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COMPARISON OF INSTANT EFFECT OF LUMBAL AND SACROILAC SPINAL MANIPULATION ON FLEXIBILITY AND JUMPING PERFORMANCE IN PROFESSIONAL SOCCER PLAYERS

PRIMERJAVA TAKOJŠNJEGA UČINKA LUMBALNE IN SAKROILAKALNE MANIPULACIJE HRBTENICE NA GIBLJIVOST IN ODRIVNO MOČ PRI PROFESIONALNIH NOGOMETAŠIH

ABSTRACT

Recent evidence suggests that spinal manipulation can acutely improve mobility and lower-limb performance. This study compared the acute effects of lumbar and sacroiliac chiropractic manipulation on flexibility and jump performance. Forty-five healthy male participants were randomly assigned to three groups: a Lumbar Manipulation Group (LMG; $n = 15$), a Sacroiliac Manipulation Group (SMG; $n = 15$), and a Control Group ($n = 15$). Flexibility was assessed using the V-Sit and Reach test, while performance was evaluated with vertical and horizontal jump tests. Lumbar manipulation was applied to the dysfunctional lumbar segment in the LMG, and sacroiliac joint manipulation was applied to the dysfunctional sacroiliac region in the SMG. No intervention was performed in the control group. Both manipulation techniques resulted in significant acute improvements in mobility and jump performance compared with the control group ($p < 0.05$), with the greatest improvement observed in vertical jump height ($p = 0.001$). No significant differences were found between the LMG and SMG. Spinal manipulation to the lumbar and sacroiliac regions appears to produce acute improvements in mobility and lower-limb power. These findings suggest that spinal manipulation may serve as a short-term performance-enhancing intervention.

Keywords: Manipulation, spinal, soccer, flexibility, jumping

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IZVLEČEK

Nedavne raziskave kažejo, da lahko spinalna manipulacija akutno izboljša gibljivost in gibalno učinkovitost spodnjih okončin. Namen te študije je bil primerjati akutne učinke spinalne manipulacije ledvene hrbtenice in sakroiliakalnega sklepa na gibljivost in odzivno moč. V raziskavo je bilo vključenih 45 zdravih moških udeležencev, ki so bili naključno razdeljeni v tri skupine: skupina za ledveno manipulacijo (LMG; $n = 15$), skupina za sakroiliakalno manipulacijo (SMG; $n = 15$) in kontrolna skupina ($n = 15$). Gibljivost je bila ocenjena z V-sit in Reach testoma, odzivna moč pa z vertikalnim in horizontalnim skokom. V skupini LMG je bila manipulacija izvedena na disfunkcionalnem ledvenem segmentu, v skupini SMG pa na disfunkcionalnem sakroiliakalnem sklepu, medtem ko kontrolna skupina ni prejela nobene intervencije. Obe manipulacijski tehniki sta povzročili statistično značilne akutne izboljšave gibljivosti in odzivne moči v primerjavi s kontrolno skupino ($p < 0.05$), pri čemer je bil največji učinek zaznan pri višini vertikalnega skoka ($p = 0.001$). Razlike med skupinama LMG in SMG niso bile statistično značilne. Spinalna manipulacija ledvene hrbtenice in sakroiliakalnega sklepa se je izkazala za učinkovito kot kratkoročen pristop za izboljšanje gibljivosti in moči spodnjih okončin.

Ključne besede: manipulacija, spinalna, nogomet, prožnost, skakanje

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INTRODUCTION

Optimizing physical performance remains a central objective in competitive sports. Athletes commonly adopt a range of strategies—physical, economic, and behavioral—to enhance their performance capacity. Emerging evidence suggests that spinal dysfunctions, including those presenting without overt symptoms, may impair the central nervous system's processing of motor and proprioceptive inputs, thereby potentially altering neuroplastic mechanisms. To address spinal mechanical dysfunction, spinal manipulative therapy (SMT) is widely employed. SMT is characterized by a high-velocity, low-amplitude thrust applied to a specific vertebral segment within the anatomical limits of the joint (Botelho et al., 2022).

