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IMPROVING MOTOR COORDINATION IN MOTION FITNESS AS A POSTURE TRAINING METHOD: A PILOT STUDY ON YOUNG KARATEKAS

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Abstract Effective kicking in karate depends on the stability of lower limb joints and the force of muscles, but little is known about how various training protocols influence these factors. Having an understanding of how specific strengthening programs influence the effectiveness of kicking and joint stability can optimize training for young karate players. Therefore, the present study investigates the effect of back-strengthening exercises executed at varying velocities on roundhouse kick performance and lower limb stability in young karatekas. Eight participants were divided into four groups, each following a 20-week, twice-weekly training program: Control (1), Classic (2), Classic with Constant Muscle Tone (3), and Steady Motion Fitness (SMF) (4). Joint angle changes in the kicking and supporting legs were analyzed before and after training using a video motion capture system, with statistical analysis conducted to assess improvements. Among the three static exercises tested, Group 4 SMF showed the most significant enhancements where $p < 0.0001$. In the right knee, the mean joint angle increased from 43.32° to 48.2° where $p < 0.05$, while the maximum joint angles improved from 118.49° to 133.42° where $p < 0.0001$. In the left knee, the mean joint angle decreased from 42.58° to 32.03° where $p < 0.05$, while the maximum angles decreased from 60.07° to 40.02° where $p < 0.0001$. These results indicate that SMF is more effective than traditional methods in enhancing lower limb strength and stability which suggests its potential as an optimal training approach to improve martial arts performance.

Keywords: karate athletes, gait cycle, swing phase hip deformity, asymmetry, motor coordination, health informatics, sports biomechanics, exercise science, knee joint biomechanics, martial arts, neuromuscular control, joint stability.

AMS Mathematics Subject Classification: 92C10, 62P10, 68U10.

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1 Introduction

In developed nations, sedentary living is a main contributor to musculoskeletal diseases, with back pain the most prevalent and incapacitating. Sitting for extended periods, increased screen time, and decreased exercise all lead to poor posture, muscle imbalances, and impaired core stability. All of these lead to chronic pain, reduced mobility, and impaired quality of life [1]. Proper posture is essential for musculoskeletal health and is primarily determined by pelvic alignment, which directly influences the positioning of the spine, thorax, shoulder girdle, and lower limb joints. Poor posture can lead to muscle imbalances, joint instability, and

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increased injury risk, particularly in physically demanding activities such as martial arts. Posture training aims to restore muscular balance, correct habitual misalignments, and enhance stability [2]. Strengthening exercise is recommended by research to replicate natural muscle function [3]. In fact the slow and controlled movements especially strengthen slow-twitch muscle fibers that are required to sustain postural stability [4]. Slow, deliberate movements are emphasized by several authors as essential in the correction of posture [5], which differentiates them from sport-specific strengthening exercises that typically are designed to enhance sports performance and not necessarily postural deficiency. General strengthening exercises differ from posture-orientated exercises in an important way. Wilmore highlights that both central nervous system and muscle tissue adaptations produce strength gains [6], which emphasizes the requirement for training programs to promote coordinated muscle function in the interests of efficient movement [7,8]. While traditional strength training methods focus on enhancing power and endurance, they may not adequately address posture-related muscle imbalances or the specific needs of athletes requiring both stability and dynamic movement control. Given that karate practitioners often experience lower back problems, pelvic positioning is of particular interest, as it has a more direct effect on lower back mechanics than on more distant body structures. Despite growing awareness of posture training benefits, limited research has explored the impact of targeted strengthening programs on joint stability and kicking efficiency in martial arts. One promising yet underexplored training method is Steady Motion Fitness (SMF), a novel approach developed over the past 15 years. While many individuals have reported its benefits anecdotally, no systematic studies have assessed its effectiveness. Consequently, this study addresses this gap by investigating how back-strengthening exercises performed at different speeds affect roundhouse kick performance and lower limb stability in young karatekas. We, specifically seek to determine the optimal velocity for posture training exercises and evaluate whether sport-specific strengthening alone can sufficiently replace dedicated posture correction methods. By comparing three distinct training approaches, this research provides new insights into the role of targeted strengthening programs in martial arts and contributes to optimize training protocols for injury prevention and performance enhancement. The significance of this study lies in its systematic assessment of SMF as a training method and its potential to improve posture and movement efficiency in young karate athletes. Unlike traditional strength training, which often overlooks postural alignment, this study integrates posture correction with sport-specific conditioning, offering a more holistic approach to athletic training. The findings have practical implications for coaches, trainers, and athletes, potentially guiding the development of more effective training programs that enhance both stability and dynamic performance in martial arts and other sports.

