The Effect of Kinesio Taping on Handgrip and Active Range of Motion of Hand in Children with Cerebral Palsy

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Abstract

Objective

Kinesio taping is a relatively new technique, which uses in rehabilitation of neurologic diseases. The aim of this study was to investigate the effects of Kinesio taping on hand grip and active range of motion of hand in children with cerebral palsy (CP).

Materials and Methods

In this experimental study with pre-test and three post-tests, 32 children with CP randomly were placed in experimental (n=17) and control group (n=15). Kinesio taping was applied on dorsum of forearm and hand. Evaluation was performed initially, two days after taping and two days after tape removal. Goniometer was used to evaluate active range of motion of wrist extension. In addition, vigorimeter was used to evaluate grip strength.

Results

In pre-test, there was no difference between groups but in post-tests; initially after application of taping with P<0.05, two days after application of taping with P<0.05 and follow-up (two days after removed taping) with P<0.05 were significant differences between trial and control group.

Conclusion

Kinesio taping in neurorehabilitation of children with CP can be a useful option to promote power or grip strength and active range of motion of wrist and thumb.

Keywords: Cerebral palsy; Kinesio taping; Grip strength; Range of motion

Introduction

Cerebral palsy (CP) resulting from damage to non-mature brain that occurring before, during, or after birth and causes permanent disorder of movement and posture (1). The classification of CP is topographically (hemiplegia, diplegia, and quadriplegia) or based on motor function as spastic and non-spastic (including athetoid, ataxic and Dystonic). CP prevalence per 1000 live births is about 2 to 2.5 (1, 2). CP leads to spasticity, intensify reflexes, co-contraction, weakness or loss of movement control, muscle weakness, defects in sensory integration, lack of muscle coordination, balance and postural control limitation (3, 4).
Neurological lesion in CP is non-progressive, but musculoskeletal lesions is progressive (5). Secondary musculoskeletal effects like muscle weakness or muscle imbalance, pain, restriction of active and passive range of motion and poor functional use of limbs can be seen (6). Muscle deficiency in CP can lead to limitations in range of motion, accurate timing, power and hand manipulation skills (7). One of the main challenges in children with CP is dysfunctional of hand which interference in use of hands and limits the child’s ability in activities of daily living, communication and social contacts (8, 9). Neurologic deficits such as spasticity, co-contractions, muscle weakness and limited range of motion have negative effects on dexterity and functional use of hands (10). The most common upper extremity posture in children with CP include internal rotation of the shoulder, elbow flexion, internal rotation of the forearm, wrist flexion, fingers flexion, and thumb in palm(11). Wrist position can affect the grip and hands strength so that in wrist flexion (common hand problem in cerebral palsy) reduction in hand strength is significant.

The American Society of Hand Therapists noted that in 0 to 35 degrees of wrist extension, strength is greater than other positions (12-14). Grip, pinch, and dexterity are the main functions of hands and support the daily activities; if these performances are disrupted due to neuromuscular disorders such as CP, child’s performance is reduced in activities such as homework, self-care and the interact with peers (7). Hand function is necessary to interact with the environment and discovering the world. Hands provide performance through contact with people and objects; and are a tool used many times for play, work and perform activities of daily living, (15).

International classification of functioning system (ICF) explains that CP affects the body structures (e.g. limbs), body function (e.g. intellectual function), activities (e.g. standing/walking) and participation (e.g. sport). “Psychomotor disorders in children with CP results in limitation in use of the limbs, more paralysis, difficulty in performing activities of daily living (ADL), more dependence and ultimately lower quality of life(16, 17). Many therapeutic methods are used to treating the sign of CP including botulinum toxin injection(18), orthopedic surgery, constraint-induced movement therapy (CIMT), medications (19), occupational and physical therapy (20-23). Occupational and physical therapy use various dynamic approaches including Bobath (24), sensory integration (SI), proprioceptive neuromuscular facilitation (PNF) (25) and the Brunnstrom techniques (1, 24) to adjust the muscle tone, reduce contractures, improve the range of motion (ROM), improve the sensory and cognitive problems, improve muscles strength hand fostering children’s independence level in ADL (26-28).

