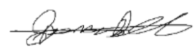
The Effect of IA-HVLA Manipulation to the Midfoot of Asymptomatic Adult Sprinters on Performance During a Unilateral Horizontal Drop Jump Test: A Pilot Project

Author 1: Spencer Bell, DC MASc [a]



Author 2: Samuel Howarth, PhD[b]

[a] Division of Graduate Studies, Sports Science, Canadian Memorial Chiropractic College, Canada
[b]Assistant Professor, Canadian Memorial Chiropractic College, Clinical Education, 6100 Leslie Street, Toronto, Ontario, Canada

Disclaimers: None

Statement that patient consent was obtained: Patient consent was obtained for all data collected in this investigation.

Sources of financial support, if any: No financial support

Key words: sports chiropractic, sprinting, foot, feet, track and field

Corresponding Author: Dr. Spencer Bell
sbell@cmcc.ca
T: 416-482-2340 ext. 501
6100 Leslie Street
Toronto, Ontario, Canada
M2H 3J1

Abstract

Introduction/Background: Sprinters and athletic coaches frequently describe anecdotal improvements to sprinting performance following instrument-assisted high-velocity low-amplitude (IA-HVLA) manipulation applied to the athlete's feet; however, there is minimal published data investigating these claims. Based on recent neurophysiological research demonstrating acute improvements in force production and fatigue resistance following spinal manipulation, a positive impact on sprint performance is plausible, although this remains unexplored in trained sprinters.

Objective: To investigate acute effects of IA-HVLA manipulation to the mid-foot region on jump distance in competitive adult sprinters during a standardized unilateral horizontal drop-jump (U-HDJ) test, which is strongly correlated to sprint performance.

Methods: A convenience sample of asymptomatic adult competitive sprinters were recruited. Testing was conducted on the dominant leg. Participants completed a ten-minute self-selected warm-up, followed by a 6-jump familiarization period with the U-HDJ test. All participants completed 3 trials before and after receiving an IA-HVLA manipulation, assessed and delivered to the midfoot by a trained chiropractor. Primary outcome from the U-HDJ test was horizontal displacement, measured using an optoelectronic motion capture system. Descriptive summary measures (mean, standard deviation and 95% confidence interval limits) were determined for the post-treatment change in jump distance.

Results: Seven participants (4 female, 3 male) were tested. The median value for each participant's pre- and post-manipulation trials were grouped for analysis. There was an increase in jump distance following IA-HVLA manipulation to the midfoot region (Pre-manipulation: M=1.713m, SD=0.317, 95%CI [1.477, 1.948]; Post-manipulation: M= 1.776m, SD=0.314, 95%CI [1.543, 2.008]).

Clinical Implications: This study suggests acute change in performance following IA-HVLA manipulation in a field test with positive correlation to sprinting.

Conclusions: Results demonstrated improvement in horizontal distance jumped following IA-HVLA manipulation. Further research is required to investigate performance changes and clinical relevance in a sprinting population.

Introduction

Despite mixed findings of performance benefits in previous investigations and reviews [Shrier; Hedlund, Kamali; Miners; Corso; Nook], athletes and chiropractors continue to report anecdotal benefits, particularly in power-based athletes, with pre-competition treatment, more commonly referred to as performance therapy, regardless of their symptom status [Miners; Corso; Nook; Miners; Hurwitz]. The connection between high-velocity low-amplitude (HVLA) manipulation is rooted in neurophysiological research, however, the connection between these neurophysiological outcomes and performance benefits have not necessarily been derived at this point.

Recent neurophysiological literature has begun to illustrate effects related to HVLA manipulation, particularly the way in which it affects sensorimotor integration. Recent findings in asymptomatic subjects demonstrate increased cortical drive and decreased H-reflex threshold, and increased voluntary muscle force production and fatigue resistance in the soleus muscle for 30 to 60 minutes following lumbar manipulation. [Niazi; Christiansen] For context, these improvements were comparable to those found after 3 weeks of a full body strength training program [Villa-Cha]. The body of literature surrounding extremity manipulation is comparably very small and primarily directed towards symptomatic populations. Nonetheless, comparable increases in H-reflex/M-wave ratios from the soleus muscle have been observed, along with significant improvements in functional performance on single leg hop, speed, and Y-balance tests following distal lower limb joint manipulation [Grindstaff; Kamali]. The confluence of findings suggests the presence of neurophysiological adaptations that may manifest in improvements in functional performance. A recent high-level systematic review acknowledged a trend of improved performance following manipulation-based therapies, despite a heavy emphasis on the need for improved methodology and scientific investigation [Botelho]. The developing neurophysiological understanding of HVLA manipulation sets a framework for how these techniques may have an impact on athletic performance – a topic that requires further evaluation. Furthermore, it sets the stage to dig deeper into performance improvements in relevant functional tasks, since it remains largely unknown whether these neurophysiological changes may ultimately lead to improvements in sprint performance.

