Original Research

Improvement in Motor Function Measured by Grip Strength Following Chiropractic Adjustments to Reduce Vertebral Subluxation in 100 Subjects

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Abstract

Objective: To describe the improvement in motor function measured by grip strength in 100 patients following chiropractic care.

Methods: Motor function was measured by grip strength was recorded for 100 patients pre and post adjustment following Koren Specific Technique.

Results: Areas of vertebral subluxation were identified and adjusted using Koren Specific Technique. Results were statistically significant and demonstrated an increase in motor function as measured by grip strength post adjustment.

Conclusion: Chiropractic care deemed successful in improving motor function measured by grip strength for the patient population described. More research is warranted in this subject area to add to the current body of literature detailing the potential benefits of chiropractic care as it relates to motor function and grip strength.

Keywords: *Grip strength, motor function, quality of life, Koren Specific Technique, vertebral subluxation, adjustment*

Introduction

Most people who visit a chiropractor complain of some form of discomfort, very commonly in the neck and lower back. Chiropractic adjustments have long been known to be a popular choice in helping to alleviate these discomforts. To date, numerous studies have suggested that other than symptomatic relief, chiropractic care can improve muscular strength.

This paper was originally a case study of a 47-year-old female patient who was diagnosed with carpal tunnel syndrome by her specialist hand surgeon and was recommended to undergo a surgery. She had reported numbness and tingling in both thumbs and her second and third digits, and was medically diagnosed with moderately severe carpal tunnel syndrome in both hands via a motor conduction study ("MCS"). The electromyography (EMG) report showed absent median sensory potential from digit II bilaterally, prolonged median distal motor latency bilaterally and reduced compound muscle action potential over thenar muscles bilaterally.

By the fourth session of her chiropractic care, she had reported that the numbness was "almost gone." After undergoing 15 sessions of chiropractic treatment, she reported that her hands were completely free from numbness and she had regained strength in her hands. She was offered by the author to undergo the MCS for a reassessment but declined as she felt that the test was painful and traumatizing. However, she agreed to have her grip strength measured using a hand dynamometer as an alternative. (See Appendix 1)

On the 19th session, her grip strength was measured: Right hand measured 55.6lbs while her left hand measured 51.8lbs (both measured only post adjustment). Based on the "Physical Status According to the Test Result Given by the Dynamometer" (Appendix 2), her grip strength measured was considered normal for her age of 47 years old. (Note: Normal grip strength range for female in the age range of 45-49 years old is between 41.0 to 71.4lbs)

Reportedly, she regained sensory and motor functions of her hands. Experimentally, her grip strength on her 20th visit was remeasured before and after the chiropractic adjustment was rendered. The following results in Table 1 were obtained:

Table 1

Hand	Grip strength		Increase	Status
	before adjustment (lbs)	post adjustment (lbs)	(%)	(Appendix)
Right	53.4	59.7	12	Normal [41.0-71.4lbs]
Left	51.8	53.4	3	Normal [41.0-71.4lbs]

Evidently, her right hand recorded a twelve percent increase, while her left hand recorded a three percent increase. The patient's vertebral subluxation was analyzed and corrected using the Koren Specific Technique ("KST") with the use of the AccuStim instrument. During the 15 visits, patient's fifth cervical vertebra (C5) appeared to be most consistently subluxated.

As the increase in hand grip strength for this case was encouraging, the author decided to collect more data to ascertain the effects of chiropractic adjustments on grip strength. As such, the hand grip strength test was further performed on another 99 patients. The study was approved by the Foundation for Vertebral Subluxation's Independent Review Board.

The results of the 100 patients are listed in Appendix 3.

Strength

There are numerous definitions of strength. Dorland's Medical Dictionary[1] defines strength as intensity or power and subclassifies muscular strength as the greatest force that can be put forth by a muscle. Gray's Anatomy[2] describes it as an expression of the skillful activation and co-ordination of these muscles as it is a measure of the forces that they contribute individually. Wilmore and Costill[3] defines strength as the maximal force that a muscle or muscle group can generate. For the purpose of this paper, grip strength shall simply be referred as the maximum force that a hand can generate.

Methods

An electronic hand grip dynamometer (CAMRY EH101) ("EHGD") (Appendix 2) was used to measure the hand grip strength of 100 patients. The testing range on a dual scale was (0-90) kg / (0-198) lb. Each patient was told to let their arm hang freely by their side after the EHGD was handed to them (See Appendix 3). Prior to that, the author explained to each patient the purpose of the test and each patient was shown how to use the EHGD. The patient was asked to squeeze the EHGD as hard as possible while keeping the elbow straight, their body still, and till their right hand trembled, indicating that they have used their maximum strength. The measurement was recorded and the procedure was repeated with the left hand. For consistency, there was only one dynamometer (the same dynamometer) used throughout the study, and the author was the only assessor of the grip strength. Measurements on both hands were taken before chiropractic adjustments were rendered on each patient. Immediately after the adjustment the measurement procedure was repeated and the patient was shown the pre and post measurement results. The chiropractic adjustments were rendered throughout the study using KST with the use of the AccuStim instrument.

