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Original article

STRETCHING AND CORE-BASED EXERCISES AS A PROPHYLACTIC APPROACH TO SPINE INSTABILITY/LOWER BACK PAIN - A PILOT STUDY

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Abstract

Aim. The aim of this study was to evaluate the paravertebral left–right muscle imbalance before and after a stretching and Core-based exercise workout, aiming to represent a prophylactic tool for spine instability and lower back pain.

Methods. The muscle force (mV) of the erector spine was evaluated in 3 healthy subjects, average age 25 years, using 4 EMG surface electrodes annexed to the VICON system, recordings performed before and after specific muscle training, during correct and incorrect movements with the box, means picking up and down the box and returning to orthostatic starting position. This pilot study includes a specific training program, based on specific exercises to workout muscle force and core stability, promoting rebalancing and restoring muscle force and control. We evaluated the muscle imbalance between the left and right sides.

Results. We calculated the average of the muscle force (mV) imbalance and found that the difference between left and right in correct movement with the box is 0,00015mV before training and 0,000185 mV after training, which means an increase of muscle force of approximately 24%. Regarding incorrect movement with the box, we found that before the training, muscle imbalance is 0,000149 mV and after training 0,000169 mV, which means an increase in muscle force 13%. Both results demonstrated that such a training program generates an increase in muscle force and could be a way to develop a muscle training to prevent muscle imbalance and reduce the risk of spine instability.

Conclusions. The proposed therapeutic approach using VICON/EMG modern devices for the capture and analysis of motion and measurement of muscular force provides consistent and valuable evaluations of different muscle' parameters and dynamic behavior.

Keywords: Core-based exercises, muscle force imbalances, spine instability, electromyography.

Introduction

Spine instability, which often leads to episodes of lower back pain, is directly related to weakness and lack of muscular force and muscle tone in the lumbar region. Many studies have shown the importance of prophylaxis of lower back pain and spine instability using the so-called core-based exercise programs that target the training of the core muscles region. Public health programs should educate the public on the prevention of low back pain (Foster et al., 2018). Policymakers both internationally and nationally need to fund and promote the prevention of low back pain (Buchbinder et. al, 2018). There are studies that have shown that physical exercises improve physical fitness and health, helping to reduce pain and prevent lower back pain, whereas the lack of physical exercises leads to physical and mental deconditioning, leading to pain and fear of injury and, consequently, fear of movement and practicing physical exercises (George et al., 2021). As the title of a recent study conducted by Ayre, Jenkins, McCaffery, Maher, & Hancock (2022) rightly shows, physiotherapists have some hesitations and unmet needs regarding the delivery of exercise programs for lower back pain prevention in adults. Silva, Gelain & Candotti (2021) compared the intensity of lower back pain, behavioral habits, and the level of disability and kinesiophobia among exercising and non-exercising subjects, concluding that exercising individuals appear to present with a lower risk for occurrence of lower back pain, lower level of disability, and absence of work-related kinesiophobia (Silva et al., 2021). A systematic review conducted by Steffens et al. (2016) found that exercise, when combined with education, has a positive effect in reducing the risk of a future episode of lower back pain with a relative risk, whereas other interventions were ineffective or lacked evidence. Importantly, similar to our present pilot study, these authors included individuals without lower back pain at the time of inclusion in the research (Steffens et al., 2016).

The aim of the present study was to evaluate paravertebral left–right muscle imbalance using wireless surface electromiography before and after a stretching and core-based exercise program, which could represent a prophylactic tool to prevent lower spine instability and back pain.