2 Materials and Methods

2.1 Participants

The participants for the study consisted of eight adolescents practicing karate from Budapest, Hungary which includes seven male athletes and one female athlete with an average age of 15.00 years old. Each of them was actively participating in Shotokan Karate competitions and held at least a blue belt or a brown belt. This shows that they were quite advanced in their training and were just a few kyu tests away from becoming a black belt. The criteria used for the selection were strict enough to make certain that the candidates had adequate technical expertise, training history, and physical fitness needed to reliably perform the prescribed kicking actions. Also, all the subjects had been training regularly with professionals which reduced their differences in skills and movements.

2.2 Study Overview and Hypothesis

Normal pelvic positioning depends on the coordinated function of the trunk and hip flexors and extensors. Posterior pelvic tilt results from the activation of the hip extensors and abdominal muscles, while anterior pelvic tilt is driven by the quadratus lumborum, deep trunk extensors, and hip flexors. In an optimal alignment, the anterior and posterior superior iliac spines remain in a horizontal plane, ensuring balanced load distribution and minimizing excessive stress on the lumbar spine [8,28]. Lateral pelvic stability is supported by the lateral trunk muscles and ipsilateral hip adductors, along with the contralateral hip adductors. Excessive forward pelvic tilt increases lumbar lordosis, leading to deep back muscle overcontraction and overstretching of the abdominal and posterior thigh muscles, resulting in weakness. Moderate hip flexor contraction can further increase lumbar lordosis, knee flexion, and foot positioning changes. More pronounced hip flexor contraction can cause equinus foot positioning, preventing heels from touching the ground during gait. Conversely, reduced lumbar lordosis deactivates deep back muscles, leading to decreased spinal flexibility [9,10,5,4,20,21,22,23]. Lateral pelvic inclination can initiate muscle imbalances, affecting multiple regions. Shortened hip abductors may cause tightness in the contralateral lower back muscles or overstretching of the hip adductors on the opposite side [11,12,24]. While muscle imbalances may result from neurological disorders, this study focuses on postural dysfunction as the primary cause. In karate, repetitive high-impact movements, particularly kicking, can pose risks to lower back stability. Repeated external rotation during kicking can strain muscles, particularly when performed frequently [13,27]. The kicks and punches generate force which exceeds the target's resistance, whether an opponent or a training board. According to Newton's second law, striking a fixed target produces an equal and opposite reaction force that transfers through the limbs to the spine. High side kicks, especially those reaching head height while balancing on one leg, place significant stress on the lower back. If posture is weak or abdominal engagement is insufficient, sudden contractions of the quadratus lumborum and lower trunk muscles can further increase lumbar lordosis, either immediately or over time. Additionally, abrupt trunk rotations, where opposing body segments, e.g., the shoulder and arm on one side and the opposite leg move forward, can exacerbate spinal strain [14,25,26]. Proper abdominal muscle activation is essential to counteract these forces and minimize lower back stress. Consequently, this study hypothesizes that targeted back-strengthening exercises performed at different speeds can improve lower limb stability and enhance kicking performance in young karatekas. Specifically, training protocols that optimize muscle coordination and postural control will yield greater improvements in stability and kicking efficiency. The study hypothesizes the following.

The holding time of static exercises is increased significantly in the SMF group, which shows greater improvement than other groups. Furthermore, a significant increase is observed in the change of the right (kicking) knee angle from the initial position to the final position in the SMF group. However, a significant decrease is observed in the change of the left (supporting) knee angle from the initial position to the final position in the SMF group. Additionally, the hip angle is decreased significantly in the SMF group.

2.3 Research Strategy

The study employs a two-phase assessment protocol which includes static and dynamic exercises to evaluate participants' postural control, muscle endurance, and movement efficiency.