One challenge that present itself in elite athletics is the creation of dynamic clinical assessments that provide insight to athletic performance without placing the athlete at risk. [Manske] Such assessments are valuable in providing accurate and reliable evaluation of a treatment modality's impact on sprint performance, while minimizing risk to health status. [Manske] One metric with particular relevance to sprinting performance is leg power [Cronin; Lockie], for which there are several assessment variations, selection of which is dependent on the targeted variable [Schuster; Maulder; McCurdy]. Historically, there has been little attention paid to the specific tests used to assess power. [Maulder; Arteaga] Although traditional testing strategies utilize bilateral strategies, such as the well-known bilateral vertical jump test [Arteaga], there is an inconsistent relationship between performance in vertical jump height and sprint performance [Schuster; Loturco]. In fact, many field tests share less than 50% common variance [Maulder], concluding that vertical and horizontal tests are actually measuring different qualities of leg power and cannot be used interchangeably. Recent data suggests that assessments of horizontal jump performance might provide better insight into sprint performance [Schuster; Maulder; McCurdy; Loturco; Stalbom; Hunter; Holm; Dobbs]. Furthermore, unilateral assessments have been demonstrated to correlate better with sprint performance than bilateral assessments in both the horizontal and vertical planes [Schuster; Dobbs], providing a better indication of symmetry-of-performance through the legs, and in the case of the injured athlete, providing a baseline for comparison in the healthy leg [Hopper]. Finally, the ability to generate unilateral, horizontal force has been shown to better reflect the acceleration phase of sprinting [Dobbs; McCurdy] – a premise also rooted in logic, given the strong horizontal component associated with the acceleration phase, and the high amount of time spent in unilateral stance overall.

The unilateral horizontal drop-jump assessment (U-HDJ), which combines vertical and horizontal measures of power, has recently emerged as a reliable and valid method for predicting sprint performance over short distances [Schuster; Maulder; Stalbom; Hunter; Dobbs]. Components of the U-HDJ include generation of vertical and horizontal forces, preload, and a unilateral propulsive force. In addition to being reliable and stable, the U-HDJ has demonstrated a moderate correlation with the acceleration phase of sprinting, especially in comparison to other popular field tests. [Schuster; Dobbs; Maulder].

The primary goal of this pilot project was exploratory, with the intention of investigating performance-related changes in horizontal jump distance on the U-HDJ assessment following instrument-assisted HVLA manipulation to the midfoot of elite sprinters.

Methods

Participants

A convenience sample of healthy adult competitive sprinters aged 18-34 years were selected for this study from a pool of elite track and field athletes in Ontario, Canada. To be included in this study, participants were required to (1) be training a minimum of 3 sessions per week (2) have no history of lower extremity or low back injury in the past 6 months, with injury defined as any condition which would alter the individual's training program (3) be a competitive sprinter, defined as any athlete competing at the college, university, national, or international level. All testing was conducted at the Biomechanics Lab at the Canadian Memorial Chiropractic College in Toronto, Ontario, Canada. The study protocol was approved by the Canadian Memorial Chiropractic College's Research Ethics Board.

