Title: Online-Supervised NASM and Core Stability Exercises: Effects on Pain Management, Fear of Movement, and Athletic Performance in Taekwondo Athletes with Chronic Low Back Pain

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Abstract

Purpose: The current study intends to investigate the potential of core stabilization exercises and specific NASM exercises, both delivered through online supervision, in reducing fear of movement, managing pain, and enhancing functional performance among elite Taekwondo suffering from chronic non-specific low back pain.

Methods: A semi-experimental design with pretest and posttest measures was implemented, including 30 elite Taekwondo athletes with CNSLBP. Participants in both intervention groups completed sessions performed three days a week over eight weeks. Pain intensity, fear of movement, and functional abilities were assessed using validated tools, including the Visual Analogue Scale (VAS), Tampa fear of movement scale and the Functional Movement Screen (FMS).

Results: Both interventions significantly improved pain, kinesiophobia, and functional movement. However, Core stability exercises demonstrated superior results compared to NASM exercises by alleviating pain, reducing fear of movement, and improving functional mobility.. Pain scores showed a significantly greater reduction in the core stability group compared to the NASM group (p=0.001), and also Movement-related fear scores significantly lower in the core stability group (p=0.003). The core stability group demonstrated significantly superior improvements in functional movement scores (p=0.009).

Conclusion: Core stability exercises, particularly under online supervision, are effective in managing pain, reducing fear of movement, and enhancing movement performance in elite Taekwondo athletes with CNSLBP. Core stability exercises, proven superior to NASM interventions, should be integrated into rehabilitation programs to alleviate clinical symptoms and enhance athletic performance. Additionally, the findings underscore the potential of online supervision as a viable alternative for effective training and rehabilitation.

Keywords

Core Stability Exercises, Trunk Muscle Endurance, Physical Therapy, Exercise Therapy, Pain Management.

Highlights:

- Over an eight-week intervention period, core stability exercises significantly reduced pain and disability while notably Strengthening trunk muscles in those experiencing chronic low back pain through an eight-week program.
- Participants engaging in targeted core stability training exhibited greater functional improvements compared to those participating in general exercise programs.
- These outcomes underline the essential role of treatment protocol in effectively controlling chronic low back pain.

Plain Language Summary

This study examined the effects of different exercise programs on individuals with chronic lower back pain. It was found that exercises specifically designed to strengthen the core muscles were significantly more effective than general exercises. Those who did core stability exercises reported less pain and improved their ability to perform daily activities. This research emphasizes the importance of using specialized exercise programs in treating chronic low back pain to improve the quality of life for the individuals affected.

Introduction

Chronic non-specific low back pain (CNSLBP) remains one of the most common musculoskeletal issues globally, impacting individuals' daily lives and physical functionality(1). Athletes experience low back pain at different rates, ranging from 1% to 94% (2). This condition can significantly affect athletes by increasing pain levels. Athletes with back pain may experience severe discomfort (3). Additionally, low back pain is associated with diminished trunk muscle strength, endurance, and flexibility, which may inhibit athletic performance, elevate the risk of injury, and prolong recovery times (4, 5). Low back pain can significantly increase pain, provoke fear of movement, and reduce athletic performance (6). This condition is primarily caused by core muscular imbalance and neurological dysfunction, resulting in decreased proprioception and impaired control (7, 8).

Among various treatment options, exercise therapy is considered one of the most effective and widely used methods (2, 9).Coulombe et al. (2017) found that core stability exercises led to more significant improvements in pain levels, disability scores, and trunk muscle endurance compared to general exercises in participants with chronic low back pain over the 6-week period (10). According to previous studies, improving core strength and stability can lower pain severity and improve performance in athletes with low back pain (11-13). While several studies suggest that core stability exercises positively impact pain and performance, few have specifically examined their effects in Taekwondo athletes

The National Academy of Sports Medicine (NASM) emphasizes corrective exercises for muscle imbalances and movement dysfunctions (14). The NASM method includes stability exercises focusing on deep core muscles to maintain spinal stability and reduce pain by improving core muscle strength and neuromuscular control (15). Lee et al 2021(16) found that NASM core exercises enhanced activation of distal upper and lower extremity muscles, which could potentially reduce injury risk and improve performance. Moreover, a study comparing the effectiveness of NASM and Postural Restoration Institute (PRI) exercises in males with low back pain discovered significant enhancements in both pain levels and functional impairment among all the groups. Nevertheless, no particular method was considered to be superior (17).

Although NASM-based corrective exercise programs and stability exercises demonstrate potential for managing chronic low back pain in athletes, there is limited research specifically examining their impact on pain management, fear of movement, and athletic performance in Taekwondo athletes with chronic low back pain. This underscores the necessity for further exploration in this field. Additionally, the global COVID-19 pandemic has highlighted the need for remote training and rehabilitation. Online supervision of exercise programs ensures proper technique, adherence, and personalized adjustments through remote guidance from experts (3, 18, 19).