A new method recently used for reducing problems of hand and upper limb in children with cerebral palsy is Kinesio taping (KT). Although, KT initially was used in sport or orthopedic fields and then approved as an adjunctive treatment in other functional impairments such as neurological disorders (6, 29-31). KT is latex-free with 100% cotton fibers that has no pharmaceutical effect (32), designed to mimic the elasticity properties of the muscle, skin, and fascia (31). Skin, lymphatic system, circulatory system, fascia, muscle, and joint can influence by KT (33). KT can cause enhancing proprioception (34), diminishing pain and edema, reducing muscle spasms, and strengthening the muscles (35, 36). KT can effect on muscle performance and support joint by improving proprioception, normalizing muscle tone, correct the inappropriate positions and stimulate skin receptors (4, 37-39). KT is used for strengthening weak muscles and improves joint stability and alignment to influence positively use of hand in task(6, 37, 38).

Although, the use KT with pediatric populations is not well studied, but studies show KT when applied in adjunct with traditional therapy interventions such as stretching, neurodevelopmental therapy, practicing functional tasks can further improve recovery in children with CP (40). This study aimed to determine the effect of KT on handgrip and active range of motion (AROM) on hand in children with CP.

Materials & Methods

Subjects
Based on inclusion criteria, thirty-two subjects with CP were randomly selected from the Occupational Therapy Clinic in Tehran, Iran. Subjects were divided into two equal groups (trial and control group). They were between 4 and 14 yr of age. Inclusion criteria including:
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Procedure

In this experimental study with pre-test and 3 post-tests (initially and 2 d after taping, 2 d after tape removal), 32 children who had the inclusion criteria, randomly were placed in experimental and control group (17 in experimental group and 15 in control group). This study was performed in Tehran, Iran from 2015 to 2016. In the beginning of the study and after taking pre-test, KT applied as follows: in intervention group, from origin of extensor digitrumcombines muscle to metacarpophalangeal (MP) joint of fingers; and from origin of extensor and abductor policieslongs to MP joint of thumb. Tension of tape in muscular zone was 30% and in joint area was 75% (Figure1). Purpose of KT application in these manners was to improve the function of muscles and joint re-alignment (correction the wrist flexion and thumb in palm deformities). In control group, KT was used as placebo in similar method with another group but with no tension and as sham. Evaluations were taken immediately and two days after application of taping and then KT was removed from the hand. Two days after KT removal, testing was done again.

1- children with cerebral palsy, confirmed by pediatric neurologist, 2- Hand and/or wrist spasticity less than three according to Modified Ashworth Scale (MAS), 3- have thumb in palm and wrist flexion deformities without upper extremity passive range of motion limitation, 4- Sufficient cognitive level to follow the directions of the testing protocols and tape acceptance. Exclusion criterion was allergy to taping.

This study was approved by the human research Ethics Committees of the Baqiyatallah University of Medical Sciences, Tehran, Iran. An informed consent was obtained from all parents of subjects, including agreement of the children to participate as volunteers.

For evaluation of grip strength and AROM, we used Vigorimeter (A common tool in hand therapy, which measures the grip strength by pressing the rubber bulb). It has three rubber bulbs in different sizes that measure power in terms of kilopascal (kPa) (41, 42). We used these means to assess the power grip (a grasp with opposed thumb and flexed fingers (43) by pressing the large bulb with all fingers. Testing performs in standard posture suggested by the American Society of Hand Therapists for grip strength tests: sitting on a chair with no armrest, shoulder adducting and rotating to the neutral position, 90° elbow flexion, and forearm and the wrist joint in the neutral position (44). Children do it three times and finally, the average of these three attempts was recorded as the final number.

Goniometer: was used to evaluate AROM of wrist extension (45). To measure the range of motion, children sat on a chair with a standard height and standard desk in front. Then, for wrist extension, fisted hand with middle position of the forearm were placed on the table and asked child to fully extend him/her wrist and hold in the end of range. Axis of goniometer placed above the radial styloid process in the snuffbox, stationary arm placed parallel to radius bone and moveable arm parallel to metacarpal bone of index finger and then the number to be recorded (46). To examine thumb extension for measuring the thumb extension, palm of hand was placed on the table (full forearm pronation with the full adduction of all fingers). Then asked child’s too far out the thumb from other fingers, fully (47-49).