Instrumentation

Participants were wearing comfortable athletic attire and self-selected running shoes for all testing. Horizontal displacement was assessed using an optoelectronic three-dimensional motion capture system (Optotrak Certus, Northern Digital Inc., Waterloo, ON, Canada). Four individual active infrared light emitting diodes (IREDs) were secured to the most anterior point and the most posterior aspect on each of the participant's shoes using double-sided adhesive prior to commencing each session. Three-dimensional coordinates from each of the IREDs was used to quantify jump distance. Ground contact was identified using reaction kinetic data from a ground-mounted force plate (BP400600, AMTI Inc., Watertown, MA, USA). [Figure 1]

The U-HDJ assessment involved the participant dropping from a 20cm platform, landing on one leg before exploding forward for maximal horizontal displacement and landing on two feet [Stalbom] [Figure 2]. A standardized instruction was verbally dictated to each participant prior to their first test. Secondary data was collected for exploratory purposes using a 3-dimensional AMTI force plate (Advanced Mechanical Technology, Watertown, MA) under the initial landing zone of each participants to measure landing and take-off ground reaction kinetic data.

Figure 1: Lab setup to capture ground reaction force and horizontal displacement during the U-HDJ assessment.

Figure 2: The unilateral horizontal ldrop-jump (U-HDJ) assessment. Participants drop from a 20cm platform, landing on one leg before exploding forward for maximal horizontal displacement and landing on two feet. [Stalbom]

Experimental Protocol

Written informed consent was obtained from each participant prior to testing. Testing was conducted on the dominant leg as defined by a previously validated 11-item leg dominance questionnaire [Chapman]. Demographic, anthropometric, and additional sprint-specific background information was collected. Participants completed a 10-minute self-selected warm-up. Results from an unpublished pilot project performed by the authors indicated that 6 trials were required to mitigate learning effects associated with the U-HDJ. Thus, each participant completed an initial set of 6 U-HDJ trials, with a standardized 1-minute rest between successive trials, to familiarize themselves with the test.

Each participant then conducted 3 consecutive trials with 1-minute rest between each trial to mitigate against the development of neuromuscular fatigue. The participant then removed the running shoe from their dominant foot, and an assessment was performed for hypomobility of joints in the midfoot region. For any participant found to have a joint restriction, instrument-assisted HVLA manipulation of the mid-foot region was performed using a Thuli Extremity Drop piece (Thuli Tables, Dodgeville, WI, USA). Following each manipulation, joint palpation was performed by the treating chiropractor to assess the need for further treatment. Assessment and manipulations were performed by a chiropractor with intimate familiarity with sprint athletes. A maximum of 3 manipulations to the midfoot region of the dominant foot was performed as required, and the number of manipulations as well as the targeted region was recorded for each participant. The treatment block was standardized at 5 minutes. Each participant then replaced their shoe and conducted 3 post-manipulation trials with a 1-minute rest interval.

Data Processing

The primary outcome from the U-HDJ test was horizontal displacement, measured using an optoelectronic motion capture system. Secondary biomechanical data including ground reaction kinetics were collected from participants for exploratory purposes. Jumping distance was defined as the change in coordinates between the first and second instances of ground contact.

Statistical Analysis

The median value for each participant's pre- and post-manipulation trials were grouped for analysis. Descriptive summary measures (mean, standard deviation and 95% confidence interval limits) were determined for the post-treatment change in jump distance.

Results

Table 1 shows the baseline characteristics of all participants. Seven participants (4 female, 3 male) were tested overall (Table 1). Individual pre- and post-manipulation data is found in Table 2. Overall, there was an observable increase in jump distance following IA-HVLA manipulation to the midfoot region (Pre-manipulation: M=1.713m, SD=0.317, 95%CI [1.477, 1.948]; Post-manipulation: M= 1.776m, SD=0.314, 95%CI [1.543, 2.008]; Effect size: 1.30) (Table 3).

Table 1: Baseline characteristics

	Avg (SD)
Participants	n = 7 (4 female, 3 male)
Age (years)	25.7 (2.5)
Height (m)	1.73 (0.10)
Mass (kg)	70.0 (10.7)
Leg Dominance	Right (5), Left (2)
Sprint Event* (**self-described best event*)	60m (1) 100m (3) 200m (2) 400m (1)
Sprinting Experience (years)	8.6 (3.3)

Table 2: Individual participant pre- and post-manipulation results.

Participant	Pre-Manipulation Displacement (m)	Post-Manipulation Displacement (m)	Difference (m)
1	2.34	2.42	**+ 0.08**
2	1.84	1.91	**+ 0.07**
3	1.64	1.69	**+ 0.05**
4	1.56	1.62	**+ 0.06**
5	1.75	1.74	**- 0.01**
6	1.38	1.53	**+ 0.15**
7	1.48	1.52	**+ 0.04**

Table 3: Pre- and post-manipulation result comparison.