Koren Specific Technique

KST was developed in 2003 by Tedd Koren, D.C. The procedure[4] is made up of three steps:

The first step, challenging, is part of the analysis procedure, which involves the analysis of the entire structural system: skull, spine, discs, hips, ribs, sternum, shoulders, arms, legs, hands and feet.

The second step, checking, involves analyzing if the body part is in its proper position. KST uses the occipital drop, which is a binary neurological biofeedback device to locate vertebral subluxations. The base of the skull is used as a yes/no device and using a binary or yes/no system to assess if an area needs or does not need to be corrected or adjusted. This system is akin to muscle testing (applied kinesiology or AK) wherein a muscle will become weak when confronted with a negative impulse.

The third step is correcting. When an adjustment is needed the area is corrected using the AccuStim adjusting instrument.

AccuStim/ArthroStim

The AccuStim, also commonly knowns as ArthroStim, is an FDA approved instrument developed by IMPAC technology in Oregon, and has more than 22 years of history.[5] The instrument produces a "vibracussion" rhythm of 12-14 min-toggle recoils per second. It is held in the secondary hand and the vibracussion influence sustains and substantiates the input delivered by the practitioner's primary (free) hand.[5] By rendering fast, accurate, low force and controlled adjustments, it is able to introduce energy/force/information to the body to realign segments and remove nerve pressure.

Results

The grip strengths of 100 patients were collected in this study and listed in Appendix 1. A summary of the change in hand grip strength for the patients immediately after the chiropractic adjustment is shown in Table 2 below.

Table 2

Percentage of increase	Percentage of patients registering grip strength increase
0-5%	5
6-10%	19
11-15%	31
16-20%	15
21-25%	13
26-30%	3
31-40%	7
>40%	7

The results obtained showed that 95% of the patients registered more than 5% increase in grip strength immediately after chiropractic adjustments using the KST. A majority (31%) of the patients showed between 11-15% increase in grip strength. It is to be noted that there was one patient in the >40% increase group whose grip strength increased by 85%. There were two patients who showed a -1% change post adjustment. It is possible that this arose from the way the participant held the dynamometer.

Less than 5% showed negligible improvement (less than 5% increase in grip strength). None of the patients showed a deterioration of grip strength post adjustment.

A Paired Sample T- Test showed the results to be statistically significant. See Table 3 and 4.

Table 3

Paired Samples T-Test

Paired Samples T-Test

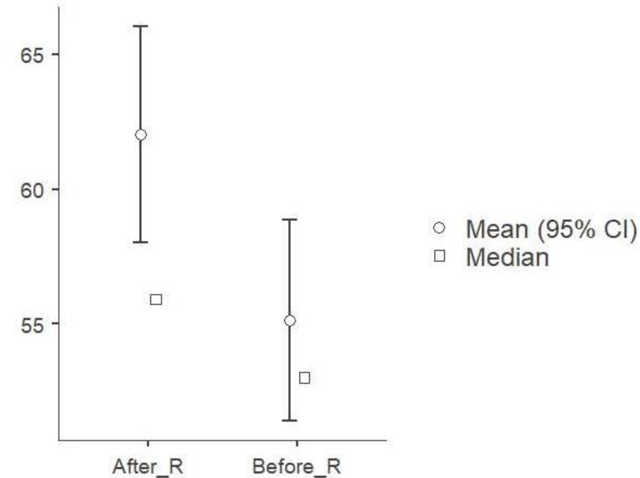
			statistic	df	p	Mean difference	SE difference	95% Confidence Interval Lower	95% Confidence Interval Upper	Cohen's d
After_R	Before_R	Student's t	11.8	99.0	< .001	6.88	0.583	5.73	8.04	1.18
		Wilcoxon W	4646 [a]		< .001	6.30	0.583	5.20	7.70	1.18
After_L	Before_L	Student's t	12.1	99.0	< .001	5.72	0.471	4.78	6.65	1.21
		Wilcoxon W	4635 [a]		< .001	5.50	0.471	4.65	6.40	1.21