Within the biomechanical framework of soccer, performance is generated through a sequence of segmental movements originating in the spine and propagating distally along the open kinetic chain. The lumbar spine and sacroiliac joints represent the proximal components of this chain, providing mechanical stability as well as initiating force transmission for subsequent lower-limb actions (Kellis & Katis, 2007). Efficient execution of complex motor tasks is associated with enhanced neuromuscular coordination, in which the integrity of lumbopelvic structures is essential. The sacroiliac joint, situated between the lumbar spine and the sacrum, plays a critical role in the modulation and transfer of forces through the lower kinetic chain. Harmonized function of the hip and sacroiliac musculature is considered fundamental for optimal pelvic motion (Suter & Forscher, 2000; Kellis & Katis, 2007). Although the lumbopelvic region is biomechanically important, the acute effects of spinal manipulation are likely mediated by neurophysiological rather than mechanical mechanisms. Lumbar or sacroiliac dysfunction may induce reflexive muscle inhibition and altered motor control. Manipulation can transiently reduce such inhibition by modulating afferent input and improving motor unit activation. Therefore, the observed performance improvements may result from the removal of inhibitory factors rather than a direct increase in force production.

Although anecdotal observations frequently report performance enhancements following SMT, the scientific literature remains heterogeneous and, in many cases, methodologically limited. Nevertheless, existing evidence indicates that SMT may positively influence spinal mechanics, neuromuscular coordination, motor activation patterns, and reaction time (Bialosky et al., 2009; Herzog, 2010). Systematic reviews have further suggested that SMT can acutely enhance parameters such as running velocity, muscular strength, and ball-striking or throwing power

across various athletic populations, including soccer, judo, endurance running, and basketball athletes (Corso et al., 2019; Botelho et al., 2017).

Flexibility and jump performance constitute key determinants of athletic capability, alongside other influential variables such as warm-up efficiency, technical execution, tactical understanding, psychological readiness, competitive level, and chronological age. Modern sports science therefore increasingly employs non-pharmacological, health-oriented interventions to achieve acute improvements in these performance components.

Grounded in the current body of evidence, we hypothesized that SMT applied to the lumbar and sacroiliac regions would yield acute improvements in flexibility and jump performance. Furthermore, consistent with prior findings, we expected that although both techniques would produce beneficial outcomes, neither would demonstrate clear superiority. Accordingly, the primary aim of this study was to compare the acute effects of lumbar and sacroiliac SMT on flexibility and jump performance in healthy male participants.

METHODS

Study Design

Ethical approval was obtained from the Gümüşhane University Scientific Research and Publication Ethics Committee (dated 26 October 2022; No. 2022/6), and the required institutional permissions were granted by the sports club. The study was registered on ClinicalTrials.gov (Registration Number: NCT06568666). The research was designed as a randomized controlled clinical trial conducted on the club's soccer field and within its medical cabin. A total of 45 athletes who met the inclusion criteria and provided informed consent were randomly selected using the sealed-envelope method and allocated into three equal groups: the Lumbar Manipulation Group (LMG, n=15), the Sacroiliac Joint Manipulation Group (SIJMP, n=15), and the Control Group (CG, n=15). All assessments were performed under standardized conditions and included both baseline and post-intervention measurements. In order to prevent any handicap in the motivation levels of the participants and their performance during the evaluations, the days and hours of the study were determined by taking into account the training and match schedule of the soccer team. The areas to be used during the evaluations in the soccer field and the institutional building were made ready by determining the appropriate places according to the test, standardizing them with fixed markings for the test starting positions, determining the test ending positions and markers for distance measurements. The area where

high-velocity low-amplitude (HVLA) will be applied in the health cabin was made ready by organizing it in a way to respect the privacy of the participants.

V-Sit Reach Test, Vertical Jump, and Horizontal Jump tests were performed first. Each test was performed twice, and the best value was recorded in centimeters. After a 5-minute rest period, the lumbar spine or sacroiliac joints were evaluated, and the HVLA technique was applied to the dysfunctional segment(s). The same tests were then repeated under identical conditions as the final assessment. The rest intervals between the manipulation procedure and the post-intervention assessments were standardized using a stopwatch.