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Methods

This study included 3 healthy subjects, with an average age of 25 years old, average weight 70 kg, average height 170 cm, and average body mass index (BMI) 25. Of the 3 subjects, one was a male (S2) who participated in the exercises program specific for core stabilization during 2 months, a one-day on/ one-day off workout; the other 2 subjects were females (S1, S3) who did not participate in the specific core stabilization physical exercises program, but were included in a classic physical exercises program based on paravertebral muscle strength. The main inclusion criteria were the absence of any episodes of lower back pain and did not participate before to any therapeutic or prophylactic similar program. The muscle force (mV) of the erector spine muscles was evaluated in these three healthy subjects, using four wireless surface electromyography (EMG) electrodes annexed to the VICON system. The recordings were performed before and after specific muscle training, during the correct and incorrect movements, meaning: picking up and down the box and returning to orthostatic starting position. The movement analysis includes two types of movement as described. Incorrect movement consists of the following steps: the subjects were requested to perform the movement incorrectly, that is, starting from orthostatic position, bending down without keeping the back straight and without any flexion of the knees, lifting the box from the floor and placing it up, then placing it back on the floor in the same incorrect manner and then returning to the starting position (Figure 1). Correct movement of manipulating the box means: keeping the back straight and flexing the knees when bending to take the box from the floor (Figure 2). We analyzed from the biomechanical perspective the movement of lifting a box with a weight of 5 kg. Muscles imbalance between the left and right sides was evaluated using wireless surface EMG attached to the VICON movement capture system.

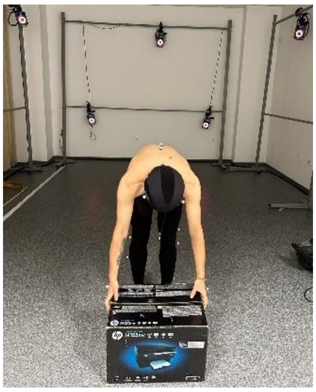

Figure 1. Incorrect movement with the box (original)

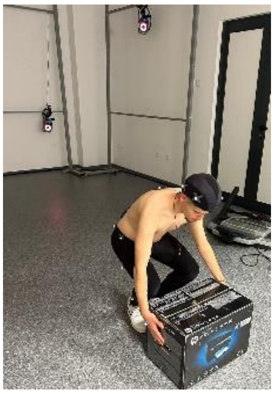

Figure 2. Correct movement with the box

During the execution of these movements with the box, the 4 wireless surface electrodes of EMG were placed 2 on the left and 2 on the right paravertebral muscles of the lower back region (Figures 3 and 4). The parameters measured were represented by the amplitude of the EMG waves that express the muscular force.

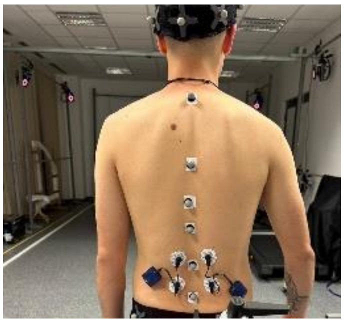

Figure 3. Wireless surface EMG electrods (original)

Figure 4. Wireless surface EMG electrods (original)

This pilot study includes a specific training program based on specific exercises to workout muscle force and core stability, promoting rebalancing and restoring muscle force and control. The recordings performed with surface EMG during incorrect and correct movements with the box were realized before and after the execution of a core-based workout exercise program, containing the following exercises, targeting the training of core strength, balance and stability, for subject S2, as presented in Figures 5, 6, 7, 8, 9:

Hurdler lat stretch (Figure 5) - a stretching exercise that balances both sides of the back. Dosage - 4 sets, holding the positions for 10 seconds for each set.

The technique of execution: from a seated position with both lower limbs comfortably apart to the side with one leg drawn towards the groin and the toe touching the medial side of the opposite knee, extend both upper limbs toward the extended lower limb, pulling with the hands on the toe. Sit evenly on your pelvic bones. Hold the posture wherever you feel comfortable, either on your knees or on your toes if you can. Try to bring both shoulders as parallel to the floor as possible. Inhale, round your back and lower your head. Maintain the stretch by holding it firmly with your hands on the outside of the ball of your foot. Exhale pull your hands forward, round your back even more, and look towards your navel. Repeat 4 more times, then release your hands, roll your shoulders and repeat on the other side.

Figure 5. Hurdler lat stretch (original)

Lunge opener (Figure 6) - a stretching that prepares the body to stand fully and trains the movement patterns so it is not lopsided/deformed and to appears imbalant. Dosage - 4 sets, holding the positions for 10 seconds for each set.