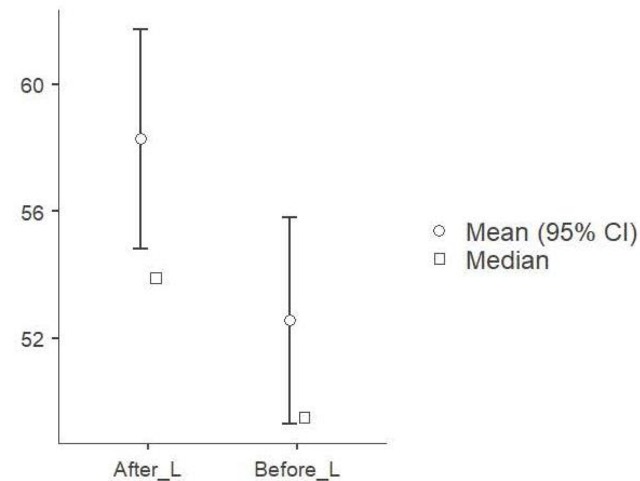
[a] 4 pair(s) of values were tied

Descriptives

	N	Mean	Median	SD	SE
After_R	100	62.0	55.9	20.5	2.05
Before_R	100	55.1	53.0	19.0	1.90
After_L	100	58.3	53.9	17.6	1.76
Before_L	100	52.6	49.5	16.6	1.66

Table 4





Discussion

Chiropractic has been considered to be an effective and safe therapy for musculoskeletal disorders with significant results in both short and long term.[6-10] It is comparatively safe when performed on patients without contraindications.[11-16]

Numerous studies have shown that chiropractic can result in positive neuromuscular changes. For example, Colloca et al[17] demonstrated that manipulation can generate neuromuscular reflex responses in surface electromyography in patients with lower back pain, while Hillerman et al[18] observed quadriceps' strength increase after manipulation of the sacroiliac joint. Dishman et al[19] demonstrated that temporary excitatory inhibition of motor neurons in the neck and lower back resulted from manipulation.

To date, there are at least 13 studies[20-32] examining the influence of chiropractic adjustments on strength/tension. Of these, four of them were on grip strength.

Zasadny et al[22] found that there was a significant increase in strength of the first dorsal interosseus following cervical manipulation. Howitt-Wilson found that 21 patients had significant contralateral grip strength increase following a thumb move at T1. Unger[26] found significant strength increase in 15 of 16 muscles following Category II blocking (Sacral Occipital Technique). Marcelo et al[31] concluded that grip strength of national level judo athletes receiving chiropractic SMT improved.

This paper looks at grip strength changes of 100 patients following chiropractic adjustments using KST. Throughout the study, no manual or rotary manipulation were administered. Instead, the adjustments were administered using the AccuStim instrument. Hence, the term "adjustments" were used instead of "manipulations". The AccuStim was appropriate because of its high velocity and low force. Research by Herzog et al[33] showed that reflex electromyographical activation observed after manipulation only occurred after high-velocity, low amplitude manipulations, and the audible release does not (by itself) evoke muscle activation or a joint proprioceptive reflex response.

Vertebral subluxations are known to cause kinesiopathology, or segmental spinal dysfunction, where hyper or hypo-mobility can result in spinal units. This can cause spinal nerves passing through the intervertebral foramen to be compressed, thus leading to nerve compression. Dr D.D. Palmer called this the "foot-on-the-hose theory."[34]

Evidently, muscular function impairment can be caused by neurological interferences[35-36] and nerve root compression is considered a type of neurological dysfunction.

The effects of nerve root compression or the compression subluxation[37] caused by vertebral subluxation can be extensive, as summarized in Dean's paper.[20] These include clinical effects[38-42] such as loss of muscular function, disturbance of blood flow, tissue inflammation, neurological dysfunction and loss of nerve function.

Normal muscular function can also be disrupted by spinal cord segmental neurology and inflammation of the related area, as it can cause and maintain a level of hyper-excitability in the spinal cord.[43]

Colloca et al[44] observed that impulsive SMTs in human subjects were found to stimulate spinal nerve root responses that were temporally related to the onset of vertebral motion. According to Taylor et al,[45] spinal manipulation of dysfunctional neck joints can alter cortical motor control of two upper limb muscles in a muscle-specific manner and may also alter sensorimotor integration. Haavik et al[32] demonstrated that spinal function and/or movement has a significant impact on central cortical processing that improves the accuracy of the brain's awareness of limb position and alters the way it controls upper and lower limb movement patterns. Increases in strength following spinal manipulation were due to descending cortical drive.

Conclusion

From the results of this study, cervical segment C5 was consistently found to be subluxated in all 100 patients and was adjusted using KST.

