

# THE EFFECT OF SINGLE HIGH-VELOCITY, LOW-AMPLITUDE SPINE MANIPULATION ON POSTURE, FUNCTIONAL STATE OF TORSO, THIGH MUSCLES, AND VERTICAL JUMP HEIGHT

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**Abstract.** *The effects impact of single high-velocity, low-amplitude (HVLA) spinal manipulation on posture, torso, and thigh functional condition, and the height of the vertical jump have not been adequately studied. The research aims to investigate the immediate changes caused by a single spinal vertebral HVLA manipulation 3 weeks after posture, torso, and thigh muscle functional state, and vertical jump height. The study involved 46 men aged 18-25 years old who practiced indoor volleyball training at least twice a week, as well as a deviation of the vertebral vertebrae from the non-thymic position. Initially, posture was assessed using the photogrammetry method and muscle length was assessed using the goniometry method. A vertical jump height test was performed by the Sargent Jump test. A single HVLA spinal manipulation was performed by a certified chiropractor for segment correction. Then, a re-assessment of posture (photogrammetry), re-assessment of movement volume (goniometry) as well a re-assessment of vertical jump height test- the Sargent Jump test was performed. After 3 weeks post HVLA manipulation participants were retested. The main findings are: immediately after the HVLA spinal correction changes in posture were observed in all evaluated parameters, deviations from the norm decreased by  $25.45\% \pm 1.27\%$  ( $p < .005$ ), while the vertical jump height test results immediately after HVLA increased by  $4.34\% \pm 0.11\%$  ( $p < .005$ ). After 3 weeks post HVLA spine manipulation therapeutic effect was reduced by  $5.48\% \pm 1.27\%$  ( $p < .005$ ), while the Sargent Jump test result 3 weeks after manipulation decreased by  $0.05\% \pm 0.11\%$  ( $p > .005$ ). Conclusion: the persistence of the effect of a single HVLA spine manipulation was maintained for 3 weeks after the manipulation into the posture.*

**Keywords:** *manipulation, Photogrammetry, posture, vertical jump height, volleyball.*

## Introduction

Keeping physically active is important from both cultural and social perspectives. Nowadays, volleyball has grown in popularity, with around 800 million people playing it at least once a week. At both the amateur and professional levels, players pay more attention to their state of health to avoid injury and improve their physical performance (Bahr & Reeser, 2003; Verhagen,

Van der Beek, Bouter, Bahr & Mechelen, 2004; Hughes & Watkins, 2008). The ever-increasing development of volleyball as a sport is forcing volleyball players to improve themselves not only tactically and technically, but also physically. Difficult and intense training, as well as sport-specific physical activity- often lead to injuries. Injuries cannot be completely avoided, but it is possible to reduce the risk factors that can contribute to these injuries, which in turn can have a positive effect on the performance of athletes (Bahr & Reeser, 2003; Verhagen et al., 2004; Hughes, & Watkins, 2008).

Volleyball is a sport that requires a combination of strength, power, agility, and coordination. The biomechanics of the volleyball strike involve a complex interaction between the musculoskeletal components of the body, including the shoulder, elbow, wrist, and trunk (Aspegren, Hyde & Miller, 2007; Ditcharles, Yiou, Delafontaine & Hamaoui, 2017).

Due to the high demands placed on the body during volleyball, athletes may experience musculoskeletal injuries or pain, particularly in the spine. Spinal manipulation, including high-velocity, low-amplitude manipulation, has been studied for its potential benefits in improving joint function, decreasing pain, and increasing range of motion in athletes, including volleyball players.

### **Literature review**

Many authors talk about the human body as a holistic being, influencing one system will change other systems (Frost, 2002; Lewit, 2005; Galeja, 2015).

Many books and studies have mentioned how reduced body mobility and stability of volleyball players can be a contributing factor to a variety of injuries, such as ankle sprains, and cross-ligament injuries. The most common overload injuries in volleyball are patellar tendinitis and functional problems in the shoulder joint (tendonitis, rupture, etc.). Of course, lumbar, and lower limb overloads cannot be forgotten either Based on these studies, we can conclude that many injuries can be prevented by correcting the functional state of the body (Bahr & Reeser, 2003; Verhagen et al., 2004; Hughes, & Watkins, 2008).

The results of researches show the influence of various manipulations and exercises on the mobility, stability, and height of the vertical jump of volleyball players (Leporace et al., 2011; Sharma, Geovinson & Singh Sandhu, 2012; Pedak, Port, Rannama & Bazanov, 2019; Gouttebarga, van Sluis, Verhagen & Zwerver, 2017). During the training process, deviations in the functional state of the athlete's musculoskeletal system from the optimal position are often associated with soft tissue overload, which can lead to incorrect loading of the involved joint in both statics and dynamics. The above factors can lead to functional restrictions and block the movements of improperly loaded joints. Soft

tissue and joints are the functional limitations and blocks of these joints so that the specific segment can function optimally (Learman et al., 2009).