Phase 1: Static Exercise Assessment The first phase includes three control exercises from the Hungarian Spine Society primary prevention program [5]. This phase is fully elaborated and discussed at the IEEE 20th International Symposium on Computational Intelligence and Informatics (CINTI) [32] in a presentation entitled Effects of Steady Motion Fitness as a Posture Training Method: A Pilot Study. The primary objective is defined as the assessment of the ability to maintain postural stability under static conditions. Because the original tests require five-second holding periods, the maximum duration for which each participant sustains the prescribed positions is measured. Each exercise is repeated three times, with short rest intervals applied between repetitions. Then, the average holding time is recorded for each exercise and each participant.In Prone Extension (Routine No. 3), a prone position is assumed, in which the arms are extended overhead and aligned with the ears. Both arms and legs are lifted simultaneously from the ground, and the position is maintained.In Abdominal Curl (Routine No. 4), a supine position is adopted, in which the knees are flexed and the feet are placed flat on the ground. The upper body is lifted, the arms are extended forward over the knees, and the position is maintained.In Wall Sit (Routine No. 6), an upright position is assumed, in which the back is supported against a wall. A 90-degree flexion is maintained at the hips and knees, while the arms are kept relaxed at the sides. The position is sustained for the maximum possible duration.

Phase 2: Dynamic Motion Analysis

The second phase analyzed the biomechanics of a right-leg roundhouse kick, a fundamental technique in martial arts. Participants executed the kick while standing on their left foot, performing a semicircular leg swing to strike with the front of the foot. Given the physical demands of the movement, the supporting (left) leg was expected to provide stability, while the kicking (right) leg was required to generate force and maintain controlled mobility. Left leg stability is evaluated through the analysis of variations in the left knee joint angle during the kicking action. The knee angle is recorded from the initial position to the final position, which reflects postural control during execution. Larger deviations between these positions are interpreted as lower stability. For this reason, reduced angular change is associated with improved lower limb control. Furthermore, stability is inferred as long as consistent joint alignment is preserved throughout the movement.Right leg mobility is assessed through the evaluation of joint angles at the finishing position of the kick. The final configuration of the right knee joint is used as an indicator of movement effectiveness. A larger range of motion is interpreted as greater force application. Therefore, increased angular displacement of the right knee is associated with enhanced kicking performance. Moreover, mobility is defined by the ability to reach functional extremes without loss of control.Motion capture markers are placed on major joints, e.g., the knees, hips, and shoulders, which serve as anatomical reference points. These reference points are used to define a kinematic model, in which joint movements are quantified objectively. Joint positions are recorded continuously throughout the kicking cycle. After data acquisition, functional minima and maxima of joint positions are identified. Then, joint angle ranges are calculated as the difference between these extrema as presented in Figure 1. As a result, precise quantification of joint mobility and stability is achieved.

2.4 Interventions

Following the initial assessment, participants engaged in a structured strengthening program conducted twice weekly over 20 weeks. A post-intervention assessment was performed to evaluate the effects of different exercise velocities on lower back posture correction. The study utilized simple yet targeted exercises to ensure consistency and minimize external variables that could impact the results. The participants with similar postural concerns were divided into four groups to standardize training conditions and mitigate confounding factors. The

Figure 1: Roundhouse kick

strengthening protocol was isotonic and designed to enhance muscular endurance. According to Dubecz, isotonic training improves muscle strength when performed with a high number of repetitions, with a minimum threshold of 32 repetitions per session [7,16]. To ensure individualized training intensity, each participant performed maximal repetitions of designated abdominal and hip extensor exercises during the first session at a standardized pace of 60 beats per minute, controlled by a metronome. This initial performance determined each individual's baseline capacity, and the same movement speed was maintained throughout the study. Gradual progression was applied weekly by modifying one training variable at a time, including the number of repetitions, limb elevation, or joint angle [7]. Additionally, the sequence of targeted muscle groups was altered every two weeks, and the starting side was occasionally switched. Strengthening exercises were consistently scheduled before karate training sessions to facilitate neuromuscular adaptations and integrate muscle activation patterns into dynamic movements such as kicks [17]. The participant grouping and exercise execution are explained as follows. The eight participants were randomly assigned to four distinct training groups:

- Group 1 (Control Group): Participants underwent only the initial and post-intervention assessments without engaging in the strengthening program.
- Group 2 (Classic Strengthening): Participants performed conventional isotonic exercises, executing alternating muscle contractions every two seconds, i.e., lifting the limb on one beat and lowering it on the next.
- Group 3 (Constant Muscle Tone Strengthening): Participants performed the same isotonic exercises but maintained partial muscle engagement throughout. Instead of starting from a fully relaxed position, they initiated movement with pre-contracted muscles and executed eccentric lowering with sustained contraction.
- Group 4 (SMF): This group followed a slower, controlled strengthening protocol. Both the lifting and lowering phases were extended to three seconds each, ensuring a steady, continuous engagement of the muscles.