A person's grip strength is primarily affected by the musculocutaneous nerve (cervical roots C5, C6 and C7), which innervates biceps muscles; median nerve (cervical roots C5, C6 and C7), which innervates forearm anterior muscles and short thumb muscles; and ulnar nerve (C8 and T1), which supplies ulnar carpal flexor, the ulnar half of the deep finger flexors, thumb adductor, and the deep part of its short flexor.[46]

One can infer from the 47-year-old female's resolution of the numbness in her hands that the chiropractic adjustments rendered at the cervical spine, particularly at C5, corrected the vertebral subluxation that may be responsible for her numbness. Prior to her adjustments, the MCS showed "absent median sensory potential from digit II bilaterally, prolonged median distal motor latency bilaterally and reduced compound muscle action potential over thenar muscles bilaterally." The subluxation detected in the patient was consistent with the innervation of C5 nerve root to the digits and thenar muscles. Logically, when the subluxation is removed, the sensory and motor deficit is reduced. Hence, resolution of the numbness in her hands.

This study suggests that the chiropractic adjustments using KST at the mid cervical spine (particularly C5) can result in increased grip strength. The correction of the vertebral subluxation can stimulate the corresponding spinal nerve roots responsible for grip strength. Cortical changes are likely to have resulted in the increases in the grip strength following the KST adjustments. The data also suggests that chiropractic adjustments using the KST and AccuStim do not cause any adverse effects on grip strength. It appears that gender does not influence the grip strength increase.

Extrapolation of such improvements in nerve functions in our body as a result of removal of vertebral subluxation can lead to improved motor function, better body function and healthier well-being.

Future Studies

A larger sample size could be obtained to further demonstrate that chiropractic adjustments in lower cervical spine can improve grip strength. A more established dynamometer such as Jamar Analogue Hand Dynamometer could be used in future studies, along with measuring the arms in different positions. The standardized positioning, instruction and calculation adopted by the American Society for Surgery of the Hand and the American Society of Hand Therapists[47] can be considered.

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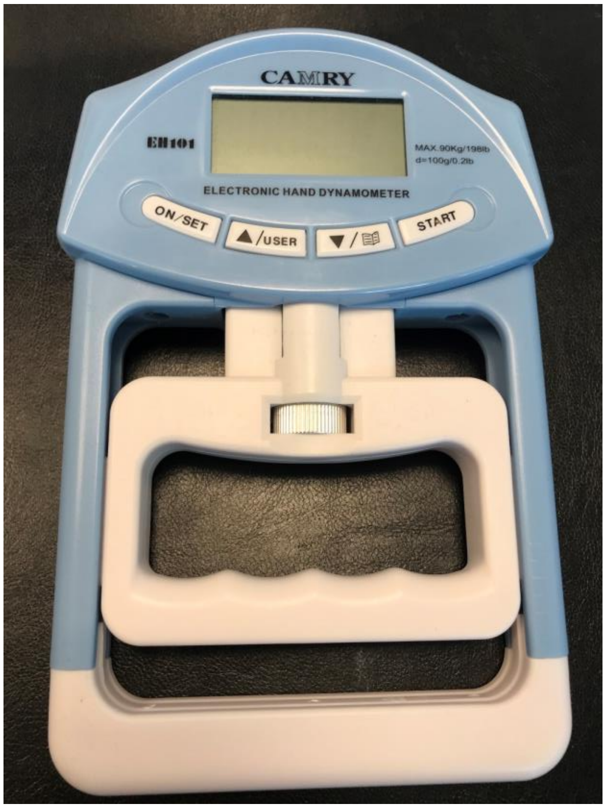
References

1. Williams PL, Bannister LH. Gray's Anatomy: the anatomical basis of medicine and surgery. New York, NY: Churchill Livingstone, 1995.
2. Dorland's Illustrated Medical Dictionary (28th ed.). Philadelphia, PA: W.B. Saunders Company.
3. Wilmore JH, Costill DL. Physiology of sport and exercise. 1999. Champaign, IL: Human Kinetics Pub, 1999.
4. Koren Specific Technique. Accessed September 18, 2018. http://www.korenspecifictechnique.com/kst.asp.
5. The AccuStim Instrument Manual Version Ser 09-08-14ACC. Salem, OR: Innovative Machinery Packaging and Converting, Inc, 2014.
6. Wilkey A, Gregory M, Byfield D, McCarthy PW. A comparison between chiropractic management and pain clinic management for chronic low-back pain in a national health service outpatient clinic. J Altern Complement Med, 2008; 14:465-73.
7. Santilli V, Beghi E, Finucci S. Chiropractic manipulation in the treatment of acute back pain and sciatica with disc protrusion: a randomized double-blind clinical trial of active and simulated spinal manipulations. Spine J, 2006;6:131-7.
8. Hoiriis KT, Pfleger B, McDuffie FC, et al. A randomized clinical trial comparing chiropractic adjustments to muscle relaxants for subacute low back pain. J Manipulative Physiol Ther 2004; 27:388-98.
9. Giles LG, Muller R. Chronic spinal pain: a randomized clinical trial comparing medication, acupuncture and spinal manipulation. Spine 2003; 28:1490-502.
10. Giles LG, Muller R. Chronic spinal pain syndromes: a clinical pilot trial comparing acupuncture, a nonsteroidal