The technique of execution: standing on the hands and knees, extending one leg forward, taking the other leg back, and leaning on the front leg. Lift your glutes toward your head and place your pelvis underneath. Grab your hands and reach behind your head, holding onto your skull with your palms. Inhale open your elbows and lift your chest. Expire. Bring your elbows forward and down. Repeat 4 times, then bring the other leg forward and repeat.

Figure 6. Lunge opener (original)

Back extension (Figure 7) - improves the stability and force of the erector spinae paravertebral muscles, improves the range of motion of the lower back, and has a rehabilitative effect on poor lumbar or thoracic back posture.

Dosage: 4 sets of 10 repetitions, with a maximum of 10 seconds rest after each set. Technique of execution - Initial position – Lying forward, with arms extended forward in shoulder extension (lower limbs extended, upper limbs extended in head extension), chest support on the anterior aspect of the hips, thighs and knees extended on the ground. Inhale deeply.

Time 1 - on a deep exhalation, the trunk rises from the ground, without flexing the head, arms raised forward highly

Time 2 - still exhaling, bending the arms with the elbows facing the trunk.

Time 3 – return to Time 1

Time 4 – return to the starting position

Compensation - 10sec. – seated on the hands and knees, with the buttocks pressed against the heels, the trunk forward with the arms forward in shoulder extension, opening the knees and squatting back, bringing your hips close to your heels.

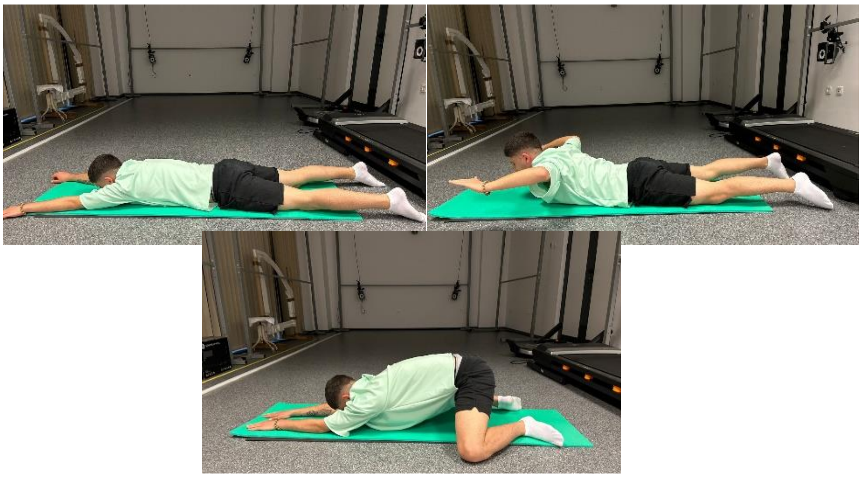

Figure 7. Back extension (original)

Back extension with opposite arm and leg reach - builds strength throughout the entire upper and lower back and core, improving the force of the erector spinae paravertebral muscles and flexibility and mobility in both the upper and lower body (Figure 8).

Dosage: 4 sets of 10 repetitions, with a maximum of 10 seconds rest after each set.

The technique of execution: Initial position – lying forward, with arms stretched out in front, looking at the ground. Inhale deeply. Time 1 – Exhale deeply with arm lift – opposite leg, simultaneously raising the left arm with the right lower limb extended, the gaze always remains toward the ground, without making an extension movement of the cervical spine - which must remain in line with the trunk. Time 2 – Return.

Compensation - 10sec. – seated on the hands and knees, with the buttocks pressed against the heels, the trunk forward with the arms forward in shoulder extension, opening the knees and squatting back, bringing your hips close to your heels.

Figure 8. Back extension with opposite arm and leg reach (original)

*Plank (*Figure 9) - an isometric core and strength-building exercise that engages a wide range of core muscles, including the erector spinae.

Dosage: 3 sets of 10 repetitions, rest 10-15 sec. Keep each plank for 20-30 sec.