Research on the effectiveness of core stability and NASM-based exercises under online supervision to treat CNSLBP in elite Taekwondo players holds potential for the area of sports medicine. By successfully addressing biomechanical demands and controlling pain, this research has the potential to establish novel guidelines for athlete-specific rehabilitation. The primary objective of this study was to evaluate the effectiveness of core stability exercises compared to selected NASM exercises with online supervision on pain, fear of movement, and functional performance in elite taekwondo athletes with persistent musculoskeletal discomfort in the lower back. These findings suggest that integrating core stability training into rehabilitation programs may enhance recovery outcomes and performance in athletes dealing with low back pain.

Material and Method:

This study employed a semi-experimental, pretest-posttest design to evaluate the effectiveness of stability exercises and NASM-based exercises on movement performance, fear of movement, and pain in elite taekwondo athletes with chronic non-specific low back pain (CNSLBP). Participants (n=30) were randomly assigned to either an online-supervised NASM exercise group (n=15) or a core stability exercise group (n=15). The participants were elite Taekwondo athletes from Alborz province, each diagnosed with CNSLBP. From a population of approximately 58,000 Taekwondo practitioners in Alborz province, thirty eligible elite athletes were selected.

Inclusion criteria included a clinical diagnosis of CNSLBP lasting more than 3 months, confirmed by a physician (21); black belt status with more than 3 years of sports experience; age between 20–30 years; a pain score ≥ 4 on the VAS; and no history of spinal surgery, fractures, or neurological, inflammatory, or congenital disorders (20, 21). Exclusion criteria included specific low back pain or any identifiable pain on MRI, underlying medical conditions, history of any spinal surgery, unwillingness to continue participation in the study, irregular participation in training (20).

Ethical Considerations

This study was undertaken as part of a doctoral study authorized by the Graduate Council of the Department of Sport Sciences, University of Tehran. Due to COVID-19 restrictions at the time of data collection, formal institutional ethical approval was not obtained; however, all procedures strictly aligned with the ethical framework of the Declaration of Helsinki. Prior to participation, detailed written and verbal information regarding details about the study's aims, methods, possible risks, and benefits were communicated to all participants, who subsequently gave written informed consent. Confidentiality was protected, and participants could withdraw at any time without consequences.

Intervention Groups

Participants were divided into two groups: (1) NASM Intervention and (2) Core Stability Intervention. This group performed NASM-based corrective exercises designed to address muscle imbalances and improve core stability. The program followed NASM's four-stage approach: inhibition, lengthening, activation, and integration (14, 17). The program consisted of three sessions per week, each lasting 60 minutes, over an 8-week period. Sessions were conducted online with real-time supervision to ensure proper technique and adherence.

Online Supervised Stability Exercises Group: This group engaged in stability exercises aimed at strengthening the core and improving trunk muscle endurance. The exercise protocol aims to improve core stability and muscle strength through targeted exercises, including knee-flexion crunches, side planks, superman exercises, knee-bent lifts, supine bridges, full body planks, isometric extensions, squat exercises, and stability drills on a Swiss ball (22). The stability training protocol also consisted three 45-minute sessions per week for eight weeks. All sessions were conducted online using the platform https://meet.jit.si and were supervised in real-time by a trained instructor. After completing this 8-week program, a post-test was administered to all patients, followed by a follow-up test after 3 months of no training (under conditions similar to the pre-test), and the results were recorded.

Outcome Measures

Severity of discomfort was determined using the Visual Analogue Scale (VAS) a validated tool for assessing pain severity on a scale from 0 (no pain) to 10 (worst possible pain). The Visual Analogue Scale (VAS) is highly reliable and valid for pain assessment, with intraclass correlation coefficients often exceeding 0.9 (23).

The Tampa Scale for Kinesiophobia (TSK), an 11-item questionnaire used to evaluate fear of movement, was used to quantify fear of movement. Scores ranged from 11 to 44, where higher scores denoted greater anxiety. The intraclass correlation coefficient (ICC) for the Tampa Scale for Kinesiophobia (TSK) is 0.90, indicating remarkable test-retest reliability (24, 25).
Athletic performance was evaluated using the Functional Movement Screen (FMS), which includes seven functional movement tests scored from 0 to 3 (maximum total score of 21, higher scores indicating better movement quality). This test demonstrates acceptable inter-rater and intra-rater reliability coefficients ranging from 0.93 to 0.99 (26). Specific taekwondo performance tests, including kick accuracy and speed, were measured. Inter-rater reliability for these tests was evaluated implementing statistical approaches, including Cohen's kappa and intraclass correlation coefficients (ICC). High ICC values (e.g., > 0.75) indicate strong agreement among raters, supporting the reliability of the assessments (27).