anti-inflammatory drug and spinal manipulation. J Manipulatives Physiol Ther 1999; 22:376-81.
11. Al Bedah A, Amigoni M, Caizzi, et al. Directrizes da OMS sobre a formacao basica e a seguranca em Quiropraxia. Genebra: Organizacao Mundial de Saude/Feevale; 2006.
12. Rubinstein SM, Leboeuf-Yde C, Koekkoek TE, et al. 2008. Predictors of adverse events following chiropractic care for patients with neck pain. J Manipulative Physio Ther 2008; 31:94-103.
13. Rubinstein SM, Peerdeman SM, Van Tulder MW, et al. A systematic review of the risk factors for cervical artery dissection. Stroke 2005; 36:1575-80.
14. Haldeman S, Kohlbeck FJ, McGregor M. Stroke, cerebral artery dissection, and cervical spine manipulation therapy. J neurol 2002; 249:1098-104.
15. Carstensen M. Letters to the editor. J Manupulative Physiol Ther 2004;27:69-70.
16. Rothwell PM, Norris JW. Cerebrovascular complications of therapeutic neck manipulation the need for reliable data on risks and risks factors. J Neurol 2002;249:1105-6.
17. Colloca CJ, Keller TS. 2001. Electromyographic reflex responses to mechanical force, manually assisted spinal manipulative therapy. Spine 2001; 26:1117-24.
18. Hillerman B, Gomes AN, Korporaal C, et al. A pilot study comparing the effects of spinal manipulative therapy with those of extra-spinal manipulative therapy on quadriceps muscle strength. J Manipulative Physio Ther 2006; 29:145-9.
19. Dishman JD, Burke J. Spinal reflex excitability changes after cervical and lumbar spinal manipulation: a comparative study. Spine J 2003; 3:204-12.
20. Dean LS, Ronald HC. Muscular strength and chiropractic: Theoretical mechanisms and health implications. J.Vertebral Subluxation Res. 1999-2000;3(4):1-13.
21. Pollard H, Ward G. Strength change of quadriceps femoris following a single manipulation of the L3/4 vertebral motion segment: A Preliminary Investigation. JNMS 1996;4(4):137-144.
22. Zasadny HR, Tasharski CC, Heinze WJ. Electromyographic analysis following chiropractic manipulation of the cervical spine: a model to study manipulation induced peripheral muscle changes. J Manipulative Physio Ther 1981;4(2):61-63.
23. Schwartzbauer J, Kolber K, et al. Athletic performance and physiological measures in baseball players following upper cervical chiropractic care: a pilot study. Journal of Vertebral Subluxation Research 1997;(4):33-39.
24. Bonci AS, Ratliff RC. Strength modulation of the biceps brachii muscles immediately following a single manipulation of the C4/5 intervertebral motor unit in healthy subjects; preliminary report. Am J Chiropractic Med 1990; 3(1):14-18.
25. Howitt-Wilson MB. Grip strength and chiropractic adjustment. Anglo-European College of Chiropractic, 1975.
26. Unger, JF. The effects of a pelvic blocking procedure upon muscle strength: a pilot study. Chiropractic Technique 1998;10(4)150-155.
27. Haas M, Peterson D, Hoyer D, Ross G. Muscle testing response to provocative vertebral challenge and spinal manipulation: a randomized controlled trial of construct validity. J Manipulative Physiol Ther 1994;17(3):141-148.
28. Suter E, McMorland G, Herzog W, Bray R. Decrease in quadriceps inhibition after sacroiliac joint manipulation in patients with anterior knee pain. J Manipulative Physiol Ther 1999;22(3):149-153.
29. Shambaugh, P. Changes in electrical activity in muscles resulting from chiropractic adjustment: a pilot study. J Manip Physiol Therapeutics 1987;10(6):300-304.
30. Grice, AS. Muscle tonus change following chiropractic manipulation. Journal of the Canadian Chiropractic Association. 1974;12:29-31.
31. Marcelo BB, Bruno BA. Effect of Cervical Spine Manipulative Therapy on Judo Athletes' Grip Strength. J Manipulative Physio Ther 2012;35:38-44.
32. Haavik H, Niazi NK, Jochumsen M, Sherwin D, Flavel S, Turker KS. Impact of Spinal Manipulation on Cortical Drive to Upper and Lower Limb Muscles. Brain Sci 2017,7,2;doi:10.3390/brainsci7010002.
33. Herzog W, Conway JD, Zhang YT, Gal J, Guimaraes AC. Reflex responses associated with manipulative treatments on the thoracic spine: A pilot study. J Manip Physio Ther 1995;18:233-236.
34. Palmer DD. The science, art, and philosophy of chiropractic. Portland OR: Portland Printing House. 1910.
35. Ghez C. The control of movement, In: Schwartz JH, Kandel ER, eds. Principles of neural science. New York, NY: Elsevier, 1991.
36. Darby SA, Daley DL. Neuroanatomy of the spinal cord. In: Cramer GD, Darby SA, eds. Basic and clinical anatomy of the spine, spinal cord and ans. St. Louis, MO: Mosby, 1995.
37. Halderman S, Drum D. The compression subluxation. J Clinical Chiropractic 1971;7:10-21.
38. Rydevik BL. The effects of compression on the physiology of nerve roots. J Manipulative Physiol Ther 1992;15(1):62.
39. Matsui T, Takahashi K, Moriya M, et al. Qualitative analysis of edema in the dorsal nerve roots induced by acute mechanical compression. Spine 1998;23(18):1931-1936.
40. Swenson RS. The neurophysiology of chiropractic. Washington DC: Chiropractic Centennial Foundation Conference, 1995.
41. Olmarker K, Rydevik B, Holm S. Edema formation in spinal nerve roots induced by experimental, graded compression: an experimental study on the pig cauda equina with special reference to differences in effects between rapid and slow onset of compression. Spine 1989a;14:579-63.
42. Sunderland S. Nerves and nerve injuries, 2nd edition. Edinburgh, England: Churchill-Livingstone, 1978.
43. Patterson MM. The spinal cord: Participant in disorder. Spinal Manipulation 1993;9(3):2-11.