Statistical analysis

The normal distribution of variables was assessed with the Kolmogorov-Smirnov test. An independent sample t-test was used for comparison of age and gender between the two groups. Analysis of Variance (ANOVA) was used to identify between groups differences. Statistical analysis was performed with SPSS ver. 17.0 (Chicago, IL, USA), with P-values less than 0.05 as statistically significant.

Results

Only two subjects in trial group did not succeed to complete the protocol due to delay in referral for follow
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up assessment. Thirty children with CP participated in this study; 15 subjects in trial group (age range 5-14 yr, mean age 8.33 yr) and 15 subjects in control group (age range 4-13 yr, mean age 7.4 yr). Comparison of age and gender between two groups were done with independent sample t-test. There were no significant differences between groups with P=0.31 and P=0.072, respectively. Table1 shows some descriptive information of groups.

Descriptive and analytic statistics for grip strength and AROM (wrist extension and thumb extension/abduction) of two groups (Trial and Control) in pre-test, post-tests, and follow-up situations are shown in Table 2 and 3. In all variable, there was no difference between groups but in post-tests (initially, 2 d) and follow-up (2 d after removed taping) were significantly differences (Table 2 and 3).

Table 1. Descriptive statics in the trial and control groups

|             | Mean age | Gender | Affected hand | CP type |
|-------------|----------|--------|---------------|---------|
|             |          |        |               |         |
|             |          | M      | F             | R       | L       | Hemiplegia | Diplegia | Quadriplegia |
| Trial group | 8.33     | 5      | 10            | 11      | 4       | 5          | 3        | 7           |
| Control group | 7.40    | 10     | 5             | 11      | 4       | 6          | 1        | 8           |

M; male, F; female, R; right, L; left

Table 2. Comparison of AROM between groups

| Wrist extension          | Thumb extension | Thumb Abduction |
|--------------------------|-----------------|-----------------|
|                          | Mean±SD         | P-value         | Mean±SD         | P-value         | Mean±SD         | P-value         |
|                          | Trial           | Control         | Trial           | Control         | Trial           | Control         |
|                          | P0              | P1              | P2              | P3              | P0              | P1              | P2              | P3              |
| 28.87±7.51               | 23.07±11.7      | 0.1             | 26.53±10.56     | 20.93±11.68     | 0.18            | 28.33±11.83     | 21.07±11.62     | 0.1             |
| 37.67±7.41               | 25±11.13        | 0.001           | 36.87±8.32      | 22.6±10.56      | 0.000           | 34.8±11.37      | 21.73±10.51     | 0.003           |
| 37.47±6.08               | 24.27±10.91     | 0.000           | 37±8.12         | 22.87±10.27     | 0.000           | 36.73±8.16      | 21.87±10.53     | 0.000           |
| 34.07±6.99               | 23.2±11.16      | 0.003           | 32.87±10.5      | 23.2±10.35      | 0.01            | 32.67±11.31     | 22.47±10.67     | 0.01            |

SD; standard deviation, P0; pre-test, P1; post-test 1, P2; post-test2, P3; post-test 3

Table 3. Comparison of Grip strength between two groups

| Mean±SD | P0        | P1        | P2        | P3        |
|---------|-----------|-----------|-----------|-----------|
| Trial   | 12.07±7.72| 16.07±9.15| 18.47±10.04| 14.4±8.19 |
| Control | 8.8±5.82  | 8.8±5.77  | 8.4±5.66  | 8.47±5.69 |
| P-value | 0.201     | 0.015     | 0.002     | 0.029     |