2.5 Targeted Exercises and Execution Parameters

The training regimen is designed to strengthen the lower back through two targeted exercises, i.e., abdominal muscle training in a supine position and hip extensor training in a prone position [18,9]. These exercises are selected because controlled trunk and pelvic stabilization is required during execution. Furthermore, standardized positioning is applied to ensure consistency across participants. As a result, comparable mechanical demands are imposed during training.In abdominal muscle training, a supine position is adopted with a fixed knee angle. This knee angle is maintained by placing a ball behind the knees when required. For posture control, a cord is secured around the waist at the level of the umbilicus. The opposite end of the cord is fixed to a wall at a height that establishes a 40-degree trunk-to-cord angle. This configuration is applied to standardize trunk elevation. Participants are instructed to lift the upper body until contact with the cord is achieved using the nose or chin. Therefore, excessive cervical flexion and forward head posture are minimized. Additionally, a pole is positioned beneath the neck, which restricts rounded shoulder posture and excessive thoracic flexion (Figure 2). In this way, isolated activation of the abdominal musculature is promoted while compensatory strategies are limited.Hip extensor training is conducted in a prone position. The movement pattern is defined to emphasize activation of the posterior kinetic chain. Controlled elevation of the lower limbs is required, which places mechanical demand on the hip extensors and lumbar stabilizers. Execution parameters are standardized across participants, which ensures reproducibility of the task. Moreover, trunk alignment is preserved as long as excessive lumbar extension is avoided.By controlled manipulation of training variables, i.e., body position and movement execution, consistent loading conditions are established. Therefore, the influence of different movement velocities on lumbar posture correction is examined with reduced variability. In addition, muscle activation patterns are assessed under standardized conditions. As a result, the relationship between exercise velocity, postural alignment, and lower back muscle engagement is evaluated objectively.

2.6 Statistical analysis

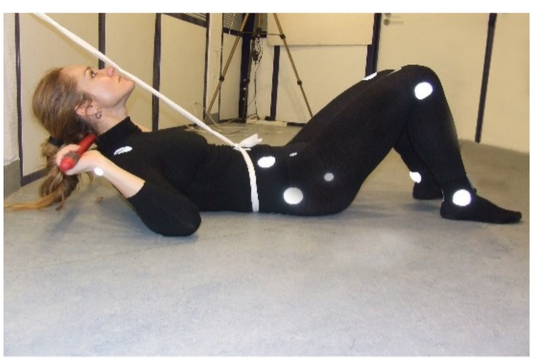

Figure 2: Abdominal muscle training

Figure 3: Hip extensor training

Extensor training is conducted on a stool, in which a prone trunk position is adopted. The thighs are left unsupported, which increases the mechanical demand placed on the posterior musculature. A constant knee angle is required throughout the task. This knee angle is maintained by placing a ball in the popliteal region when necessary. Therefore, uniform joint positioning is preserved across repetitions.For participants assigned to groups 3 and 4, the starting position is defined by allowing the thighs to descend 50 degrees from the vertical alignment. This inclined position is standardized through the use of cords, which extend from the edge of the stool to the floor and the wall. Additionally, the vertical reference position is also marked using the same method. As a result, spatial consistency is ensured for both reference positions.For participants assigned to group 2, only the vertical thigh position is fixed. This condition is applied because the starting position is established on the ground. Therefore, the need for an inclined reference position is eliminated in this group. However, identical alignment criteria are applied as long as the vertical orientation is maintained.Task difficulty is regulated through controlled modification of the thigh abduction angle. When the thighs are kept closed, the condition is defined as Level 1. When a 50-degree abduction angle is applied, the condition is defined as Level 2. When a 100-degree abduction angle is applied, the condition is defined as Level 3 (Figure 3). Hence, progressive mechanical demand is introduced through systematic adjustment of lower limb alignment.

2.7 Statistical analysis

A detailed statistical analysis is conducted to evaluate differences within and between groups. Multiple methods are applied, including the T-test, paired T-test, Mann-Whitney test, and ANOVA. These tests are chosen to provide rigorous comparison of pre- and post-intervention data. Furthermore, both parametric and non-parametric distributions are considered, which ensures that the analysis accommodates different types of data.In addition, the selection of these statistical tests allows for the detection of significant changes at both individual and group levels. The T-test and paired T-test are applied to compare means within groups, while the Mann-Whitney test is used for non-parametric data that do not satisfy normality assumptions. ANOVA is employed to examine differences across multiple groups simultaneously. As a result, the combination of these methods provides a thorough evaluation of intervention effects and validates the reliability of the observed outcomes..