The technique of execution: position the forearms on the floor with the elbows placed in line with the shoulders, keeping the forearms parallel and hands facing each other. Dorsiflex the ankles, toes pointed into the floor and supporting your weight. Hands and toes are the only parts of your body that are touch the floor. Draw the navel in toward the spine and squeeze the glutes, paying careful attention to the lumbar spine, to avoid any excessive arching of the lower back. The spine must be kept in proper alignment, so as to form a straight line from your heels to your shoulders. Compensation: 10-15 sec. – seated on the hands and knees, with the buttocks pressed against the heels, the trunk forward with the arms forward in shoulder extension, opening the knees and squatting back, bringing your hips close to your heels.

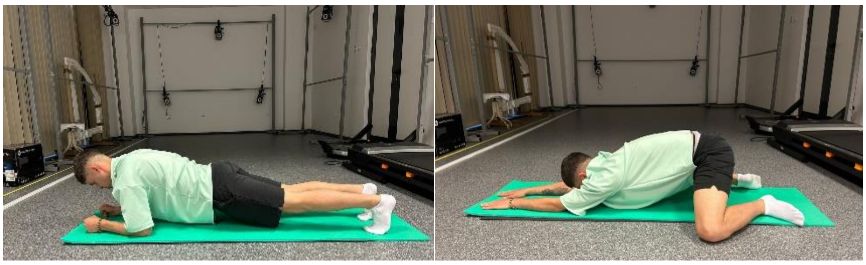

Figure 9. Plank (original)

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Results

The results are presented in tables 1, 2, 3 in the two situations before and after the workout program of exercises, in conditions of incorrect and correct performance of the movement with the box. The results include the average of muscle force asymmetry before and after the exercises and the symmetry, which represents the ratio between the symmetry index right and left, for each movement phase. Analysis of table 1 demonstrates that for subject 1 (S1), the symmetry index (SI) increases after two types of movement (incorrect and correct), especially in the hand-up phase, and the average symmetry index is 2.15 (incorrect movement) and 1.85 (correct movement).

Table 1. Average values of muscle force (mV) and symmetry index for subject 1

Movement phases	**Average values of muscle force**					
	Incorrect			**Correct**		
	Before	After	symmetry index	Before	After	symmetry index
Orthostatic Position	0.0000122	0.0000712	5.82	0.0000134	0.0000826	6.16
Bending 1	0.0001950	0.0001830	0.94	0.0001170	0.0001710	1.46
Straightening 1	0.0001160	0.0003450	2.97	0.0001850	0.0002930	1.58
Hand up	0.0000169	0.0002870	16.98	0.0000186	0.0002440	13.08
Bending 2	0.0001030	0.0002080	2.02	0.0000675	0.0001830	2.71
Straightening 2	0.0001550	0.0001910	1.23	0.0002370	0.0002060	0.87
Average values	0.0000997	0.0002142	2.15	0.0001064	0.0001966	1.85

Analysis of table 2 demonstrates that for subject 2 (S2), the symmetry index decreases after two types of movement (incorrect and correct), especially in the orthostatic position, hand up phase in incorrect movement and in the orthostatic position in correct movement. The average symmetry index is 0.64 (incorrect movement) and 0.86 (correct movement). We can conclude that in both movements, the symmetry index decreases, indicated an improvement in muscle symmetry after the core stabilization exercises program.

Table 2. Average values of muscle force (mV) and symmetry index for subject 2

Movement phases	**Average values of muscle force**					
	Incorrect			**Correct**		
	Before	After	symmetry index	Before	After	symmetry index
Orthostatic Position1	0.0000772	0.0000587	0.76	0.0000762	0.0000614	0.81
Bending 1	0.0001650	0.0000850	0.51	0.0002270	0.0001640	0.72
Straightening 1	0.0003340	0.0002400	0.72	0.0002360	0.0002660	1.13
Hand up	0.0002220	0.0001600	0.72	0.0002070	0.0002200	1.06
Bending 2	0.0002780	0.0001280	0.46	0.0002640	0.0001950	0.74
Straightening 2	0.0002490	0.0001620	0.65	0.0002140	0.0001560	0.73
Orthostatic Position2	0.0000801	0.0000640	0.80	0.0000759	0.0000599	0.79
Average values	0.0002008	0.0001282	0.64	0.0001857	0.0001603	0.86

Analysis of table 3 demonstrates that for S3, the symmetry index increases after two types of movement (incorrect and correct), especially in the hand-up phase, and the average symmetry index is 1.12 (incorrect movement) and 1.26 (correct movement).

