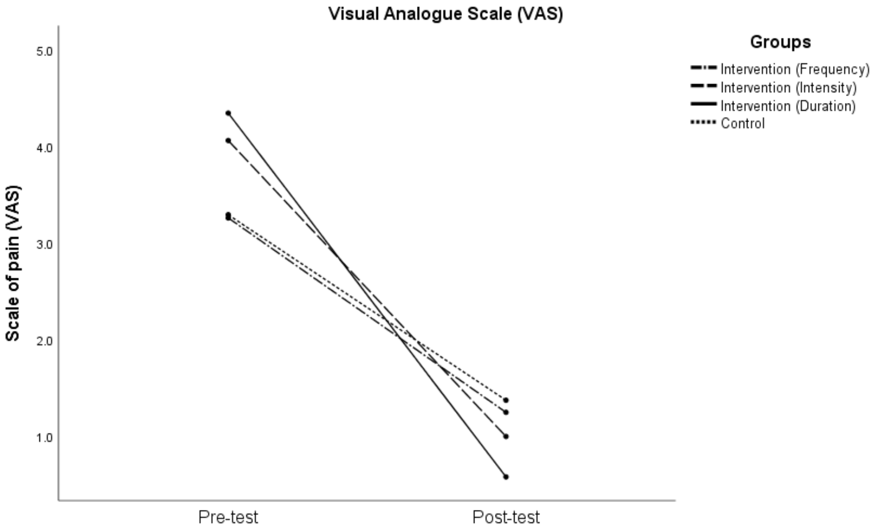

Figure 2. VAS between groups in the pre-test and post-test.

Participants' holding time with static posture were also measured using a PDSLR test, in which a greater holding time in a specific position represented a greater isometric endurance of the lower spinal extensor muscles regardless of chronic NSLBP. Table 5 shows the distribution of mean time in PDSLR test of the study groups.

Table 5: The mean time in PDSLR test of participants

Group	*n*	Mean ± SD	
		Pre-test	Post-test
Intervention (Frequency)	12	43.33±20.20	95.660±65.28
Intervention (Intensity)	12	52.69 ±32.38	155.59 ±64.62
Intervention (Duration)	12	39.26±35.02	96.85 ±70.58
Control	12	49.54 ±40.98	39.76 ±35.79

Total	48	46.20±32.39	96.96± 71.79

A SPANOVA analysis was conducted to analyze the changes of mean time in PDSLR test between pre-test and post-test as well as the difference between intervention groups and control group. Table 6 shows the results of the analysis.

Table 6: The SPANOVA of PDSLR test

Predictor	**Wilks' lambda**	***F***	***p***	**Partial eta square**
Time (pre-test vs. post-test)	0.61	28.73	< .001	0.40
Time*group (intervention vs. control)	0.71	5.98	.002	0.29

The comparison between the mean time of PDSLR test between pre-test and post-test was significant, Wilks' lambda, Λ = 0.61, F (1, 44) = 28.73, $p < .001$, with a large effect size, $\eta_p^2 = 0.40$. Thus, the overall mean time of PDSLR test was significantly improved with the exercise programs. There was also a significant interaction between time and groups (pre-test vs. post-test), Wilk's Lambda, Λ = 0.71, F (1, 44) = 5.98, p = .002, with a large effect size, $\eta_p^2 = 0.29$. The intervention groups showed a significant pre-test and post-test improvement of mean time in PDSLR test, but the control group showed a significant reduction of mean time in PDSLR test in pre-test-post-test. Furthermore, multivariate between-group differences were also significant, F (3, 44) = 5.52, p = .003, with a large effect size, $\eta_p^2 = 0.27$. Figure 3 shows the comparison between groups on pre-post interventions..

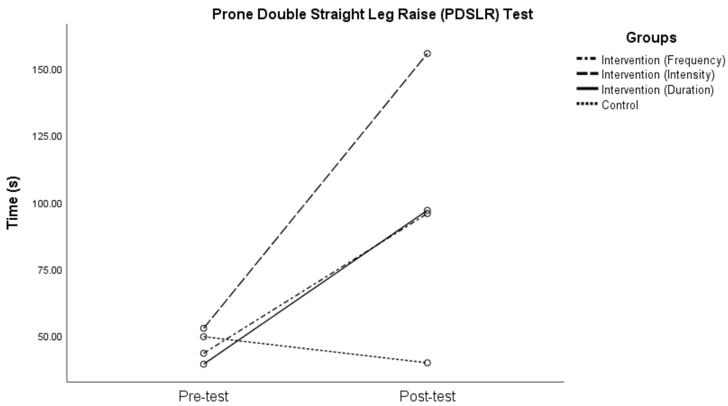

Figure 3. PDSLR test between groups in the pre-test and post-test.

5. Discussion

Despite the increasing number of studies demonstrating the effectiveness of core exercises for chronic NSLBP, a consensus on a standard core exercise program with optimal dosage has not yet been established. To best of our knowledge, this is the first study to present a novel core exercise program that specifically targets 29 pairs of core region muscles that strengthens a greater magnitude of muscle mass compared to other core exercise programs.

The results of this study indicated that the 360° TitaniUM Core Strength Exercise© was effective for the management of chronic NSLBP, with statistically significant reductions in pain (VAS) and improvements in isometric endurance of the lower spinal extensor muscle (PDSLR) compared to control group. These findings are consistent with previous study conducted by Akhtar et al. (2017), who concluded that core exercise program resulted in a significant reduction in pain at 2nd, 4th, and 6th week in patients with chronic NSLBP compared to those who underwent routine physical therapy exercise.

