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Effect of chiropractic treatment on hip extension ability and running velocity among young male running athletes☆

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Abstract

Objective: This study investigates the effect of chiropractic treatment on hip joint extension ability and running velocity.

Methods: This was a prospective, randomized, controlled experimental pilot study. Seventeen healthy male junior athletes (age, 17-20 years) training in middle distance running were recruited from local Swedish athletic associations. Hip extension ability and running velocity were measured before and after the study period. Chiropractic investigations comprised motion palpation of the sacroiliac and hip joints and modified Thomas test of the ability to extend the leg. In the treatment group, findings of restrictive joint dysfunctions formed the basis for the choice of chiropractic treatment. The interventions were based on a pragmatic approach consisting of high-velocity, low-amplitude manipulations targeted toward, but not exclusively to, the sacroiliac joints.

Results: The treatment group showed significantly greater hip extension ability after chiropractic treatment than did controls ($P < .05$). Participants in the treatment group did not show a significant decrease in time for running 30 m after treatment (average, −0.065 seconds; $P = .0572$), whereas the difference was even smaller for the control subjects (average, −0.003; $P = .7344$).

Conclusions: The results imply that chiropractic treatment can improve hip extensibility in subjects with restriction as measured by the modified Thomas test. It could be speculated that the running step was amplified by increasing the angle of step through facilitated hip joint extension ability. The possible effect of chiropractic treatment to enhance the running velocity, by increasing the hip joint extension ability and thereby increasing the running step, remains unproven.

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Introduction

The speed of an "athlete on legs" (henceforth referred to as *runner*) is the product of the length of each step and the frequency of step, with *step* defined as a half running cycle, existing from foot contact to the next contact of the opposite foot.[1] Accordingly, an increase in one factor will result in improved running velocity, as long as the other factor does not undergo a simultaneous and proportionally similar or larger decrease. The basic biomechanical restriction for running velocity is the step frequency in combination with the step length, although the nature of the relation between these 2 parameters is controversial.[2] A simplified model would be that the step length depends on leg length and step angle (extension-flexion maximum in hip joints). A wide variety of biomechanical factors appears to affect running and running economy, and it has been proposed that a runner runs more effectively when the length of step is freely chosen.[3] Increased length of step by force is likely to cause premature fatigue. Thus, to improve, the runner would need to lengthen the freely chosen step without using, in each step, considerable muscle force to overcome passive forces caused by reduced hip extension ability. Reduced hip extension has been attributed to tight hip flexor muscles or decreased elasticity of joint or tendon structures, leading to increased anterior tilt of the pelvis that could explain decreased running performance.[4] With chiropractic treatment, it is theoretically possible to contribute to increased length of step by adjusting restrictive joint dysfunctions and thereby improving conditions in the arthrokinematic chain to maximize movement when running.

The use of chiropractic manipulation in an asymptomatic individual or in an individual without an identifiable clinical condition is considered neither medically nor ethically appropriate. Still, many athletes seek chiropractic care in an effort to get a performance advantage—an ergogenic effect. Few studies have investigated the ergogenic effects of chiropractic care, and it has not been subject to investigation to a great extent in the literature.[5,6] Studies on asymptomatic subjects indicating improved function due to chiropractic procedures include hip range of motion (ROM),[7,8] ankle ROM,[9,10] and muscle strength.[10] There is a scarcity of data regarding paraspinal conditions and chiropractic treatment.[11] In comparison, a large amount of studies supports the use of manipulation in both acute and chronic musculoskeletal syndromes related to the spine.[12-15] It should be emphasized that nowhere does this study state or imply that chiropractic manipulation should be used only for symptomatic patients without identifiable joint restrictions. The purpose of this pilot study was to investigate the effect of chiropractic treatment on hip joint extension ability and running velocity in young runners with identifiable joint restrictions.

Methods

Study design

This was a prospective, randomized, controlled experimental pilot study.