44. Colloca CJ, Keller TS, Gunzburg R. Biomechanical and neurophysiological responses to spinal manipulation in patients with lumbar radiculopathy. J Manipulative Physiol Ther 2004;27:1-15.
45. Taylor, HH., Murphy B. Altered sensorimotor integration with cervical spine manipulation. J Manip. Physio. The. 2008;31,115-126
46. Netter FH. Atlas de anatomia humana, 2nd ed. Artmed: Porto Alegre; 2000.
47. Fess EE. Grip strength. In Clinical assessment recommendations. 2nd edition. Edited by: Casanova JS, Chicago: American Society of Hand Therapists. 1992: 41-45.

Appendix 1



Appendix 2

- APPENDIX: PHYSICAL STATUS ACCORDING TO THE TEST RESULTGIVEN BY THE DYNAMOMETER (UNIT: LBS)

AGE	MALE			FEMALE		
	Weak	Normal	Strong	Weak	Normal	Strong
10-11	<27.8	27.8-49.4	>49.4	<26.0	26.0-47.6	>47.6
12-13	<42.8	42.8-68.8	>68.8	<32.2	32.2-53.8	>53.8
14-15	<62.8	62.8-97.7	>97.7	<34.2	34.2-60.2	>60.2
16-17	<71.9	71.9-115.5	>115.5	<37.9	37.9-63.9	>63.9
18-19	<78.7	78.7-122.4	>122.4	<42.3	42.3-68.3	>68.3
20-24	<81.1	81.1-124.8	>124.8	<47.4	47.4-77.8	>77.8
25-29	<83.1	83.1-126.8	>126.8	<56.4	56.4-91.3	>91.3
30-34	<79.4	79.4-123.0	>123.0	<47.4	47.4-77.8	>77.8
35-39	<78.9	78.9-122.6	>122.6	<44.8	44.8-75.2	>75.2
40-44	<78.3	78.3-121.9	>121.9	<41.7	41.7-72.1	>72.1
45-49	<76.5	76.5-120.2	>120.2	<41.0	41.0-71.4	>71.4
50-54	<72.5	72.5-111.8	>111.8	<39.9	39.9-70.3	>70.3
55-59	<67.7	67.7-106.9	>106.9	<39.0	39.0-69.4	>69.4
60-64	<66.6	66.6-105.8	>105.8	<37.9	37.9-68.3	>68.3
65-69	<62.2	62.2-97.0	>97.0	<34.0	34.0-60.0	>60.0
70-99	<47.0	47.0-77.4	>77.4	<32.4	32.4-54.0	>54.0

Source: CAMRY Electronic Hand Dynamometer Instruction Manual

Appendix 3: Results of grip strength of 100 patients pre and post chiropractic adjustment