2.8 The Goethe Gait Lab Motion Testing System

A video-based, computer-assisted GGL motion capture system is applied for the quantitative analysis of movement. Four cameras record motion from multiple perspectives, including front, rear, and both lateral views. The cameras are 60Hz PAL Sony video devices, which operate at a sampling rate of 50 frames per second and a shutter speed of 1/250 seconds [15]. This configuration ensures precise temporal resolution and minimizes motion blur, which is essential for high-speed movements such as kicks.Captured images are processed using an anthropometrically controlled body model, which consists of 16 key points. Four of these points are specialized markers designed to detect hip rotation and torsion. The model evaluates multiple variables, including joint displacements and angles, which allows detailed assessment of kinematics during the roundhouse kick. Proper calibration of the system is required to ensure accurate image acquisition, with a minimum frame overlap of 40 Percentage necessary for reliable data collection. In this study, a 60 Percentage overlap is achieved to enhance spatial and temporal precision [29].In addition, a Depth Map Matrix is implemented to improve spatial resolution [30]. This technique provides three-dimensional reconstruction of joint positions and movement trajectories, which increases the accuracy of biomechanical measurements. Consequently, the system captures subtle changes in joint angles and limb positions during dynamic tasks. Furthermore, the combination of multiple camera views, anthropometric modeling, and depth mapping ensures that both linear and angular kinematic variables are recorded consistently, which strengthens the reliability of subsequent data analysis.

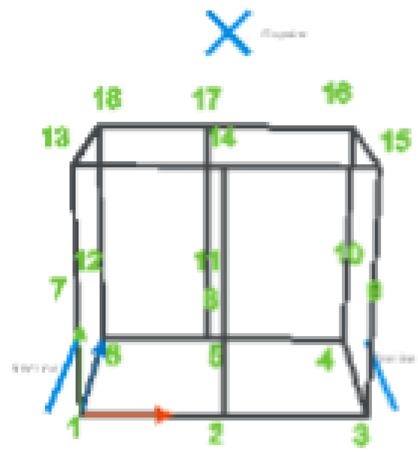

Figure 4: Validation, calibration and Body model

3 Results

The evaluation of the three static exercises yielded average holding times, measured in seconds. Table I presents the differences between the initial and final measurements for each group, which demonstrates a statistically significant improvement, i.e., $p < 0.0001$. A positive value indicates an increase in holding time, whereas a negative value signifies a decrease. Among all groups, Group 4, i.e., SMF, exhibited the most substantial enhancement in holding time, suggesting superior muscular endurance and postural control. These findings indicate that the SMF training method is particularly effective in improving muscle stabilization, optimizing force application, and enhancing neuromuscular coordination. Additionally, the results imply that SMF facilitates more efficient muscle engagement, contributing to better overall balance and movement regulation.

Table 1: Results of the time difference between initial and final static exercises in seconds

Group	Arm and leg holding	Abdominal holding	Standing by the wall
1 (Control)	-22	19	-14
2 (Classic)	-2	110	6
3 (Classic, contracted muscles)	8	111	-2,5
4 (SMF)	17	210	35

The changes in mean joint angle values in the right knee are analyzed in the classic and SMF groups. In the classic contracted group, the joint angle increases from 32.16 to 44.87 degrees. This change is significant and indicates a notable alteration in knee position. However, the maximum value in this group remains close to the data observed in the SMF group before intervention. Therefore, while a significant shift occurs, the range does not surpass the baseline observed in the SMF group.In the classic group, the mean joint angles of the right knee demonstrate a decline, with values changing from 47.30 to 38.68 degrees. This reduction reflects a worsening in knee alignment. In contrast, after SMF intervention within the same group, the parameter increases from 43.32 to 48.2 degrees. This improvement indicates that SMF positively influences knee joint angles, reversing the previous decline. The results also suggest that SMF produces a more consistent increase in joint mobility compared to natural changes in the classic group.Statistical analyses confirm the significance of these changes. Student t-test, ANOVA, and Mann–Whitney tests indicate $p < 0.05$, demonstrating that the observed differences are unlikely due to chance. The data are illustrated in Figure 5, which highlights the contrasting trends between classic and SMF groups. In other words, SMF intervention produces measurable and significant improvements in right knee joint angles, which can be quantified and compared with the classic group's natural variations.