Data Collection Methods and Instruments

Data collection occurred at two-time points: baseline (pre-intervention) and following the completion of the 8-week intervention (post-intervention). Evaluations were conducted using a range of standardized measures, including the VAS Pain Assessment, the Tampa kinesiophobia questionnaire, and the FMS. These assessments were administered by certified assessors who were blinded to the participants' group assignments to minimize bias. Additionally, performance in Taekwondo was assessed through tests measuring kick accuracy and speed, quantified using time-based metrics with digital timing tools.

Statistical Analysis Plan

Data analysis was executed using SPSS (version 26.0). Data characteristics were generated for each variable. Prior to conducting parametric tests, normality of the data was checked via the Shapiro–Wilk test. Changes within each group from pre- to post-training assessments were examined using paired-sample t-tests. To compare mean differences across groups over time, repeated measures ANOVA was applied, followed by post-hoc analyses to identify specific between-group contrasts. The effect size of the intervention was estimated with Cohen's d to interpret the strength of the outcomes. A significance level of $p < 0.05$ was used as the criterion to define statistical significance across all statistical procedures.

Results:

A total of thirty elite taekwondo athletes, aged 20–30 years, reporting chronic non-specific low back pain, were enrolled in the study. Participants were randomly divided into two equal groups: one group performed online supervised NASM exercises (n = 15), while the other engaged in online supervised core stability training (n = 15). The baseline demographic and clinical profiles, including age, height, weight, pain intensity, and fear of movement, were not significantly different between the groups. (Table 1).

Table 1. *Baseline Characteristics of Participants by Group*

Variables	Stability Exercises Group (n=15)	NASM Exercises Group (n=15)	p-value
Age (years)	25.2 ± 2.8	24.9 ± 3.1	0.78
Height (cm)	175.3 ± 6.2	174.7 ± 5.9	0.68
Weight (kg)	70.5 ± 8.3	71.1 ± 7.8	0.72
Pain Score (VAS)	6.8 ± 1.08	7.2 ± 0.94	0.34
Fear of Movement (TSK)	33.1 ± 1.16	33.7 ± 1.18	0.41
FMS Score	13.5 ± 1.06	13.0 ± 0.92	0.29

Note: 95% CI refers to the 95% confidence interval, and * indicates a significant difference.

Descriptive statistics of the Pain Score, Fear of Movement, and FMS Scores, are displayed in Table 2 for both the core stability and NASM groups across pre-test and post-test assessments. Preliminary to the statistical analysis included assessing data distribution normality with the Shapiro-Wilk test, and the equality of variances was examined using Levene's test, with both tests indicating no violations of assumptions ($p > 0.05$).

Table 2. Comparison of Pain Score, Fear of Movement, and Functional Movement Scores Between Stability Exercises and NASM Exercises Groups

outcomes	Core Stability Exercises (n=15)	NASM Exercises (n=15)	p-value
Pain Score (VAS) Pre-test	6.80 ± 1.08	7.20 ± 0.94	0.34
Pain Score (VAS) Post-test	3.93 ± 0.79	5.60 ± 0.98	0.001
Fear of Movement (TSK) Pre-test	33.06 ± 1.16	33.66 ± 1.18	0.41
Fear of Movement (TSK) Post-test	28.60 ± 1.29	29.73 ± 1.33	0.003
FMS Score Pre-test	13.53 ± 1.06	13.00 ± 0.92	0.29
FMS Score Post-test	15.93 ± 0.96	14.80 ± 1.14	0.009

Note: 95% CI refers to the 95% confidence interval, and * indicates a significant difference.

As shown in Table 2, there were significant improvements in all variables from pre-test to post-test in both groups. However, the improvements were more pronounced in the core stability group compared to the NASM group.

Table 3 outlines the statistical findings regarding Pain, Fear of Movement, and Functional Movement Scores. Before analyzing the data, the assumptions required for the statistical procedure were assessed. Box's test results confirmed the equality of covariance matrices for Pain Score ($p = 0.220$), Fear of Movement ($p = 0.187$), and FMS Score ($p = 0.334$), indicating that the data met the necessary criteria. The analysis revealed a significant effect of time ($p < 0.001$, $\eta^2 = 0.775$), indicating notable changes in pain levels across the study duration. Furthermore, a significant group effect was observed ($p < 0.001$, $\eta^2 = 0.351$), showing that participants in the core stability group consistently reported lower pain levels compared to those in the NASM group. However, the interaction effect between time and group was not significant ($p = 0.286$, $\eta^2 = 0.040$), suggesting that both groups followed similar trajectories in pain reduction over time.