No warm-up activities were performed before the intervention or the assessments in order to avoid any pre-procedural alterations in baseline joint mobility that could potentially confound the treatment effects.

Participants

This study was conducted in the soccer field and health cabin of a private sports club with 45 voluntary healthy participants between the ages of 18-35 years who were part of the club. Participants were informed in detail about their right to confidentiality, the scope of the study, the objectives of the researchers and the methods to be applied, and the voluntary consent form was read and signed.

The inclusion criteria were: signing the voluntary consent form, being male, aged 18–35 years, being a licensed soccer player with at least 6 months of professional experience, and having an asymptomatic dysfunction of the lumbar spine or sacroiliac joint. Exclusion criteria included having an injury to the lower extremities, lumbar spine, or sacroiliac region within the last 6 months, or having any contraindication to chiropractic treatment. Participants were removed from the study if they sustained an injury during the procedures or if they voluntarily chose to discontinue participation. The planned number of potential participants within the organization was reached before starting the study with those who met the criteria, and this number was maintained throughout the study.

Screening for Asymptomatic Dysfunction

Asymptomatic dysfunction of the lumbar spine or sacroiliac joint was defined as clinically detectable movement restriction without pain. Prior to inclusion, all participants underwent a standardized screening that included active lumbar range of motion tests, segmental mobility assessment (central and unilateral PA mobilization), the prone instability test, and sacroiliac

joint provocation tests (Gillet, standing flexion, sacral thrust, compression–distraction, and Gaenslen tests). Individuals with at least one mobility restriction and no lumbar or sacroiliac pain in the previous 3 months were included.

Sample Size

An a priori sample size calculation was not conducted. A pragmatic sampling approach was used due to the limited number of eligible athletes available during the data collection period. All participants who met the inclusion criteria and volunteered were enrolled, yielding a total of 45 individuals equally allocated into three groups.

Intervention

Lumbar and sacroiliac joint manipulations were applied using a standardized HVLA protocol. Each technique involved a single high-velocity low-amplitude thrust following 2–3 seconds of pre-tension, with no repeated thrusts. The total manipulation time per participant was approximately 3–5 minutes. All interventions were performed by the same practitioner to maintain consistency.

Sacroiliac joint spinal manipulation: The participant lay on his/her side on the healthy side; the lower knee was kept in extension, while the upper knee was flexed and placed in the popliteal fossa of the lower knee. The participant's hands were left free on the lower ribs. The practitioner crossed the movement barrier with the stabilizing hand, allowing the tissues to relax. An HVLA thrust was then delivered to the iliac bone into posterior or anterior rotation (opposite to the direction of dysfunction) using the stabilizing hand (Pośluszny & Waszak, 2021).

Lumbar spinal manipulation: Lumbar spinal manipulation was also performed in the lateral recumbent position and HVLA thrust was applied to the segment where dysfunction was detected. The spinal process was determined as the contact point and the direction of HVLA thrust was from posterior to anterior (Nim et al., 2020).

Measurements

Demographic characteristics: Participants' age and soccer age were checked from their identity information and recorded. Body weights were measured with a digital scale and recorded in kg. Height was measured with a mechanical height meter and recorded. Soccer playing time (years of continuous licensed soccer participation) was recorded for each athlete through club registration data and self-report to describe their training background.

Body Mass Index: Body Mass Index (BMI) was calculated as body weight in kilograms divided by height in meters squared (kg/m^2), following standard anthropometric procedures (Toppino, Longo, Martini, Abbate-Daga, & Marzola, 2022).

V-Sit reach test: In the V-sit reach test, participants sit on the floor with legs extended and heels on the ground approximately 30 cm apart. The line connecting the heel points is marked as the zero line. Participants reach forward with both hands extended together, one hand placed over the other with fingers fully extended, while keeping the knees in full extension. The distance from the reached point to the zero line is measured in centimeters and recorded as (+) or (-). The test is performed twice, and the best value is recorded (Lu et al., 2022).