	Pre-Manipulation Displacement (m)	**Post-Manipulation Displacement (m)**	**Difference (m)**	**Effect Size**
Mean	1.71 m	1.78 m	0.06 m	1.30
Std Dev	0.32	0.31	0.05	
95% CI	[1.48, 1.95]	[1.54, 2.01]	[0.03, 0.10]	

Discussion

This exploratory study demonstrated acute changes in horizontal distance jumped during a unilateral horizontal drop jump (U-HDJ) assessment – a clinical assessment with positive correlation to sprinting performance – following IA-HVLA manipulation to the midfoot region in a population of elite sprinters. In this study, horizontal jump distance was measured in an acute timeframe following IA-HVLA manipulation, providing additional support to recent literature which suggests neurophysiological benefits up to 60-minutes post-manipulation [Niazi; Christiansen; Grindstaff; Kalmali].

There is a push in sport science settings to establish and expand on dynamic clinical assessments, which have been demonstrated as a useful proxy for athletic performance in the absence of competition or high threshold stressors. Selection of an appropriate assessment, also referred to as a 'field test', is an important consideration in sports science settings, with reliability, validity, expense, ease of administration, and portability being just a few items to consider in designing an assessment [Maulder]. A battery of tests with the ability to differentiate precise, specific aspects of an athletic trait while also providing information on global movement function are of great diagnostic and prognostic value to the clinician and coach [Maulder].

A true understanding of the mechanistic emphasis of each assessment, and selection of the most appropriate assessment for a specific athlete or athletic endeavour, becomes essential. Results can inform decision-making for an athlete's management team, including coaches and medical professionals, on rehabilitation progress, efficacy of a training program, and physical preparedness for competition. As an example, despite a wide variety of jumping tests to measure leg power, there is a low to moderate relationship between horizontal and vertical jump assessments [Maulder], as well as between unilateral and bilateral jumping approaches. [REF]. These findings question the common assumption that jump-based assessments are all measuring leg power equally, instead indicating that horizontal and vertical displacement tests may be measuring *different qualities* of leg power and cannot be used interchangeably. Furthermore, predilection in the literature to use vertical based jump tests to assess leg power in sprinters continues to disregard the large horizontal force production essential to sprint performance – an aspect that is poorly assessed using vertical assessments. [Stalbom; Maulder] Thus, while each assessment may hold inherent value in context, establishing a foundational framework for assessing and evaluating specific elements of performance, combined with intelligent understanding of the biomechanical parameters to be assessed, can then provide important insight into an athlete's needs without compromising safety. The importance of this study lies in investigating acute performance changes in an elite sprinting population following extremity manipulation in a field test with demonstrated reliability, stability and correlation with sprint performance.

The unilateral horizontal drop-jump (U-HDJ) assessment is a logical choice for assessing sprint performance and was chosen accordingly for this investigation. In addition to high demonstrated reliability (ICC: 0.95-0.99) [Schuster; Maulder; Maulder; Stalbom], it is mechanistically analogous at face value to the generation of unilateral, horizontal and vertical propulsive forces generated during sprinting

[Maulder]. The U-HDJ incorporates a high level of unilateral horizontal and vertical force production during a high stretch-shorten cycle (SSC) [Holm], comparable to the specific aspect of power required during this movement pattern. [Maulder]

It remains largely unknown how changes in jump distance may be reflected in sprint performance. Previously there has been a negative correlation found between jump distance and sprint time over 20m in the U-HDL [Schuster] and an overall positive trend between horizontal jump distance and sprint performance at 5, 10, and 25m splits during a 25m sprint [Holm 2008]. Comparable results have been observed using a 5-step horizontal jump compared to a 40m sprint [Nesser 1996]. Thus, an increase in jump distance could suggest a decrease in sprint time, although, due to the presence of confounding variables such as tapering, training load, nutritional status, and travel schedule – to name but a few – this connection requires further research [Loturco].