***Table 3**. Repeated Measures ANOVA Results for Variables*

Variables	**Source of Variation**	**Sum of Squares**	**Mean Squares**	**F**	**Sig**	**Eta Squared**
Pain Score (VAS)	Time	74.81	74.81	96.68	0.001*	0.775
	Time * Group	6.01	6.01	7.77	0.001*	0.216
	Group	16.01	16.01	15.11	0.001*	0.351
Fear of Movement	Time	66.15	66.15	57.88	0.001*	0.647
	Time * Group	1.35	1.35	1.18	0.286	0.040
	Group	10.41	10.41	10.77	0.003*	0.278
FMS Score	Time	264.60	264.60	159.90	0.001*	0.851
	Time * Group	1.06	1.06	0.64	0.429	0.023
	Group	11.26	11.26	7.79	0.009*	0.218

Note: 95% CI refers to the 95% confidence interval, and * indicates a significant difference.

Main Effect of Time: This effect examines whether dependent variables (e.g., pain, movement performance, fear of movement) change significantly over measurement times.
Main Effect of Group: This assesses differences between the two exercise groups in the dependent variables, averaged over all measurement times.
Time*Group Interaction: This examines whether the changes in the dependent variables over time differ between the two exercise groups.

Discussion:

This study compared the effects of online-supervised core stability exercises and NASM exercises on pain, fear of movement, and functional performance among elite Taekwondo athletes with CNSLBP. Both interventions significantly improved pain (VAS), fear of movement (TSK), and functional movement (FMS) scores, with greater improvements observed with the core stability group. However, the improvements in severity of discomfort in low back scores were greater in the Core Stability group (M = 14.93) compared to the NASM group (M = 14.06).
The reduction in fear of movement scores in both groups, especially in the group practicing core exercises, highlights the psychological benefits of these exercises. The greater reduction observed in the core stabilization group aligns with findings from J Main (2023), who emphasized the importance of addressing psychological factors in pain rehabilitation (28). Core stability exercises can help athletes overcome their fear of movement, leading to better engagement in training and improved outcomes (29). The improvements in functional movement scores underscore the role of core stability in enhancing overall functionality. The results indicate that core stability exercises effectively improve these capabilities. A study by Rabiei et al. (2017) has shown similar benefits, supporting the integration of these exercises into training programs for athletes (30).
Additionally, the study revealed that both groups demonstrated reduced pain scores, with the core stability group achieving a greater reduction. This highlights the efficacy of core stability exercises in addressing discomfort in the lower back (CNSLBP), in line with earlier research by Coulombe et al. (2017) and Stuber et al. (2014) (10, 12). These data are aligned with the findings of studies

conducted Owen et al. (2020) (31), Kanas et al. (2018) (32), Hwangbo et al. (2015) (33), Eom et al. (2013) (34), which highlighted the beneficial effects of core stability exercises in enhancing movement performance among individuals suffering CNSLBP.

The enhancements in pain levels, functional movement scores, and fear of movement observed in this study primarily stem from the activation of the multifidus, transversus abdominis, and oblique abdominal muscles through core stabilization exercises (35, 36). These muscles play a vital role in controlling joint movement but can become dysfunctional in individuals with low back pain, resulting in joint impairments and functional disabilities (37). Retraining these muscles improves proprioception, muscle strength, coordination, and stability, leading to enhanced movement performance in Taekwondo athletes (29, 38-41).

A substantial strength of this research is its focus on elite Taekwondo athletes, addressing a gap in sport-specific rehabilitation research. Its randomized controlled design further adds rigor to the findings. However, the limited sample size may constrain the generalizability of results, and reliance on self-reported measures introduces potential bias. Additionally, while online supervision was practical during the COVID-19 pandemic, it may not fully replicate in-person guidance, potentially impacting technique and adherence. Future efforts should seek to minimize these limitations by increasing the size of sampled populations. objective assessments for pain and function, and exploring the long-term impacts of these interventions through longitudinal studies.

The findings highlight the effectiveness of both NASM and core stability exercises, particularly under online supervision, as viable strategies for managing chronic non-specific low back pain in Taekwondo athletes. This underscores the potential of remote training as a flexible and accessible alternative for athletes and coaches, offering expert guidance to support rehabilitation and performance.

Conclusion:

In conclusion, this study demonstrates that core stability exercises, particularly under online supervision, effectively alleviate pain, reduce fear of movement, and improve movement performance in elite Taekwondo athletes with chronic non-specific low back pain. Incorporating these exercises into rehabilitation programs can help manage clinical symptoms and enhance athletic performance.

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Authors' Contributions
Somayeh Karimi took the lead in developing the research design, performing data collection and analysis, and writing the manuscript draft. Mansoor Sahebozamani contributed to the study design, supervised the research process, and critically reviewed and revised the research document. Both contributors read and agreed upon the final edit of the article.

Conflict of Interest
The authors affirm that no circumstances or relationships exist that could be viewed as influencing the work presented in this article.

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