Table 3. Average values of muscle force (mV) and symmetry index for subject 3

Movement phases	**Average values of muscle force**					
	Incorrect			**Correct**		
	Before	After	symmetry index	Before	After	symmetry index
Orthostatic Position1	0.0000544	0.0000808	1.49	0.0000704	0.0000649	0.92
Bending 1	0.0001190	0.0000885	0.74	0.0001350	0.0001700	1.26
Straightening 1	0.0002400	0.0002510	1.05	0.0002480	0.0003150	1.27
Hand up	0.0001960	0.0003100	1.58	0.0001620	0.0002800	1.73
Bending 2	0.0001480	0.0001510	1.02	0.0001960	0.0002280	1.16
Straightening 2	0.0002050	0.0001950	0.95	0.0002250	0.0002690	1.20
Orthostatic Position2	0.0000717	0.0000780	1.09	0.0000693	0.0000686	0.99
Average values	0.0001477	0.0001649	1.12	0.0001580	0.0001993	1.26

Based on these EMG recordings, we calculated the average of the muscle force (mV) imbalance and found that the difference between left and right in correct movement with the box is 0,00015 mV before training and 0,000185 mV after training, which means an increase in muscle force of about 24%. Regarding incorrect movement with the box, we found that before the training, muscle imbalance is 0,000149 mV and after training 0,000169 mV, which means an increase in muscle force 13%. Both of these results demonstrated that such a training program of exercises generates an increase in muscle force and could be a way for developing muscle training for prevention of the musclular imbalances and for reducing the risk of affecting spine stability.

The results presented in tables 1, 2 and 3 provide information about how muscle symmetry could be influenced by physical exercises, especially the specific core stabilization exercises program applied to subject 2. This demonstrates that these types of exercises, such as the prophylactic program, help to reduce the muscle imbalance in paravertebral muscles.

Discussions

Our results, based on an identification of the parameters that define muscle balance assessed with the help of surface EMG at the lumbar level, highlight the importance of evaluating the muscle force for paravertebral muscle symmetry. Several other studies have demonstrated that the greater the electromyographic (EMG) activity, the greater the challenge to the neuromuscular system; thus, core-type exercises that increase EMG activity may be useful for strengthening the core muscles (Martuscello et al., 2013). Zheng et al. (2019) also found that monitoring the core exercises can significantly activate and improve the core musculature in healthy individuals, providing a potential strategy to prevent and treat lower back pain more effectively (Zheng et al., 2019). Although physical therapy cannot solve all lower back pain cases, given the large number of people suffering from lower back pain and the associated costs, lost work, and frustration - the question of what role physical exercise can play in both prevention and rehabilitation requires significant further research (Silva et al., 2021).

Conclusions

This therapeutic approach using VICON/EMG modern devices for the capture and analysis of motion and measurement of muscular force provides consistent and valuable evaluations of different muscle' parameters and behavior in dynamic.

The calculation of the symmetry indices by reporting the values of the right and left muscle force before and after the execution of an exercise program highlights the importance of the most objective evaluation of the muscle force in the context of the evolution of paravertebral muscle symmetry.

We can conclude that in both types of movements with the box after the workout of the Core-based exercises program, the symmetry index decreases, indicated an improvement of muscle symmetry as a consequence and result of the Core stabilization exercises program.

Our results offer information about how muscle symmetry could be influenced by specific core stabilization exercises, demonstrating that this program could represent a prophylactic tool to prevent spine instability and lower back pain.

Further research studying the effects of core exercises programs is desired to find the best among these types of exercises, so they might be implemented in the current practice of prophylaxis of spine instability and lower back pain.

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