			Dynamometer reading (lbs)						
			Before	After	% increase	Before	After	% increase	Cervical/Thoracic
No	Sex	Age	R	R		L	L		segments adjusted
1	F	19	101.4	104.3	3%	93.0	94.6	2%	C1R, C5R, T5inf
2	F	29	48.7	51.4	5%	47.2	48.3	2%	C1R, C5R
3	M	39	64.4	67.9	5%	55.6	57.8	4%	C1R, C5post, T5 post
4	F	46	69.2	71.7	4%	65.3	65.3	0%	C1R, C5R, C5 post
5	F	50	54.2	54.2	0%	45.9	47.0	2%	C1R, C5 post
6	F	21	74.1	80.7	9%	68.8	74.7	9%	C1R, C5R, T3L
7	F	27	53.8	54.9	2%	50.7	53.8	6%	C1R, C5R, C5 post
8	F	29	62.6	67.2	7%	71.9	72.8	1%	C1L, C5L
9	F	36	35.5	37.5	6%	37.0	39.7	7%	C1R, C5R
10	M	37	52.9	54.5	3%	50.9	54.0	6%	C1R, C5R, C5 post
11	M	37	56.7	59.1	4%	48.3	51.1	6%	C1R, C5L, C5 post
12	F	38	96.3	101.0	5%	97.2	104.3	7%	C1R, C5post, C5R
13	F	39	56.7	61.5	9%	46.1	47.6	3%	C1R, C5R, C5 post
14	M	41	48.3	52.9	10%	49.2	49.2	0%	C1R, C5post, C7 post
15	F	41	90.4	99.6	10%	81.8	80.7	-1%	C1R, C5R, C5 post
16	F	42	93.9	101.9	8%	77.6	85.3	10%	C1R, C5L
17	M	43	76.9	81.8	6%	70.3	76.3	8%	C1R, C5R, C5 post
18	F	44	49.2	53.8	9%	47.4	49.4	4%	C1R, C5R, T3 inf, T7 inf
19	F	46	43.2	47.6	10%	37.3	41.0	10%	C1R, C5R, C5 post
20	F	49	66.6	68.1	2%	60.0	63.3	6%	C1R, C5 post
21	F	49	56.7	61.7	9%	54.0	59.5	10%	C1R,5R
22	M	50	45.9	48.7	6%	39.7	42.1	6%	C1R, C5R, C5 post
23	F	52	53.6	55.8	4%	56.2	60.0	7%	C1R, C5R, C5 post
24	M	57	30.2	33.1	9%	32.2	35.3	10%	C1R, C5R, C5 post
25	F	15	65.7	71.9	9%	55.3	61.3	11%	C1R, C5R, C5 post
26	F	25	46.1	52.2	13%	58.4	64.8	11%	C1R, C5R
27	F	26	61.5	63.5	3%	44.8	49.6	11%	C1R, C5R, C5 post
28	F	29	80.7	91.3	13%	79.1	81.4	3%	C1R, C5L, C5 post
29	F	32	59.1	59.3	0%	44.3	49.2	11%	C1R, C5R, C7R
30	M	36	107.1	107.1	0%	74.7	85.3	14%	C1R, C5L, C7L
31	F	36	95.7	99.6	4%	74.5	86.0	15%	C1L, C5L
32	F	37	53.1	52.7	-1%	48.7	56.2	15%	C1R, C5L, T4L
33	F	38	37.3	38.4	3%	36.8	41.0	11%	C1R, C5post
34	F	38	26.5	30.2	14%	30.0	32.6	9%	C1R, C5R, C5 post
35	F	39	62.2	64.2	3%	50.5	57.8	14%	C1R, C5R, C5 post
36	M	39	64.4	69.2	8%	60.2	68.3	14%	C1R, C5R