High-velocity, low-amplitude (HVLA) manipulation has been studied for its effects on athletes' mobility and stability. A randomized pilot study found that HVLA applied to the thoracic spine increased spine mobility, but this increase in mobility did not lead to improved gait initiation performance, such as speed and step length (Ditcharles, Yiou, Delafontaine & Hamaoui, 2017); Shin, Kim, Jung, Cho, & Hahm, 2020).

Recent research on spinal manipulation in volleyball includes a study that investigated the effects of high-velocity, low-amplitude manipulation on a female collegiate volleyball player with thoracic outlet syndrome. The study found that the manipulation led to significant improvements in the player's symptoms and functional ability (Aspegren et al., 2007).

A more recent study investigated the effects of a single session of spinal manipulation on strength and cortical drive in elite Taekwondo athletes. The study found that the manipulation increased muscle strength and cortical drive to ankle dorsiflexion, with the effects lasting for at least 60 minutes (Christiansen et al., 2018). These studies suggest that spinal manipulation may have beneficial effects for athletes, but further research is needed to fully understand its mechanisms and potential benefits in this context.

In summary, HVLA manipulation can increase spine mobility, but its effects on athletes' mobility and stability during sports performance are not yet fully understood. Further research is needed to clarify the mechanisms and benefits of HVLA in this context.

The aim of the research is to study the immediate changes caused by a single HVLA C6-Th2 spine manipulation and the persistence after 3 weeks on posture, torso and thigh muscle length, and vertical jump height.

## **Methodology**

The study involved 46 men aged 18-25 years old. **Inclusive criteria** for volleyball players who practice volleyball training at least twice a week or more and play for more than 5 years. Also, the volleyball player has been diagnosed with changes in posture from the correct posture from the correct posture pattern and neck, and functional abnormalities of C6-Th2 vertebrae. **Exclusive criteria:** History of spinal and shoulder injuries (fractures, dislocations of the joints, chronic instability, damage of the soft tissues and ligaments of the surrounding structures). No symptoms of "Red Flag" (sudden abdominal pain, bleeding, fever, etc.); play volleyball less than 2 times a week; Contraindications for spinal manual therapy (HVLA) tumors of the joints, limbs, or internal organs; non-

specific infectious processes in the spine, joints; acute and subacute inflammatory disease of the joints.

The research took place when the participants or the research (volleyball players) did not have active physical training, so the obtained results would not be affected to the maximum.

All these experiments took place in the Scientific Lab of Physiotherapy, Latvian Academy of Sport Education, Riga, Latvia. Hygienic conditions of the room, i.e. room temperature 18-20 ° C and natural light, were provided during the study. Ethical approval Nr.130/47813 by LASE.

**Measures and procedures:** The research took place at the Scientific Lab of Physiotherapy, Latvian Academy of Sport Education, Riga in 2021.

Participants were assessed for posture, torso, and thigh muscle lengths, and vertical jump height. After the initial assessment, participants underwent a single C6-Th2 HVLA spinal manipulation. A certified manual therapist with experience in this field performed a single C6-Th2 segment HVLA manipulation of the spine in flexion concerning the material developed by the author Karl Lewit in manual therapy (Lewit, 2005).

After the spinal manipulation, the participants were in a spine position for 15 minutes, after which the participants were re-evaluated. After 3-week post-manipulation, participants were re-evaluated to see if the changes in the body caused by the manipulation had been maintained or returned to their original condition.

Postural parameters were evaluated using the photogrammetric method. The purpose of photogrammetry measurements is to obtain accurate measurements from reference points located on any fixed object. Participants were attached to specific anatomical points with circular markers 2 millimeters in diameter, exactly at the center of the specific anatomical point. This activity was performed by a researcher experienced in this research method. 3 photos were taken - in the frontal and posterior planes, as well as in the sagittal plane. The obtained photo images were processed using a special computer program ArchiCAD23. In which the angular deviation from the correct posture pattern in statics was obtained (Hoppenfeld, 1976; Kendall, McCreary, Provance, Rogers & Romani, 2005; Galeja, 2015).