Vertical jump test: The athlete stands on the designated platform where the test will take place, facing the platform. With one arm he/she reaches to the maximum point he/she can reach, the test administrator makes the marking on the platform. The athlete jumps and touches the highest point he/she can reach and is marked. The test administrator measures the distance between these two points and records it in cm. The test must be repeated twice. The best result is taken into account (Aragon, 2000).

Horizontal jump test: It is a test that can be used to measure balance, jumping strength and lower extremity strength in the vertical and horizontal planes in athletes. A marker on the floor is used to locate the test starting position. In this position, the participant initiated the preparatory phase of the jump by performing a slight forward flexion of the trunk, positioning the hands behind the body, and adopting a half-squat stance to generate the initial momentum required for take-off. At the command of the test administrator, they jump as far as they can using their single and double legs. The distance between the starting position and the jump point is measured. The test is performed 2 times and the best result is recorded in cm (Spyrou et al., 2021).

Statistical analysis

All analyses were performed using IBM SPSS Statistics. Descriptive statistics (mean and standard deviation) were calculated, and normality was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. For between-group comparisons, One-Way ANOVA with Tukey HSD post-hoc testing was used for normally distributed variables, while the Kruskal–Wallis test with Dunn’s post-hoc test was applied for non-normally distributed variables. Within-group pre–post differences were analyzed using the paired samples t-test or the

Wilcoxon signed-rank test, depending on data distribution.. Statistical significance was set at $p < 0.05$.

RESULTS

Table 1. Demographic Data of the Groups.

Parameters	LMG Mean±SD (Median)	SMG Mean±SD (Median)	CG Mean±SD (Median)	p
N	15	15	15	
Age	25,07±4,1 (24)	25,6±3,76 (26)	24,27±3,65 (23)	0,572 ^a
Soccer Playing Time	7,93±4,59 (8)	10,6±4,1 (11)	5,13±3,74 (3)	0,003^a
BMI	22,84±1,99	22,87±1,97	22,63±0,64 (22,5)	0,915 ^b

Notes. ^aKruskal Wallis Test, ^bOneway ANOVA Test, BMI: Body Mass Index, LMG: Lumbar Manipulation Group, SMG: Sacroiliac Manipulation Group, CG: Control Group, SD: Standard Deviation.

There was no statistically significant difference between the groups in terms of age, $p = 0.572$, or BMI, $p = 0.915$. However, the average number of years of professional soccer experience differed significantly between the groups, with a p -value of 0.003.

Table 2. Comparison of V-Sit Reach Test, Vertical Jump and Horizontal Jump data within and between groups.

Parameters		LMG Mean±SD (Median)	SMG Mean±SD (Median)	CG Mean±SD (Median)	p
V-Sit Reach (cm)	Pre-test	5,4±9,16 (5)	2,27±9,84 (5)	2,27±3,53 (2)	0,140 ^a
	Post-test	9,73±6,63 (10)	6,13±9,98 (8)	2,13±3,66 (2)	0,002^a
	p	0,001^c	0,001^c	0,480	
Vertical Jump (cm)	Pre-test	46,6±3,68	42,2±6,86	41,0±5,50	0,020^b
	Post-test	52,4±3,33	49,47±7,85	42,13±6,84	0,001^b
	p	0,001^d	0,001^d	0,278	
Horizontal Jump (cm)	Pre-test	190,2±25,05	190,33±18,89	183,13±9,58	0,498
	Post-test	204,33±28,05	202,93±21,98	182,47±10,66	0,013^b
	p	0,001^d	0,001^d	0,329	

Notes. ^aKruskal Wallis Test, ^bOneway ANOVA Test, ^cWilcoxon Sign Test, ^dPaired Samples t Test, LMG: Lumbar Manipulation Group, SMG: Sacroiliac Manipulation Group, CG: Control Group, SD: Standard Deviation.