This is further supported by Narouei et al. (2020), where patients with chronic NSLBP who underwent core exercise program exhibited a significant reduction in pain and disability, as well as an increase in the activity and thickness of TrA, MF, and gluteus maximus muscles in comparison to those who received transcutaneous electrical nerve stimulation and hot-pack therapy. These studies suggest that core exercises can effectively strengthen both trunk and hip muscles, thereby improving the segmental muscles' capability to provide structural support and stability to the lower back, which in turn leads to reductions in pain and improvement in physical function.

The significance of having a well-developed core muscles to alleviate LBP has also been emphasized in the literature (McGill, 2001), in which a decreased of TrA anticipatory capacity in individuals with LBP implies a decline in segmental protective function. França and team (2010) conducted a comparative study to evaluate the effect of segmental stabilization exercises versus muscular strengthening exercises on pain, functional disability, and TrA muscle activation in individuals with chronic LBP. The study discovered that individuals who underwent segmental stabilization exercises targeted at TrA and MF muscles demonstrated substantial improvement in pain and functional disability. This improvement was also accompanied by a 48.3% increase in TrA muscle activation capacity. The findings of this comparative study are consistent with the results of our study suggesting that core strengthening exercises that specifically targeting TrA and MF muscles can enhance trunk activation capacity and potentially improve segmental protective function, ultimately reducing pain and functional disability in individuals with chronic LBP.

As reported by Costa et al. (2009), motor control exercises that target the activation of TrA and MF muscles have shown to be superior to electrotherapeutic modalities in reducing pain in patients with chronic LBP, with effects can be sustained over time. This could be attributed to the changes in trunk muscle activity through motor control that potentially reduce load and improve quality of movement by improving the coordination of trunk muscles. In addition, the ability to contract MF muscle is related to the ability to contract TrA muscle, where the odds of a good contraction of MF muscle being 4.5 times higher for patients who had a good contraction of TrA muscle (Hides, Stanton, Mendis, & Sexton, 2011). Our study further supports the significance of motor control through core exercises by demonstrating the effectiveness of a specific 360° holding positions that require participants learn to control their core muscles, resulting in trunk muscles coordination and decreased compressive load on the lumbar spine. These findings are consistence with the importance of targeting specific core muscles, such as the TrA and MF, to improve neuromuscular functioning and dynamic stability of the lumbar spine, hence reducing pain and symptoms in patients with chronic NSLBP.

The significant improvement in isometric endurance of the lower spinal extensor muscle observed in all intervention groups in this study, especially the intensity group, can be attributed to the core exercises included in the 360° TitaniUM Core Strength Exercise©. The exercises were specifically designed to target the core region muscles, resulting in a true spine stability with balanced stiffening from the entire musculature. For example, the prone bridge exercises recruit trunk flexors and lumbar extensors, while the lateral bridge exercises optimally activate lower-abdominal muscles such as quadratus lumborum, TrA, external obliques, MF, longissimus thoracis, and gluteal muscles. Similarly, the supine bridge exercises recruit rectus abdominis, external obliques, erector spinae, and gluteal muscle, while the alternate hand and leg exercises recruit erector spinae, latissimus dorsi, rectus abdominis, TrA, and gluteal msucles. Lastly, the superman exercise for back-stabilizer activation recruiting erector spinae, TrA, gluteals, deltoids, and hamstrings (Behm, Leonard, Young, C. Bonsey, & Mackinnon, 2005; Graham, 2009; Lehman, Hoda, & Oliver, 2005; Tong, Wu, & Nie, 2014; Tvrdy, 2012). As these core exercises specifically target the core region muscles, which may explain their effectiveness in improving the neuromuscular functioning and dynamic stability of the lumbar spine in patients with chronic NSLBP.

The findings of this study align with previous research that suggests patients with chronic NSLBP tend to prefer simple and convenient home-based exercise programs that offer flexibility and long-term effectiveness while being more cost-efficient (Ben Salah Frih, Fendri, Jellad, Boudoukhane, & Rejeb, 2009). Hayden, van Tulder, and Tomlinson (2005) also concluded that both individually supervised and supervised home-based exercise programs resulted in significant improvements in pain scores and functional capability in patients with chronic NSLBP. Moreover, research has shown that isometric exercise programs lasting more than one hour per session may have poor adherence and higher attrition rates (Linke, Gallo, & Norman, 2011). Therefore, it is recommended to utilize exercise strategies with an appropriate dosage that could promote patients' compliance and adherence in order to achieve the best outcomes. Overall, our study demonstrates a successful completion rate of 96%, suggesting that the 360° TitaniUM Core Strength Exercise© is a feasible and effective exercise program for managing chronic NSLBP.

6. Conclusion

The 360° TitaniUM Core Strength Exercise© is a comprehensive and potentially effective core exercise program for addressing the multifactorial nature of chronic NSLBP, leading to substantial improvements in both pain and functional capacity. The right dosage of progressive increase of training duration and intensity of the core exercise program has shown to be significant in reducing pain intensity and improving trunk extensor performance in patients with chronic NSLBP, respectively. However, further research with a larger sample size is necessary to confirm the efficacy of this core exercise program in managing chronic NSLBP.

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