Due to the short-lived athletic nature of sprinting, and the fact that treatment can pragmatically be performed in close temporal proximity to performance, the potential for acute functional improvement may be of great benefit in this population in performance settings. These results add to mounting evidence suggesting acute neurophysiological adaptations may occur post-manipulation and may lead to functional performance improvements in asymptomatic athletic populations [Hedlund; Kamali; Niazi; Christiansen; Grindstaff; Botelho]. However, it is important to acknowledge that the observed improvements in performance require further evaluation in a more rigid study design. The exploratory nature of this study creates several inherent limitations which prevent definitive conclusions, including the underpowered study design and the lack of control group. Despite a strong effect size and niche population of elite, trained sprinters, further evaluation is required in a more rigid study. Furthermore, additional information and profiling is required on instrument-assisted HVLA manipulations for which there remains a paucity of published data available.

Finally, despite the intention to wash out learning effects by conducting a pilot project to identify the number of tests required during warm-up to saturate performance, in the absence of a control group, it is not possible to comment on this, and it is acknowledged that learning effects may have still influenced the outcome. The addition of a control group, or a crossover study design, which would be appropriate based on the strength of previously published between-session ICC values of 0.95 [Stalbom], would help to address the potential for learning effects to confound the results.

This exploratory study suggests acute changes in horizontal distance jumped during a unilateral horizontal drop jump (U-HDJ) assessment – a clinical assessment which has been previously demonstrated to have positive correlation to sprinting performance – following IA-HVLA manipulation to the midfoot region in elite sprinters. Future research should make strong efforts to incorporate such field tests into well-designed randomized control trials. In particular, a design which includes a control group with appropriate sham manipulations and adequate sample sizes would allow for comparative analyses and further evolution of our understanding of the effects of HVLA manipulation in a performance setting.

References

1. Shrier I, Macdonald D, Uchacz G. A pilot study on the effects of pre-event manipulation on jump height and running velocity. Br J Sports Med. 2006 Nov;40(11):947-9. Epub 2006 Sep 5.
2. Hedlund S, Nilsson H, Lenz M, Sundberg T. Effect of chiropractic manipulation on vertical jump height in young female athletes with talocrural joint dysfunction: a single-blind randomized clinical pilot trial. J Manipulative Physiol Ther. 2014 Feb;37(2):116-23.
3. Kamali F, Sinaei E, Bahadorian S. The immediate effect of talocrural joint manipulation on functional performance of 15-40 years old athletes with chronic ankle instability: A double-blind randomized clinical trial. J Bodyw Mov Ther. 2017 Oct;21(4):830-834.
4. Miners AL. Chiropractic treatment and the enhancement of sport performance: a narrative literature review. J Can Chiropr Assoc. 2010 Dec;54(4):210-21.
5. Corso M, Mior SA, Batley S, Tuff T, DaSilva-Oolup S, Howitt S, Srbely J. The effects of spinal manipulation on performance-related outcomes in healthy asymptomatic adult population: a systematic review of best evidence**.** Chiropr Man Therap (2019) 27: 25.
6. Nook DD, Nook EC, Nook BC. Utilization of chiropractic Care at the World Games 2013. J Manip Physiol Ther. 2016;39(9):693–704.
7. Miners AL, Degraauw C. A survey of Fellows in the College of Chiropractic Sports Sciences (Canada): their intervention practices and intended therapeutic outcomes when treating athletes. J Can Chiropr Assoc. 2010 Dec;54(4):282-92.
8. Hurwitz EL. Epidemiology: spinal manipulation utilization. J Electromyogr Kinesiol. 2012;22(5):648–54.
9. Niazi IK, Türker KS, Flavel S, Kinget M, Duehr J, Haavik H. Changes in H-reflex and V-waves following spinal manipulation. Exp Brain Res. 2015 Apr;233(4):1165-73.
10. Vila-Chã C, Falla D, Correia MV, Farina D. Changes in H reflex and V wave following short-term endurance and strength training. J Appl Physiol (1985). 2012 Jan;112(1):54-63.
11. Christiansen TL, Niazi IK, Holt K, Nedergaard RW, Duehr J, Allen K, Marshall P, Türker KS, Hartvigsen J, Haavik H. The effects of a single session of spinal manipulation on strength and cortical drive in athletes. Eur J Appl Physiol. 2018 Apr;118(4):737-749.
12. Grindstaff TL, Beazell JR, Sauer LD, Magrum EM, Ingersoll CD, Hertel J. Immediate effects of a tibiofibular joint manipulation on lower extremity H-reflex measurements in individuals with chronic ankle instability. J Electromyogr Kinesiol. 2011 Aug;21(4):652-8.
13. Botelho MB, Alvarenga BAP, Molina N, Ribas M, Baptista AF. Spinal manipulative therapy and sports performance enhancement: a systematic review. J Manip Physiol Ther. 2017;40(7):535–43.
14. Manske R, Reiman M. Functional Performance Testing for Power and Return to Sports. Sports Health. 2013;5(3):244-250. doi:10.1177/1941738113479925.
15. Hildebrandt C, Müller L, Zisch B, Huber R, Fink C, Raschner C. Functional assessments for decision-making regarding return to sports following ACL reconstruction. Part I: development of a new test battery. Knee Surg Sports Traumatol Arthrosc. 2015;23(5):1273-81.
16. Schuster D, Jones PA. Relationships between unilateral horizontal and vertical drop jumps and 20 m sprint performance. Phys Ther Sport. 2016 Sep;21:20-5.
17. Cronin, JB and Hansen, KT. Strength and power predictors of sports speed. J Strength Cond Res 19: 349–357, 2005
18. Lockie RG, Murphy AJ, Knight TJ, Janse de Jonge XAK. Factors that differentiate acceleration ability in field sport athletes. J Strength Cond Res. 2011;25:2704–2714.