When we made the intra-group comparison, the V-Sit Reach test data showed a statistically significant increase in the post-test compared to the pre-test in both the LMG, $p = 0.001$, and the SMG, $p = 0.001$. Similarly, the vertical jump height demonstrated a statistically significant post-test increase in the LMG, $p = 0.001$, and in the SMG, $p = 0.001$. The horizontal jump height also showed statistically significant increases in the post-test results compared to the pre-

test in the LMG, $p = 0.001$, and in the SMG, $p = 0.001$. Between-group comparisons revealed that the post-test V-Sit Reach results differed significantly, with a p -value of 0.002, and the post-test horizontal jump results also differed significantly between the groups, with a p -value of 0.013. Additionally, the vertical jump data showed statistically significant differences between groups in both the pre-test, $p = 0.020$, and the post-test, $p = 0.001$, indicating significance at the $p < 0.05$ level, as shown in Table 2.

Table 3. Post – Hoc Test Data.

Post Hoc Test	Soccer Playing Time	V-Sit Reach Test Post-test	Vertical Jump Pre-test	Vertical Jump Post-test	Horizontal Jump Post-test
	p^1	p^1	p^2	p^2	p^2
LMG-SMG	0,317	0,842	0,085	0,418	0,983
LMG-CG	0,233	0,002	0,021	0,001	0,021
SMG-CG	0,002	0,021	0,822	0,008	0,033

Notes. ¹Post Hoc Dunn's Test, ²Post Hoc Tukey HSD, $p < 0.05$, LMG: Lumbar Manipulation Group, SMG: Sacroiliac Manipulation Group, CG: Control Group.

When the post hoc test results were examined, the SMG group was found to have a statistically significantly longer soccer playing time compared to the CG group, with a p -value of 0.002. The post-test V-Sit Reach result of the CG group was statistically significantly lower than that of the LMG, $p = 0.002$, and the SMG, $p = 0.021$. The pre-test vertical jump average of the LMG group was statistically significantly higher than that of the CG group, with a p -value of 0.021. In the post-test, the vertical jump average of the CG group was statistically significantly lower than those of the LMG, $p = 0.001$, and the SMG, $p = 0.008$. Similarly, the post-test horizontal jump height of the CG group was statistically significantly lower than those of the LMG, $p = 0.021$, and the SMG, $p = 0.033$, demonstrating significance at the $p < 0.05$ level, as presented in Table 3.

DISCUSSION

This study aimed to compare the acute effects of high-velocity low-amplitude (HVLA) spinal manipulative therapy applied to the lumbar spine and sacroiliac joint on flexibility and jump performance in healthy male soccer athletes. Conducted as a randomized controlled clinical trial including lumbar manipulation, sacroiliac manipulation, and control groups, the study used standardized pre- and post-intervention assessments involving the V-Sit Reach, vertical jump, and horizontal jump tests. Based on previous evidence suggesting that SMT may modulate neuromuscular coordination, segmental mobility, and motor output, we hypothesized that both techniques would acutely improve flexibility and jump performance without one technique

demonstrating superiority. The current findings supported these hypotheses, demonstrating significant within- and between-group improvements in flexibility and jump indices following SMT, while showing no difference between lumbar and sacroiliac HVLA applications.

When compared with previous studies, our findings show several notable consistencies and distinctions. For example, Kinser et al. (2008) reported that vibration and stretching interventions significantly improved flexibility without affecting vertical jump performance in female gymnasts. In contrast, the SMT procedures in our study improved both flexibility and vertical jump performance, suggesting that manual HVLA thrusts may influence neuromuscular or kinetic chain mechanisms differently from passive stretching or vibration-based interventions. Similarly, PAP interventions such as those reviewed by Dobbs et al. (2019) increased vertical jump performance when adequate rest intervals were provided, whereas plyometric interventions required longer training periods to produce meaningful gains (Stojanović et al., 2017). Our findings parallel the acute improvements observed in PAP-based protocols but demonstrate that a single SMT session can elicit comparable immediate changes without requiring extended training durations.

Studies examining long-term training effects—such as complex training programs in basketball players (Roden et al., 2014) or FIFA 11+ interventions improving vertical jump in adolescent soccer players (Steffen et al., 2008)—also align with our results in showing improvements in explosive performance. Although these studies focused on multi-week training, their consistent improvements in jump performance reinforce that SMT-induced neuromuscular modulation may produce similar acute outcomes via different mechanisms.