The amplitude of the movements was measured using the goniometric method. A calibrated Baselin AcuAngle Inclinometer (Japan) and a standardized test were used to estimate the amplitudes of the movements, as the accuracy of the data obtained is important to ensure that the results obtained from repeated measurements are comparable with the original data. To increase the accuracy of the measurements (measurement accuracy  $\square 1 \square$ ), the operating instructions of the manufacturer's goniometer were followed, considering the following additional conditions: the measurement conditions were maximally standardized;

the research and data processing were carried out by the same person with experience in this field (Kendall et al., 2005).

Standardized muscle tests were used: m.quadratus lumborum; m.rectus femoris; and hamstring muscle group.

*Tests m. quadratus lumborum*

The subject is standing, feet together, arms along the sides. The axis of the goniometer pendulum is placed in the horizontal plane on the surface of the skull to be examined, at the point of the vertical axis. The subject performs maximal torso lateroflexion, the goniometer reads the indicated amount of movement in degrees. The examiner monitors the movement of the test subject in the frontal plane (Kendall et al., 2005).

*Tests M. rectus femoris*

The subject is lying on his stomach, on a couch, resting on his forehead. The goniometer is placed on the outer surface of the lower leg. The test subject performs maximum flexion of the knee. The inspector shall ensure that the movement is correct and that no compensating mechanisms are involved. The goniometer reads the amount of motion shown in degrees (Kendall et al., 2005).

*Test for a group of hamstring muscles*

The subject is lying on his back on a couch. The axis of the goniometer pendulum is placed parallel to the body on the anterior surface of the thigh. Test the maximum lift of the straight leg. The magnitude of the indicated movements in degrees is read on the goniometer. The examiner observes that the knee is not flexed and that no rotation is observed in the foot (Kendall et al., 2005).

The Sargent Jump test, or vertical jump height assessment test, basically involves the difference between two indicators - the person's highest possible height that can be reached in an upright position and the height that that person can reach when jumping. This difference is expressed in centimeters (cm) (de Salles, Vasconcellos, de Salles, Fonseca & Dantas, 2012).

Description of standardized tests:

1. The test subject is free to stand as far as possible with the leading hand without lifting the heels off the ground. The result is recorded in centimeters (cm).

2. The test person makes a maximum jump upwards. The result is recorded. The jump is repeated 3 times (with a 3-minute break between jumps).

3. The best result shown is taken - in centimeters (cm).

4. The result of the upward stretch is subtracted from the best vertical jump result obtained and the height of the vertical jump is obtained (de Salles et al., 2012). The measurement characteristics were recorded and processed by the same researcher with experience in such studies. The test subject performed continuous dynamic warm-ups before the test to demonstrate maximum performance.

The methods described in the study were used before a single spinal vertebral C6-Th2 manipulation and were repeated 15 min after the manipulation and after 3 weeks. All 3 evaluations were performed by the same researchers with experience in specific studies (Ianuzzi & Khalsa, 2005; Edmond, 2006; Millan, Leboeuf-Yde, Budgell, Descarreaux, & Amorim, 2012).

**Statistical analysis:** The data obtained in the research experiments were processed with Microsoft Office Excel and SPSS statistical analysis software. In the first stage, descriptive statistics and the Shapiro-Wolf test were used for data processing to determine the conformity of the data to the normal distribution (confidence interval  $p < 0.05$ ), based on which other mathematical-statistical methods were selected for further data processing.

Student's t-test for related sets was used to process the data obtained (data correspond to normal distribution). The significance level of the results ( $p$ ) was chosen to be  $p \leq 0.05$  (Galeja, 2015).

### Research results

Analyzing and comparing the results obtained 15 min after a single spinal manipulation and 3 weeks after manipulation of the initial data, we found that the evaluated muscle length tests, posture stereotype parameters, and vertical jump test show changes in the results. Examining the initial results and the results obtained immediately after the manipulation, we found that there were statistically significant changes in all evaluated parameters ( $p \leq .005$ ). After 3 weeks, the endpoints still did not return to baseline, indicating persistence of exposure, but statistically significant changes in muscle length tests and some postural stereotype parameters remained ( $p \leq .005$ ) (Table 1).