19. Maulder, Peter & Cronin, John. (2005). Horizontal and vertical jump assessment: Reliability, symmetry, discriminative and predictive ability. Physical Therapy in Sport - PHYS THER SPORT. 6. 74-82. 10.1016/j.ptsp.2005.01.001.
20. McCurdy, K. W., Walker, J. L., Langford, G. A., Kutz, M. R., Guerrero, J. M., & McMillan, J. (2010). The relationship between kinematic determinants of jump and sprint performance in division I women soccer players. Journal of Strength & Conditioning Research, 24, 3200e3208.
21. Arteaga, R., Dorado, C., Chavarren, J. and Calbert, J.A.L. (2000) Reliability of jumping performance in active men and women under different stretch loading conditions. Journal of Sports Medicine and Physical Fitness 40, 26-34
22. Loturco I, D'Angelo RA, Fernandes V, Gil S, Kobal R, Cal Abad CC, Kitamura K, Nakamura FY. Relationship between sprint ability and loaded/unloaded jump tests in elite sprinters. J Strength Cond Res. 2015 Mar;29(3):758-64. doi: 10.1519/JSC.0000000000000660. PubMed PMID: 25162648.
23. Stålbom M, Holm DJ, Cronin J, Keogh J. Reliability of kinematics and kinetics associated with horizontal single leg drop jump assessment. A brief report. J Sports Sci Med. 2007 Jun 1;6(2):261-4.
24. Hunter JP, Marshall RN, McNair PJ. Relationships between ground reaction force impulse and kinematics of sprint-running acceleration. J Appl Biomech. 2005 Feb;21(1):31-43.
25. Holm DJ, Stålbom M, Keogh JW, Cronin J. Relationship between the kinetics and kinematics of a unilateral horizontal drop jump to sprint performance. J Strength Cond Res. 2008 Sep;22(5):1589-96.
26. Dobbs CW, Gill ND, Smart DJ, McGuigan MR. Relationship between vertical and horizontal jump variables and muscular performance in athletes. J Strength Cond Res. 2015 Mar;29(3):661-71.
27. Nesser, T. W., Latin, R. W., Berg, K., & Prentice, E. (1996). Physiological determinants of 40-meter sprint performance in young male athletes. Journal of Strength and Conditioning Research, 10(4), 263–267.
28. Maulder, P, Bradshaw, EJ, and Keogh, J. Jump kinetic determinants of sprint acceleration performance from starting blocks in male sprinters. J Sports Sci Med 5: 359–366, 2006.
29. Hopper, D., Goh, S., Wentworth, L., Chan, D., Chau, J., Wooton, G., et al. (2002). Test–retest reliability of knee rating scales and functional hop tests one year following anterior cruciate ligament reconstruction. Physical Therapy in Sport, 3, 10–18 =
30. Chapman JP, Chapman LJ, Allen JJ. The measurement of foot preference. Neuropsychologia. 1987;25(3):579-84.