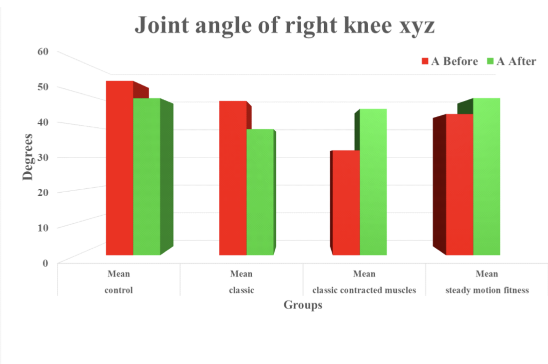

Figure 5: Mean joint angle values in the right knee before and after the 20-week programme

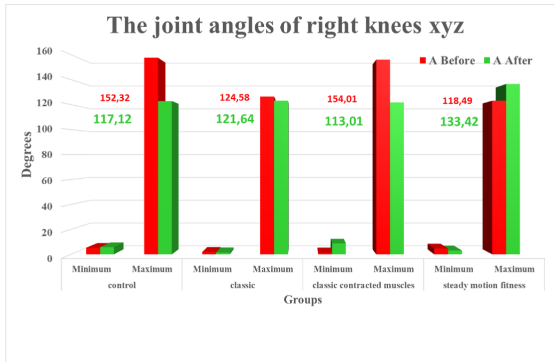

Figure 6: Minima and maxima of joint angle values in the right knee before and after the 20-week programme

The minima and maxima of joint angle values in the right knee show distinct patterns before and after interventions. In the control group, the maximum angle decreases from 152.32 to 117.12 degrees. This change is significant and indicates a marked reduction in joint excursion. In the classic group, the maximum angle decreases slightly, from 124.58 to 121.68 degrees, reflecting a minor reduction that does not reach the magnitude observed in the control group. In the classic contracted group, a larger decrease is observed, from 154.01 to 113.01 degrees, demonstrating a substantial loss in knee range.In contrast, the SMF group demonstrates a significant increase in maximum joint angle, from 118.49 to 133.42 degrees. This change indicates that the intervention positively affects knee mobility. Furthermore, the SMF group shows improvement in both minimum and maximum values, which suggests a broader functional range. The contrast between the SMF group and other groups highlights the potential of targeted interventions to restore or enhance joint movement that otherwise declines naturally or under classic conditions.The ranges of knee joint angles in three dimensions (3D) also change significantly. Statistical analysis confirms that the differences in joint range across groups reach $p < 0.000$, which demonstrates strong significance. In other words, the variations in minima and maxima are not due to random variation but reflect measurable and consistent effects of the interventions. Figure 6 illustrates these changes, showing the distinct trends between control, classic, classic contracted, and SMF groups. Thus, SMF produces a measurable improvement in knee joint function compared with other conditions.

The stability parameter for holding the left side is defined as the joint angle of the left knee. Initial means and ranges are inferior in all four groups, which indicates reduced baseline stability. After the therapy, a significant decrease in the range is observed in the SMF group. As a result, increased postural stability is indicated in this group. However, in the other groups, the ranges are increased, which reflects reduced control after the intervention. Therefore, group specific differences in stability responses are evident. Moreover, differences are observed in the means of parameter changes across the groups. In the SMF group, the mean joint angle is reduced from 42,58 to 32,03 degrees. This reduction is statistically significant based on the Student t test, Anova, and Mann Whitney test, with $p < 0{,}05$. Furthermore, in the classic contracted group, the mean value is increased from 30,88 to 33,85 degrees. Additionally, in the classic group, the mean joint angle ranges from 30,31 to 61,76 degrees, which is illustrated in Figure 7.

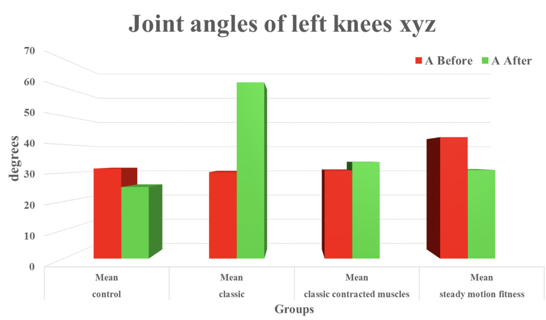

Figure 7: Mean joint angle values in the left knee before and after the 20-week programme