37	M	39	40.8	46.7	15%	45.2	47.4	5%	C1R, C5R, C5 post
38	M	40	56.0	56.9	2%	57.3	64.4	12%	C1R, c5R, T5 inf
39	F	43	38.1	38.8	2%	43.2	48.9	13%	C1R, C5 post
40	F	43	32.0	33.1	3%	28.4	32.0	12%	C1R, C5R, T5L
41	F	44	82.5	92.8	13%	73.9	76.9	4%	C1R, C5R, C5 post
42	F	44	58.2	66.6	14%	63.5	65.7	3%	C1R, C5R
43	M	46	48.9	55.6	14%	48.5	55.6	15%	C1R, C5 post, C5R, C2L
44	F	47	53.4	59.7	12%	51.8	53.4	3%	C1R, C5R, C5 post
45	F	49	82.2	92.2	12%	59.7	63.3	6%	C1L, C5L, C7L
46	M	49	47.6	53.6	13%	45.2	45.4	0%	C1R, C5L, C7R, T3L
47	F	50	43.2	48.3	12%	47.4	48.1	1%	C1R, C5R, C5 post
48	M	50	50.0	56.0	12%	50.0	49.4	-1%	C1R,5R
49	F	55	42.1	41.7	-1%	42.3	48.5	15%	C1R, C5R, T1 sup, T3 inf
50	M	56	49.8	54.5	9%	48.7	54.0	11%	C1R, C5 post
51	M	56	32.6	36.6	12%	35.5	36.2	2%	C1R, C5post
52	F	65	43.2	47.8	11%	37.9	37.9	0%	C1R, C5post
53	F	67	40.3	45.4	13%	37.7	41.2	9%	C1R, C5R
54	F	69	57.8	65.3	13%	75.4	81.8	8%	C1R, C5R, C5 post
55	F	71	38.6	43.0	11%	37.3	36.4	-2%	C1L, C5L, C5 post
56	M	32	54.7	55.3	1%	42.1	49.4	17%	C1R, C5 post, T5R
57	F	32	103.4	123.2	19%	102.5	102.5	0%	C1R, C5R
58	F	35	63.9	63.9	0%	59.3	69.4	17%	C1R, C5R, C5 post
59	F	39	38.4	44.3	16%	47.6	47.8	0%	C1R, C5R, C5 post
60	M	39	37.9	44.1	16%	34.6	41.7	20%	C1R, C5R, C5 post
61	F	40	50.7	58.9	16%	50.5	51.6	2%	C1R, C5R, C5 post
62	F	41	90.2	101.0	12%	75.2	90.4	20%	C1R, C5L, C5 post
63	F	45	54.5	63.7	17%	54.5	58.2	7%	C1R, C5L, T5 inf
64	M	46	58.4	61.3	5%	54.0	63.1	17%	C1R, C5L, C5 post
65	F	47	77.4	82.9	7%	62.2	72.3	16%	C1R, C5R, C7L, C5 post
66	F	51	41.4	44.8	8%	43.2	50.3	16%	C1R, C5R, C5 post
67	M	56	38.4	40.3	5%	29.8	34.8	17%	C1R, C5R, C5 post
68	F	71	38.1	42.5	12%	37.9	45.6	20%	C1R, C2 post, C5R, T5 inf
69	F	13	37.3	38.1	2%	26.0	32.2	24%	C1R, C5R
70	F	28	65.0	72.5	12%	62.2	73.9	19%	C1R, C5R, C5 post
71	F	29	63.7	77.2	21%	66.8	72.1	8%	C1R, C5R, C5 post
72	M	33	41.2	40.6	-2%	38.4	47.6	24%	C1R, C5R, T3 inf
73	F	33	91.9	111.1	21%	95.9	114.6	20%	C1R, C5R, C5 post, T5inf
74	M	34	87.5	93.7	7%	72.3	88.8	23%	C1R, C5, C5R, T3L
75	M	34	76.5	93.5	22%	84.7	91.9	9%	C1R, C5R

76	M	36	47.4	58.6	24%	55.3	60.2	9%	C1R, C5L, C5 post
77	F	37	67.9	84.2	24%	68.8	73.6	7%	C1R, C5post
78	M	43	59.7	59.7	0%	51.1	63.1	23%	C1R, C5R, C5 post, T5inf
79	F	45	77.6	96.1	24%	68.3	77.8	14%	C1R, C5R
80	M	47	33.7	42.1	25%	37.3	40.3	8%	C1R, C5R
81	M	55	43.0	47.2	10%	37.0	46.1	24%	C1R, C5R
82	F	57	37.3	46.5	25%	42.3	50.0	18%	C1R, C5R, C5 post
83	F	66	34.2	41.7	22%	40.6	41.7	3%	C1L, C5L, C5 post
84	M	41	62.2	79.8	28%	61.1	67.5	10%	C1R, C2 post, C5R, C6L
85	F	41	41.4	53.6	29%	31.3	40.1	28%	C1R, C5R
86	F	44	31.7	39.7	25%	29.1	37.9	30%	C1R, C5L, T3L
87	F	30	38.8	43.9	13%	38.1	50.3	32%	C1R, C5R, C5 post
88	F	36	56.2	75.2	34%	62.6	67.5	8%	C1R, C5post
89	F	38	30.4	40.3	33%	30.0	33.7	13%	C1L, C5L
90	M	42	41.2	49.8	21%	37.5	49.6	32%	C1R, C5post
91	M	46	44.3	60.0	35%	46.3	61.9	34%	C1R, C5R, C5 post
92	M	46	37.3	50.9	37%	52.0	54.5	5%	C1R, C5R, C7L
93	F	49	60.8	81.1	33%	64.6	68.8	6%	C1R, C5R, C5 post
94	F	33	47.8	68.8	44%	45.6	55.6	22%	C1R, C5R, C5 post
95	M	36	34.0	49.2	45%	35.5	46.1	30%	C1R, C5R, T5R
96	F	37	36.4	53.1	46%	49.8	50.3	1%	C1R, C5R
97	F	38	25.6	47.4	85%	30.2	38.4	27%	C1R, C5R
98	F	39	60.2	78.7	31%	57.5	84.4	47%	C1R, C5R
99	F	49	39.7	41.4	4%	31.1	47.6	53%	C1R, C5L
100	F	57	36.4	55.1	52%	43.2	49.2	14%	C1R, C5R, T5R