Research participants

Research participants (N = 17) were all male and recruited by convenience sampling from local athletic associations. All subjects in the study (Table 1) were subjectively healthy junior running athletes (age, 17-20 years) training in middle distance and therefore both able to run 800 m in around 2 minutes and 1500 m in around 4.00 to 4.10 minutes. The rationale for recruiting middle distance runners to test their sprint time was that the middle distance runners we could recruit were more homogeneous regarding time and ranking than sprinters, and the short distance was chosen to avoid influence of other factors (fatigue, lactic acid formation, etc). Because the participants' event times are highly influenced by such factors, no comparisons or correlations were made with regard to the event performance. The running athletes were all examined during the same phase of fitness training. The number of participants in the study was limited by the

Table 1 Inclusion and exclusion criteria for running athletes recruited for the study

Inclusion criteria	Exclusion criteria
Male	General contraindications for manual treatment
Age, 16-22 y	Presence of severe musculoskeletal injury
Subjectively healthy	Manual treatment within 4 wk before
Run 800 m around 2 min	
Run 1500 m around 4.00-4.10 min	

availability of volunteers at the time of the investigation. Participants gave informed consent to participate in the study, and an independent research assistant randomized the participants to either a treatment (n = 8) or a control (n = 9) group. The randomization was performed by gathering identification numbers of the eligible participants and then drawing lots using sealed opaque envelopes. To secure equal distribution of participants, an alternating procedure was used. The person responsible for randomization was not involved in determining participant eligibility. Owing to the relatively low number of participants in both groups, no stratification based on prognostic factors was done. All research participants completed the study. The project was approved by the research ethics committee of the Scandinavian College of Chiropractic, Sweden.

Investigations and experimental setup

In all participants, hip extension ability and running velocity (30 m) were measured before and after the investigation period using equipment used for the evaluation of training development at the university where the athletes trained; this was also the venue for all investigations and interventions performed during the study. A state-registered chiropractor who was blinded to the subjects' group assignment performed all the pretest and posttest measurements. The examiner performed prestudy training with the assessment tools to maximize the reliability in the testing.

Preparations

The testing session began with the runners performing a general warm-up of choice, for 30 to 45 minutes, consisting mainly of general jogging and of short high-intensity sprints and starts. After the warm-up, the hip extension ability was measured, followed by timing of running 30 m at maximum speed ("running start").

Hip extension ability

There is no general consensus on a definition of hip extension, and highly variable measurements have been published.[16] It has been reported that static and dynamic measurements of anthropometric parameters of the hip joint and related motion centers have a high degree of repeatability. The method for assessment of hip extension used in this study has previously been found to be adequately reliable when measuring normal subjects.[17]

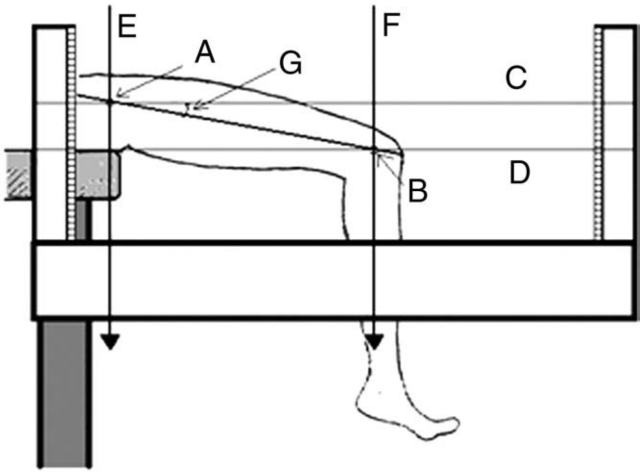

Fig 1. Schematic drawing of the equipment used to assess hip joint extension angle. *A* and *B* denote the markings of the hip joint coronal axis and the lateral femur condyle, respectively. *C* and *D* denote horizontal, moveable strings; and *E* and *F* denote the vertical plastic markers applied where *C* and *D* passed the markings *A* and *B*. The angle *G* was calculated from horizontal and vertical distances between *A* and *B*.

Hip extension angle was assessed with the help of a device mounted on an examination table (Fig 1). The measurement was done using a modified Thomas test where the participant sat on the end of the table, rolled back to a supine position, and held both knees to the chest. This ensured that the lumbar spine was flat on the table and that the pelvis was in posterior rotation. The participant held the contralateral hip in maximal flexion with the arms, whereas the tested limb was lowered toward the floor hanging off of the table, the ischial tuberosity vertical with the edge of the table (Fig 1). On each leg, the positions of the hip joint coronal axis and the lateral femur condyle were marked with a pen. One horizontal moveable string was positioned at the level of each marking. The vertical distance between the markings was measured by the distance between the strings, and the horizontal distance was measured between plastic markers attached horizontally on the moveable strings at the marked points on the leg. The angle of the femur in relation to the horizontal plane was then calculated. If the lateral femur condyle was above the hip joint axis of motion, this was defined as a *positive angle* (>0°); the lateral femur condyle below the hip joint axis of motion was defined as a *negative angle* (<0°). All markings and measurements were done by the same investigator, blinded to whether the runner was treated with chiropractic manipulation or not. Recordings were only performed regarding extension ability because the chiropractic examinations and adjustments were aimed at dysfunctions related to extension ability.