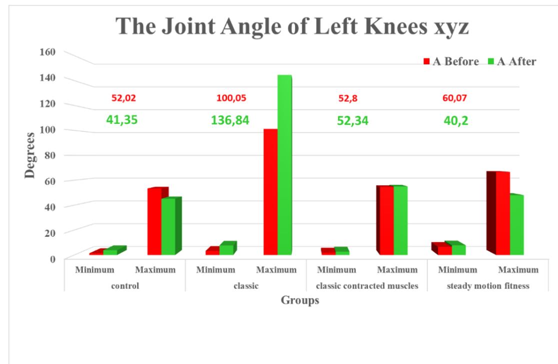

Figure 8: Minima and maxima of joint angle values in the left knee before and after the 20-week programme

The minima and maxima of joint angle values in the left knee are changed differently before and after the intervention across the groups. In the control group, the maximum value is reduced from 52,02 to 41,35 degrees, which is statistically significant. In the classic group, the maximum value is increased from 100,05 to 136,84 degrees. Furthermore, in the classic contracted group, minimal change is observed, as the value shifts from 52,8 to 52,34 degrees. However, in the SMF group, a significant decrease is observed, as the maximum value is reduced from 60,07 to 40,02 degrees. On the left side, higher stability is required to perform the roundhouse kick more efficiently. After the therapy, both the range of motion and the mean joint angle are significantly decreased in the SMF group. As a result, enhanced stability of the left knee is indicated. Moreover, these changes differ from those observed in the other groups, which show either increased or unchanged joint angle extremes. Therefore, the SMF intervention is associated with improved left knee stability, which is illustrated in Figure 8.

In the hips, four angles are measured by two methods. In the first method, angles are defined as vertical, in which the axis is set at the body model point and the branches are the trunk and the thigh. In the second method, angles are defined as horizontal, in which the axis is also set at the body model point, while the branches are the vertical hip lines and the horizontal lines between the hips. Furthermore, the means and ranges of motion are analyzed across 2*4 hip joint angles, which are illustrated in Figure 9. Therefore, a comprehensive description of hip kinematics is provided through both vertical and horizontal definitions. On the left side, the vertical parameters of hip motion are improved in the SMF group when compared with the other groups. In fact, the left side provides greater stability for the whole body, because a significant decrease in motion is observed. Moreover, the remaining angles indicate the source of this stability. The second hip angles are significantly decreased on the left side with $p = 0.000$. As a result, the contribution of sideways hip motion to overall stability is confirmed. Thus, stability is primarily derived from controlled lateral movement of the hip.