*Table 1 Results in the range of motion, posture, and the height of the vertical jump before, after, and 3 weeks after a single spinal C6-Th2 HVLA manipulation*

Test	Before	After	$p$	After 3 weeks	$p$	$r$
ML Torso lateroflexion to right	16.9°±1°	20°±1°	.001	19°±1°	.001	.200
ML torso lateroflexion to left	16.95°±1°	22°±1°	.001	19°±1°	.001	.201
ML m.rectus femoris right	120.6°±1°	129°±2°	.004	125°±1°	.003	.460
ML m.rectus femoris left	122°±1°	128°±2°	.005	124°±2°	.003	.399
ML mm.hamstring right	81°±3°	85°±3°	.004	84°±3°	.004	.142
ML mm.hamstring left	79°±3°	85°±3°	.004	84°±3°	.004	.214
SJT	46±2cm	49±2 cm	.001	48±2 cm	.091	.161
A Masteideus	2.34°±0.21°	1.50°±0,21°	.001	1.77°±0.17°	.001	.671
A Acromion	1.58°±0.18°	1.23°±0,19°	.001	1.31°±0.17°	.101	.381
A Crista iliaca	2.07°±0.26°	1.55°±0,23°	.001	1.76°±0.22°	.002	.292

A Trochanter major	1.70°±0.14°	1.43°±0,15°	<b>.002</b>	1.47°±0.1 3°	.183	.376
A Angulus superior scapulae	3.79°±0.5°	2.78°±0,46°	<b>.003</b>	2.92°±0.4 5°	<b>.002</b>	.433
A Angulus inferior scapulae	3.33°±0.43°	2.44°±0,47°	<b>.001</b>	2.83°±0.4 1°	<b>.002</b>	.260
A Tuber ischiadicum	1.28°±0.13°	1.09°±0,14°	<b>.001</b>	1.17°±0.1 3°	.174	.184
A the corner of the eye against the outer opening of the ear	20,38°±1.48°	15.97°±1,43°	<b>.004</b>	15.73°±1. 18°	.173	.769
A yoke notch against Th1	21.38°±1.1°	17.53°±1°	<b>.003</b>	17.71°±1. 03°	.181	.421

*Note.* Before = results before a single manipulation of the spinal segment C6-Th2. After = results immediately after a single manipulation of the spinal segment C6-Th2. After 3 weeks = results 3 weeks after single manipulation of spinal segment C6-Th2. *r* = effect size. ML = amplitude of motion goniometry (for a specific group of mm). SJT = Sergent Jump test (vertical jump height cm). A = deviation of a particular posture anatomical point from the correct posture pattern. *p* = Statistically significant *p* values are in boldface.

## Discussion

The main benefit of our study is that changes in the evaluated parameters were observed. Comparing the initial results with the results obtained 15 minutes after the HVLA, we found that the amount of movement increases in the muscle length tests and the vertical jump test, while we observe a decrease in deviations from the norm in the parameters characterizing the posture. Changes in results are statistically significant  $p \leq .005$  (Table 1).

Looking at the results, which characterize the changes caused by manipulation after 3 weeks, we see that they tend to deteriorate, but in none of the evaluated parameters, the results have returned to the initial state. Statistically significant changes in the results were maintained in the muscle length tests and, in some parameters, characterizing the posture stereotype (Table 1).

Scientific research into the effects of manual therapy and manipulation on the human body is increasingly being carried out. These studies show similar nuances in the rationale for research. Most of the authors attribute the mechanical effect of the manipulation on the spine to the irritation of the neural component in the capsule sac, which in turn causes the reflection of the reflectors in the surrounding tissues. Manipulation promotes changes in the reflex of neuromuscular regulation, which in turn elicits body responses that can be assessed in the static or posture of the subject, but establishes the fact that this effect of corrective manipulation is transient (Pedak et al., 2019; Gouttebauge et al., 2017; Nagy, Müller, Birö, Eszter & Iuliana, 2017). The results of our study show that immediately after the manipulation, the deviations of the posture from the correct posture pattern were reduced by  $25.45\% \pm 1.27\%$  ( $p = .001$ ). They are confirming what other researchers have said about the instantaneous and transient effects of manipulation (Ferreira, Ferreira, Latimer, Herbert, & Maher 2003; Ernst, 2007; George, Bishop, Bialosky, Zeppieri & Robinson, 2006; Häkkinen,

Salo, Tarvainen, Wirén & Ylinen, 2007; Bicalho, Setti, Macagnan, Cano & Manffra, 2010; Bishop, Beneciuk & George, 2011; Schulz et al., 2014).

In turn, our study also found that 3 weeks after a single spinal C6-Th2 manipulation, the effect of the therapeutic effect on the parameters characterizing the stereotype was maintained. Comparing the results, we find that the effect of the therapeutic effect is  $19.97\% \pm 1.27\%$  or decreased by  $5.48\%$  within 3 weeks ( $p = .001$ ).