The running start 30 m

Immediately after the assessment of hip extension ability, the running velocity was measured using photocells. The participants were allowed a distance of 30 m to accelerate to a maximum velocity, after which they passed the first photocell. The maximum speed was then maintained for 30 m, where a second photocell was passed. The time elapsed between passing the 2 photocells was registered. Two runs were carried out with a rest period of 8 to 10 minutes in between. The best time was used for analysis. Assessment of "running start 30 m" is used to evaluate running speed capacity in training middle distance running athletes and is supposed to represent the true running capacity without interference of factors influencing the capacity to start running as well as factors related to circulation, respiration, and muscular work under more anaerobic conditions that occur when longer distances are run.

Intervention

The manual examination of the participants in the treatment group included dynamic (motion) palpation of the sacroiliac (SI) and hip joints (data not reported). There are several studies indicating that dynamic palpation has variable degrees of interexaminer reliability but reasonable degrees of intraexaminer reliability over time.[18] Poor reproducibility may reflect the design of reproducibility studies, rather than the quality of the palpation procedure.[19] In the SI joints, palpation for movement restriction, with or without pain provocation, has been shown to be reliable[20,21] and valid,[22,23] particularly when multiple tests are used. Results from reliability studies of motion palpation procedures are not entirely conclusive,[18] and discounting the use of dynamic palpation as a part of the clinical evaluation would be premature and not clinically reasonable. Dynamic palpation was used in this study only as a tool for the clinician to select an appropriate modality of high-velocity, low-amplitude (HVLA) manipulation technique. All participants in both groups exhibited motion restrictions indicative for HVLA intervention. From an ethical perspective, it would be questionable to treat participants ergogenically with HVLA manipulation in the absence of joint restrictions because this hypothetically could induce iatrogenic injuries.

Treatments were thus based on a pragmatic approach consisting of HVLA manipulations targeted toward, but not exclusively to, the SI joints. In addition, manipulative thrusts were executed to the hip joints to adjust dysfunctions and improve the ability to extend the hip. The SI joint manipulation was performed as described elsewhere[24] using a side posture position with a pisiform posterior superior iliac spine contact, thrusting the posterior superior iliac spine superiorly and anteriorly, and alternatively, hypothenar ischium contact, thrusting posterior to anterior. The adjusting procedure for the hip joint consisted primarily of prone posterior to anterior glide with a contact on the posterior aspect of the proximal femur; the adjusting modality was pragmatically chosen. Impulse techniques were used on all participants in the treatment group, but the procedures did not have to elicit a joint cavitation (cracking noise). No more than 2 attempts at the adjustment were permitted. Treatments were given once a week during the 3-week study period by one experienced, state-registered chiropractor. Equal treatment frequency and duration were given to all participants in the treatment group. The posttest measurements of both groups were performed within a maximum of 3 days after the last treatment intervention of the treatment group. Because of the study's pragmatic approach, consideration regarding treating unilateral or bilateral, dominant or nondominant limb, or choice of technique was left to the discretion of the clinician. No data were collected regarding the total number or locations of HVLA manipulations.

Both the treatment group and the control group trained as usual and were given the same passive and active stretching, using hip flexor stretch, of muscles involved as a part of their usual training activities at least twice and at the most 3 times during the study period. This was methodologically considered to avoid skewed data due to inactivity and contortion of usual training recreation. The exercise regimes in the study were identical for all research participants and also between groups.

Statistical methods

For statistical analysis, nonparametric Wilcoxon matched-pairs tests (pairwise analyses of dependent groups) and Mann-Whitney *U* tests (unpaired analyses of independent groups) were used because of lack of Gaussian distributions for some of the examined parameters.[25] Statistical analyses were done using GraphPad Prism, version 5.0; and power calculations were done using GraphPad StatMate, version 2.00 (GraphPad Software, San Diego, CA; www.graphpad.com). In general, $P < .05$ is considered statistically significant. Further interpretations of statistical analyses are considered in the discussion.