Evidence from strength-training interventions provides a nuanced comparison. Contreras et al. (2017) found that squat and hip thrust training improved vertical jump performance but did not consistently enhance horizontal jump distance, whereas Gonzalo-Skok et al. (2019) reported varying effectiveness among unilateral strength programs. In our study, both vertical and horizontal jump performance improved acutely, indicating that SMT may influence proximal kinetic chain function, neuromechanical efficiency, or pre-activation patterns beyond the isolated muscular adaptations targeted in strength-training protocols.

The review by Botelho et al. (2017) provides critical insight into SMT performance studies, noting that positive results were primarily observed when manipulations targeted dysfunctional segments, while studies manipulating random segments did not show improvements. Our findings are consistent with these observations, as SMT in the present study was applied

exclusively to segments with identified asymptomatic lumbopelvic dysfunction and resulted in acute improvements in flexibility and jump performance. However, because the intervention targeted dysfunctional segments only, the observed effects cannot be generalized to all individuals or all soccer players. Instead, these findings may be applicable specifically to athletes who present with similar asymptomatic lumbopelvic dysfunction, which may remain unnoticed by both players and healthcare professionals. Conversely, Humphries et al. (2013) evaluated unilateral cervical manipulation and found no effect on grip strength or accuracy. We interpret this discrepancy as likely related to the unilateral application and the distal nature of the performance measure relative to the manipulated region. Similarly, Botelho et al. (2022) demonstrated no immediate effect of SMT on sprint and COD performance in elite soccer players when spinal or sham manipulation was added to routine training. Unlike their design, our study included a resting control group, employed segment-specific manipulations, and evaluated flexibility and jump performance—variables potentially more sensitive to immediate neuromechanical modulation.

The acute improvements in flexibility and jump performance may be explained by the neuromechanical effects of segment-specific HVLA manipulation on spinal and lumbopelvic function. Even without a warm-up, SMT may reduce joint stiffness, improve articular alignment, and enhance mechanoreceptor-mediated afferent input (Pickar, 2002; Pickar & Bolton, 2012). These changes can modulate sensorimotor integration and improve proximal stability, which is essential for efficient force transmission during jumping tasks (Lephart et al., 1997). Although passive manipulation has been reported to transiently reduce motor unit excitability in some contexts (Herzog et al., 1999), the performance outcomes assessed in this study may be more responsive to improved segmental mobility and neuromuscular coordination (Suter & McMorland, 2002). Overall, the observed acute gains likely reflect enhanced mobility and more efficient kinetic chain activation.

Strengths and limitations

A primary strength of this study is the use of a randomized controlled design with segment-specific SMT applied to clinically identified dysfunctional regions. The inclusion of three performance measures allowed for a multidimensional evaluation of acute neuromechanical changes. Additionally, all interventions were performed by the same practitioner, reducing procedural variability.

However, several limitations should be acknowledged. The study included only male participants, limiting generalizability across sexes. The investigation focused on acute effects; thus, no conclusions can be drawn about longer-term outcomes. The absence of an a priori power analysis and the use of a pragmatically limited sample may reduce statistical power and restrict generalizability. Finally, performance measures such as sprinting or COD, which may respond differently to SMT, were not included.

CONCLUSION

Both the lumbar manipulation and sacroiliac joint manipulation groups demonstrated statistically significant improvements across all evaluated outcome variables, with the most pronounced enhancement observed in vertical jump performance. Although both techniques yielded comparable benefits, neither intervention proved superior to the other. Notably, each manipulation procedure required only a brief application time of approximately 1–2 minutes, which may support their feasibility in applied sports contexts. However, because the interventions were administered exclusively to athletes presenting with asymptomatic lumbopelvic dysfunction, the generalizability of these findings to soccer players without such dysfunction remains limited. Within the scope of these results, targeted pre-competition or in-competition manipulation strategies may offer a viable means of acutely enhancing athletic performance. Nevertheless, larger-scale and longer-term investigations are warranted to substantiate and extend these preliminary observations.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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