Scientific research on the effect of manipulation on vertical jump height in young athletes with talocrural joint dysfunction yielded the following results. After manual correction, study participants ( $n = 11$ ) showed an increase in vertical jump of  $1.07 \pm 1.23$  cm ( $p = .017$ ). The results of the above studies show similarities with the results of our study on the results of the vertical jump of the Sergeant Jump test in the study participants. Participants in our study showed a pre-HVLA vertical jump of  $46 \pm 2$  cm, whereas immediately after HVLA  $49 \pm 2$  cm ( $p = .001$ ) and a 3-week post-HVLA result was  $48 \pm 2$  cm ( $p = .161$ ). These results confirm the transient effect of a single HVLA effect on vertical jump parameters (Hedlund, Nilsson, Lenz, & Sundberg, 2018).

As previously mentioned, the neuroreflective and neurophysiological effects of manual therapy on the joint capsule and surrounding tissues, surrounding muscles, and the segment. The authors confirm that this manipulative effect does not always have a sufficiently large positive effect on the functional segments, which, for example, is very important for athletes in terms of the optimal amount of movement in a particular segment. Thus, the researchers confirm that in addition to the manipulative effects on the joints, other manipulative effects on the surrounding tissues (massage, active stretching, exercises) are needed to optimize the volume of movement in the larger segment (Schmid, Brunner, Wright & Bachmann, 2008; Sharma et al., 2012; Pedak et al., 2019; Gouttebauge et al., 2017; Nagy et al., 2017).

Studies have shown that various functional disorders in the body (trigger points, increased mm. tonus, incorrect loading of the joint sac) contribute to the functional dysfunction of the reflectors in certain segments and can promote the formation of functionally weak muscles. The definition of a functionally weak muscle refers to a muscle that is functionally weak if it is unable to function autonomously in optimal situations. Under optimal conditions, the body can transfer conscious movement autonomously to the cerebral cortex system. The miotic reflex characterizes this process. When a particular movement occurs at a subconscious level, the body can act at a conscious level in another direction at the same time, maintaining the quality and efficiency of the movements at an unconscious level. With the appearance of external or internal unnecessary irritation or stress, this subconscious function can be disrupted, because of which the muscle no longer works in an autonomous state and moves to a partial level



of consciousness, resulting in inhibition of the miotic reflex (Cappabianca et al., 1999; Kibble, Halsey Colby, 2009; Ozols, 2020).

The common feature of the entire nervous system is the transmission of external environmental information to the internal environment to optimize the body's function for the changing external and internal stimuli. The spinal nerve roots and spinal cord are the carrier of information to the central nervous system. Each of the thirty-one nerve roots has a specific innervation zone and several specific motor units in the body that are most directly associated with a particular spinal nerve root (Frost, 2002; Ramšak & Gerz, 2005; Rokni & Sompolinsky, 2019; Pickar, 2012). Given the variety of information provided by studies in physiology, biomechanics, and anatomy, neurology can judge an organism as a holistic unit, which is also confirmed in our study. The therapeutic effect of a single HVAL was observed in the body as a whole, both in the increase in muscle length in the muscle length tests (m.quadratus lumborum, m.rectus femoris, and hamstring group) and the decrease in asymmetry. The results of our study demonstrate the persistence of single HVAL effects, as after 3 weeks, statistically significant changes in results ( $p \leq .005$ ) persisted in muscle length tests and some postural stereotype parameters.

An increasingly important issue in research is the development of sports, and how to increase the athlete's working capacity or performance using the available methods, techniques, and current resources. This research stimulus encourages researchers to seek new approaches to changing the regulation of the human body. Holistic, systematic, and multidisciplinary approaches to this process are increasingly being sought in modern research. This type of approach can provide athletes with fast, fast, functional results with the lowest possible risk of injury and strain, which is very important. This is due to the high demands of sports, high competition, and the unimaginably wide availability of resources for athletes (from medical staff, coaches, fitness coaches, psychological fitness coaches, nutritionists, and other professionals). Thus, many authors acknowledge the need for a multidisciplinary holistic approach to functional capacity enhancement (Borsa, Laudner & Sauers, 2008; Cech & Martin, 2012; Johnson, 2016; Botelho, Alvarenga, Molina, Ribas & Baptista, 2017; Hedlund et al., 2018; Christiansen et al., 2018; Bunn, Rodrigues, & Bezerra da Silva, 2019).

## **Conclusions**

Statically significant changes in results can be observed using spinal C6-Th2 vertebral manipulation ( $p < .005$ ). muscle length tests (m.quadratus lumborum, m.rectus femoris, and hamstring group) in the vertical jump test and posture stereotypical parameters in the frontal and sagittal planes.

On the other hand, when analyzing the persistence of manipulation-induced changes after 3 weeks, statistically significant results ( $p \leq .005$ ) remained in

muscle length tests and some postural stereotype parameters, suggesting that manipulation-induced reflex changes in neuromuscular regulation are transient in explosive force.

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