Results

Hip extension ability

Before treatment, there was no difference in hip extension ability between the 2 groups (Fig 2, Table 2). The change from start to end of study was significantly larger for the treatment group (Fig 2, Table 2).

Running start 30-m time

The average change in time for 30-m running start was 65 milliseconds for the treatment group and 3 milliseconds for the control group (Fig 3, Table 3). The difference in change was not statistically different (comparison of independent groups, Mann-Whitney *U* test: $P = .074$) nor was the comparison of the change of either group with a theoretical zero change (Wilcoxon signed ranks test: average, −0.065 seconds; $P = .057$ for treatment group; and average, −0.003; $P = .734$ for control group). The effect size for the change in running velocity during the study period calculated indicated a large effect (Cohen $d = 1.06$).[26]

Discussion

The results of this pilot study, with a limited number of participants, indicate that chiropractic care (here

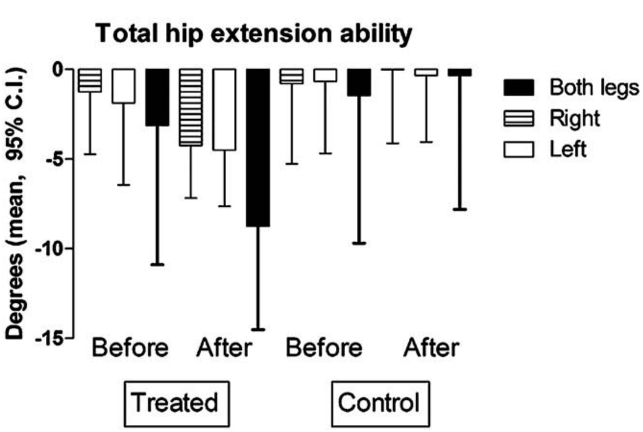

Fig 2. Average (95% confidence interval) of individual hip extension angles (degrees) in treatment (n = 8) and control groups (n = 9) before and after the study period for individual legs (right, left) and sum of extension ability for each individual (both legs).

Table 2 Hip extension ability (degrees) in treated and control group at start and end of study, and the change from start to end

	Treatment Group									Control Group								
	Start of Study			End of Study			Change			Start of Study			End of Study			Change		
	Right	Left	Sum	Right	Left	Sum	Right	Left	Sum	Right	Left	Sum	Right	Left	Sum	Right	Left	Sum
n	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9
Mean	−1.3	−1.9	−3.1	−4.3	−4.5	−8.8	−3.0	−2.6	−5.6	−0.8	−0.7	−1.4	0.0	−0.3	−0.3	0.8	0.3	1.1
SD	4.2	5.5	9.3	3.5	3.7	6.9	2.4	2.7	4.0	5.8	5.2	10.7	5.4	4.8	9.7	1.2	1.0	2.0
SE	1.5	1.9	3.3	1.2	1.3	2.4	0.9	0.9	1.4	1.9	1.7	3.6	1.8	1.6	3.2	0.4	0.3	0.7
Lower 95% CI of mean	−4.7	−6.4	−10.9	−7.2	−7.6	−14.5	−5.0	−4.9	−9.0	−5.3	−4.7	−9.7	−4.1	−4.0	−7.8	−0.1	−0.4	−0.4
Upper 95% CI of mean	2.2	2.7	4.6	−1.3	−1.4	−3.0	−1.0	−0.4	−2.3	3.7	3.3	6.8	4.1	3.4	7.1	1.7	1.1	2.7
Differences	a	b	c				d	e	f	a	b	c				d	e	f

Statistical analyses (Mann-Whitney *U* test), treatment vs control: $^aP = .73$; $^bP = .73$; $^cP = .74$; $^dP < .01$; $^eP < .05$; $^fP < .01$. *CI*, Confidence interval.