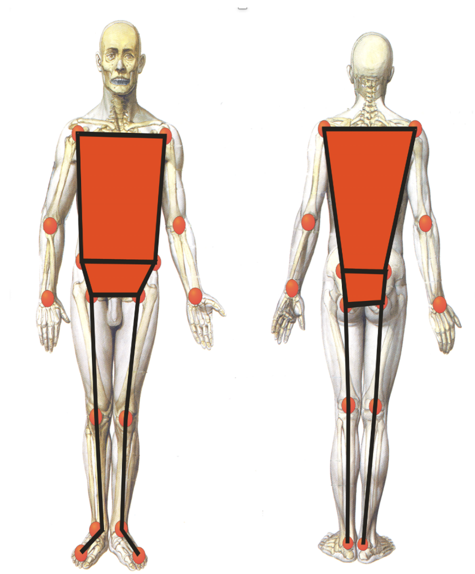

Figure 9: Measurement points (markers) and their relation to hip position

4 Discussion

Today, the inactive and sedentary lifestyles are associated with several chronic conditions, including backache. Reduced physical activity leads to weakened postural muscles, which affects spinal alignment. Correct body posture is based on an appropriate position of the pelvis. This position determines load distribution along the spine. Therefore, pelvic alignment is regarded as a central factor in musculoskeletal health. Furthermore, improper alignment increases mechanical stress on lumbar structures. Correct pelvic positioning is required during daily activities and during sports participation. Functional movements rely on coordinated pelvic control. Inadequate control disrupts kinetic chains, which reduces movement efficiency. As a result, compensatory patterns are developed. These patterns often contribute to pain and reduced performance. Thus, posture control remains essential in both preventive and performance contexts. Muscle activity during strengthening exercises should correspond to muscle activity during real practice. This correspondence ensures transfer of training effects. Therefore, a distinction is required between sport specific strengthening and posture correcting exercises. Sport specific exercises focus on force and speed. Posture correcting exercises focus on alignment and control. In other words, different objectives require different neuromuscular strategies. Many experts recommend slow and controlled movements in posture training. Such movements allow precise activation of stabilizing muscles. Additionally, slow execution reduces compensatory activation of superficial muscles. As a result, deeper postural muscles are activated more effectively. Therefore, movement quality is prioritized over movement quantity in posture training. Kicking techniques in martial arts require coordinated activation of multiple muscle groups. Almost the entire body participates in force generation and transfer. Execution of these movements requires sufficient muscular strength and skeletal integrity. Furthermore, temporal coordination between segments is required. Without this coordination, force transmission is reduced and injury risk increases. Roundhouse and sideward kicks impose high demands on balance and control. These kicks are often executed at head height. Body weight is supported by one leg during execution. Weak posture or incorrect abdominal muscle activation increases lumbar load. Because of this condition, the lumbar spine becomes vulnerable. Therefore, targeted strengthening exercises are required to protect this region. Special strengthening exercises provide both protection and performance development. These exercises support spinal stability during dynamic actions. In addition, they improve neuromuscular coordination. As a result, athletic movements become more efficient. Thus, strengthening serves both preventive and performance related purposes. The initial assessment includes static and dynamic tasks. Participants first perform three control exercises from the primary prevention program of the Hungarian Spine Society. Static tasks produce average holding times measured in seconds. These values reflect postural endurance. After intervention, the SMF group shows the greatest improvement. Holding times increase significantly more than in the other groups. Therefore, the first hypothesis is confirmed. Joint angle changes during a roundhouse kick are also examined. Mean values are recorded for the right knee during kicking and for the left knee during stance. The left knee joint angle serves as a stability parameter. This leg supports the entire body during the kick. Greater control of angular change indicates improved stability. Thus, smaller fluctuations represent better postural control. The right knee provides mobility related parameters. Changes in its joint angle indicate extension capacity. Greater extension reflects longer and stronger kicks. In the SMF group, mean values increase significantly from 43,32 to 48,2 degrees with $p < 0{,}05$. In contrast, other groups show inferior or inconsistent changes. Therefore, functional mobility improves most clearly in the SMF group. Analysis of minima and maxima supports these observations. In all groups except SMF, maximum right knee values decrease after intervention. In the SMF group, values increase significantly from 118,49 to 133,42 degrees. Thus, three dimensional knee mobility improves significantly with $p < 0{,}000$. Therefore, the second hypothesis is confirmed based on range and mean changes. Left knee analysis reveals a different pattern. After intervention, ranges increase in all groups except SMF. In the SMF group, the range decreases significantly. Mean values decrease from 42,58 to 32,03 degrees with $p < 0{,}05$. Minima and maxima also decrease from 60,07 to 40,02 degrees. As a result, improved stability of the stance leg is indicated. Thus, the third hypothesis is confirmed. Horizontal plane analysis includes four hip angles. These angles describe rotational and lateral control. On the left side, significant reductions in flexion, extension, and rotation are observed. This pattern indicates improved stability during stance. On the right side, ranges increase significantly in the SMF group. Improved mobility supports efficient kicking mechanics. Therefore, stability and mobility complement each other across sides. Hence, the fourth hypothesis is confirmed. Overall, parameters change differently across intervention groups. The SMF group demonstrates increased stability on the left side in both knee and hip joints. Reduced rotation and flexion are observed, while extension control improves. On the right side, mobility, rotation, and extension increase significantly. In other words, a balanced distribution of stability and mobility is achieved. Therefore, the SMF intervention produces superior functional outcomes compared with the other methods.

Conclusion

This study provides evidences to support the effectiveness of SMF as a posture training method for young karate practitioners. The findings suggest that SMF can improve postural stability and strengthen the lower back muscles, which are essential to execute technically sound and efficient roundhouse kicks. Compared to traditional training methods, SMF appears to be a more effective approach for improving postural control and motor coordination in karatekas. Nevertheless, this study includes several limitations that must be acknowledged. The small sample size and the homogeneity of participants, all sharing similar training backgrounds, limit the generalizability of the results to a broader population. Additionally, the study design was not optimal; a larger, double-blind, randomized controlled trial is necessary to establish more robust and reliable evidence. Moreover, the lack of a follow-up period prevents an assessment of the long-term effects of SMF training. Despite these limitations, this is the first study to investigate the feasibility and effectiveness of SMF in the context of karate training. The results indicate that SMF holds promise as a targeted intervention for posture improvement, particularly in young athletes who require enhanced postural stability for high-performance movements. Future research should focus on expanding the sample size, which incorporate participants with diverse age groups and athletic backgrounds, and implementing long-term follow-up assessments. Such studies are essential to fully determine the efficacy of SMF in addressing posture-related musculoskeletal issues, which includs lower back pain caused by insufficient muscle tone and strength.

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