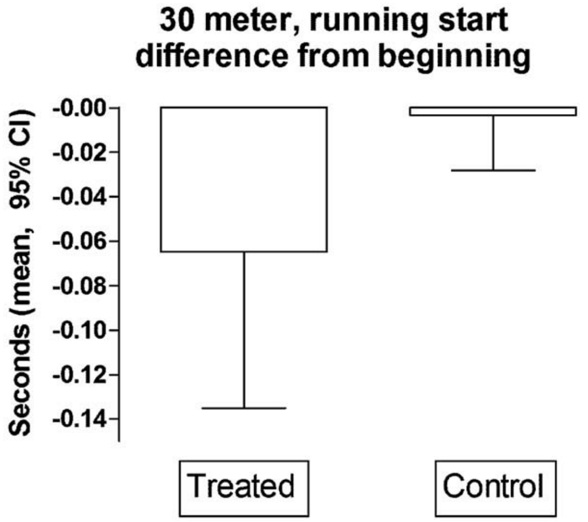

Fig 3. Average (95% confidence interval) for individual changes of duration of 30-m maximal running after running start from beginning to the end of the study period in treatment (n = 8) and control groups (n = 9), respectively.

consisting mainly of HVLA manipulation of joint dysfunctions and restrictions in the SI and pelvic regions) may influence hip extension ability and maybe also the running velocity. It could be argued that the extent of joint dysfunctions and restrictions in the SI and pelvic regions in the population before the investigation is difficult to assess reliably because the reliability and validity of dynamic palpation are not without demur. However, in the present study, the dynamic palpation was not an outcome measure but merely part of the clinician's investigations to chose an appropriate adjustment.

Although the effect on hip extension capacity was statistically significant, the decrease in time for running 30 m after running start did not meet the classic criteria for statistical significance and could therefore be discarded as not significant. However, post hoc power analysis reveals that with the present nonsignificant test result and the existing variability, the power was only 60%.[25] Therefore, it may be that the lack of statistical significance can be due to the low number of observations. The calculated effect size (1.06) also indicates that there may be a real effect.[26] Thus, larger studies are required to draw more secure conclusions regarding the possible effect of chiropractic care on running speed. Another approach that could be combined in an extended study would be a type of crossover study where the original control group is treated in a second study period, allowing the control participants to act also as their own controls. Nevertheless, the statistically significant difference for hip extension ability for the treated runners is still valid even with the low numbers of observations.

The runners in the present study were tested while sprinting from the 30-m to the 60-m mark. Over this portion of a sprint, maximum stride frequency is expected to be of greatest importance in maintaining maximum speed. In this regard, increased hip flexor performance is most likely to be of greatest benefit. An increase in hip extension range may simply mean that the runner had a greater angular distance to cover in reloading the swing limb for the next stance phase. It might be the case that increased hip extension ability may be of greater benefit in the earlier accelerative phase of a sprint, when maximal leg turnover has not yet been reached. This possibility was not tested in the present pilot study, but future studies should take this into consideration. It can be argued that the 30-m maximum sprint is not a typical condition for these athletes; however, the aim of this study was not to evaluate the effects on 800- and 1500-m events.

The runners in this study were middle distance runners. For such runners, increased hip extension is of benefit once the runner has reached a fast but sustainable pace—a pace at which the runner is operating below maximal possible stride frequency. Therefore, it could be disputed that this phase of a race occurs much later than the 60-m mark. However, the main objective of the present study was not specifically to increase the middle distance runner mean velocity but rather to examine whether chiropractic treatment of joint restrictions could improve the running performance.

It has been confirmed in animal study models as well as in studies on humans that significant functional segmental unit movements are created during HVLA manipulation.[27,28] It is tempting to speculate that the improvement in hip extension ability observed in the treatment group would be due to intra- and extra-articular changes in the SI and pelvic regions. Results from mechanical and neurophysiologic studies may thus be interpreted as if joint manipulation has both direct and indirect clinical benefits. The effect of spinal manipulation on various kinematic parameters of spine, pelvis, and hip motion has been shown to be beneficial.[7,29] Because HVLA manipulation is a mechanical intervention, it is inherently rational to assume that the mechanisms for the therapeutic effect may lie in the mechanical properties of the applied force, the body's response to the force, and the movement caused by the force, or an amalgamation of these and other factors. From a neurophysiologic point of view, the existence of mechanosensitive

Table 3 Thirty-meter running start time (seconds) in treated and control group at start and end of study, and the change from start to end

	Treatment Group			Control Group		
	Start	End	Change	Start	End	Change
n	8	8	8	9	9	9
Mean	3.55	3.49	−0.065	3.43	3.43	−0.003
SD	0.18	0.13	0.084	0.20	0.19	0.032
SE	0.06	0.05	0.030	0.07	0.06	0.011
Lower 95% CI of mean	3.40	3.38	−0.135	3.28	3.29	−0.028
Upper 95% CI of mean	3.70	3.59	0.005	3.59	3.58	0.022

afferents in spinal tissues and the role of afferent stimulation in coordinated neuromuscular stabilization of the spine provide a plausible model for investigations of the mechanisms for the clinical effect of HVLA manipulation.[30-32]

In the present study, the modified Thomas test was used to evaluate the hip extension ability. The Thomas test has been used as the standard for assessment of restricted hip extension and hip flexor contracture.[33] Regrettably, the results of the Thomas test do not only reflect the mobility of the hip joint because other joints (lumbar spine, SI, and knee joint) also influence the test. Furthermore, the ROM of the hip joint shows a high degree of variability among healthy subjects.[34,35] Variability in results can therefore depend on mobility in other joints than the hip joint as well as variability in the measuring technique (measuring device, intertester and interassay errors). Earlier work has revealed that differences between pelvic positions may strongly affect the results.[36] It is possible that investigators in different studies have used different patient positioning on the examination table or their locations for bony landmarks were improper; this might to a degree explain the poor reliability in hip extension measurements.

The results of ROM measurements are also dependent on the force applied during measurement. The changes in ROM may merely be attributable to day-to-day variations in the force applied. In the present study, the test position of each research participant was carefully controlled to achieve the best possible accuracy as suggested by the literature.[37] The modified Thomas test is in general subject to considerable examiner interpretation; and in the present study, we made efforts to reduce variability by using a bench-attached device to assess the angles and by using only one examiner who was blinded to whether the individual participant had been given HVLA treatment or not.

Restricted hip extension ROM is most likely due to hip flexor muscle tightness. Tightness of the hip flexor musculature, hip joint capsule, or surrounding anterior hip ligamentous and fascial structures in runners may reduce hip extension flexibility. Limited hip extension flexibility has been proposed as one possible cause of increased anterior pelvic tilt and lumbar lordosis during running.[4] However, the relationship between hip flexor muscle tightness and altered lumbopelvic biomechanics at present remains largely unclear. It might be disputed that the ability to extend the hip is not affected if there is a flexion inability of the ipsilateral SI joint; nevertheless, the step length would probably be reduced irrespective of restricted flexion or extension. If the total ROM is restricted, the angle between both femurs would possibly be reduced, which could lead to a shorter length of step. The aim of the treatment modalities in the present study was to enhance the angle between the femurs in the best possible way; therefore, data regarding localization and frequency that required HVLA intervention were not collected as the participants advanced through the trial. However, the treating chiropractor reported verbally that improvement was greatest using SI joint manipulation.

In the present study, it is of course possible that the treatment modality of HVLA manipulation in conjunction with the participants' normal training and stretching regimen led to the improvement of hip extension ability in the treatment group. However, the control group, with an identical stretching regimen, did not display the same improvements, indicating that stretching without chiropractic treatment did not have the same effect. It is possible and could be postulated that neurologic mechanisms of HVLA manipulation enhanced and prolonged the stretching modality that was used as part of the participants' normal training activities. It is important that future studies explore the lasting effect of HVLA manipulation on hip extensibility and also to investigate appropriate dosage.

Performance-enhancing manipulation may represent mainly a "ritualistic" behavior, but it is still commonly performed and may have negligible adverse effects. However, the ergogenic effects of manipulation have not been subject to a great deal of investigations. One should acknowledge that overdosage of HVLA manipulation might possibly induce iatrogenic adverse effects; but there seems to be an enthralling physiological basis for why manipulation may work for performance enhancement, at least when dysfunctions are present. More basic studies are essential to reach further in this area.

Conclusion

The results of this pilot study imply that chiropractic treatment can enhance hip extensibility in subjects with restriction as measured with the modified Thomas test. It could be speculated that the running velocity may be enhanced by increasing the running step and by increasing the angle of step through facilitated hip joint extension ability, but this remains unproven. Further studies are necessary to measure how chiropractic treatment may impact running velocity.

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