SD; standard deviation, P0; pre-test, P1; post-test 1, P2; post-test2, P3; post-test 3
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Discussion
The ROM is one of the essential parts of the body function and structure essentially in hand (50). Secondary contracture and joints deformity can reduce ROM. Flexor carpi ulnaris in children with cerebral is twice more rigid than healthy children that cause stiffness, movement disorder, and hand mal-posture. Hand flexion in CP is dominant which makes problem for AROM of wrist extension (51). Grip strength is the force generated by the thumb and other fingers required in different functional activities of daily living (44). An objective index assesses functional integrity of the upper extremity (14).
CP makes muscle weakness (or muscle imbalance) and restriction in active ROM, that could be a barrier to the functional use of hands (6, 7, 9, 14). In children with CP, wrist flexion reduces grip strength about 60%. Hand orthosis can significantly correct this deformity and promote wrist stability, but despite these benefits are unable to restore and enhance grip strength. Many children because of the appearance of device are not willing to accept hand orthosis (52).
In this study, we used KT to correct the wrist flexion deformity in children with CP. When the tape is applied properly, the flexibility of KT not only does not restrict ROM of soft tissue but also supports weak muscles and provides joint mobility (53).
We applied KT on dorsum aspect of wrist and forearm to support activation of extensor muscles of wrist and thumb and placed wrist in functional position. Our result showed that AROM in all testing joint (wrist extension, thumb extension/abduction) and in all post-tests has been affected by KT; and Child’s ability significantly improved in active thumb extension/abduction and wrist extension. We had two post-tests with KT and one without KT (follow-up). Post-test was significantly different; therefore, KT effects remained after it was removed (post-test 3).
The result of our study in grip strength showed that similar to AROM, KT significantly improves handgrip of children with CP. Imbalance between wrist flexor muscles (spastic) and wrist extensor muscles (weak) in children with CP leading to abnormal posture of hand that affects the ability to grasp (54) and wrist position can affect the grip and hands strength (12-14). KT can correct the abnormal posture of hand, put it in functional position via improving range of motion and stimulation wrist extensors muscles, and inhibit wrist flexors muscles (51). The purpose of the application of KT in rehabilitation of children with CP are muscular facilitation or inhabitation, the re-alignment the joints, improve proprioception and postural support (55, 56). Use of this technique provides a tactile-proprioceptive stimulation that facilitates muscle performance.
KT stimulates the skin mechanoreceptors through pressure and stretching that this stimulation may be due to physiological changes such as enough firing in muscle recruitment patterns. Increased use of muscle motor units is the result of proprioceptive stimulation that improves motor performance (4, 57). Moreover, dysfunctional muscle control (defect in neural control) in children with CP leads to tenodesis phenomena in extensor muscles (antagonist). Stability and control of wrist and proximal joints be affected by these phenomena, hence children use their fingers for mass grasp. Thus, if joint control of wrist and forearm is provided, functional control at thumb and fingers will become better, which may facilitate improved functional hand skills and grip strength (58).
The effect of KT on handgrip strength (KT was used on the anterior surface of the forearm) of 75 healthy women aged 18-30 yr old. The results showed a significant increase in grip strength in 30 min, 24 h and 48 h after the KT application (59).
In another study, KT was applied on the wrist extensor muscles of 15 children with CP to measure the wrist extension AROM. The results were in accordance with our results and AROM of wrist extension (with and without functional ball grasping) were significantly improved (P<0.05) (51).
Immediate effect of correction KT was assessed on hand span in children with CP (60). In that study, KT was applied to help wrist extension. Goniometer was used to measure the wrist extension and a ruler to measure hand span (from index finger to thumb, with hand wide open) (60). All results of these studies were similar to our results and the mean of both variables was significantly increased (51, 59, 60).
Although in a study, the opposite results were reported, approximately. After using KT on extensor surface of forearm, the AROM of wrist extension was increased.
but statistically were not significant (61). The effect of KT was investigated on maximum grip strength in 22 healthy athletes’ student. Evaluation was performed in three conditions (without KT, placebo KT, KT). In this study, no significant differences between three conditions were seen (62).

In Iran, the effects of KT on grip strength in three areas were measured. Participants were healthy students and KT application was done on the extensor, flexors and extensors/flexors to determine the best mode. In all three modes, KT could increase grip strength, but application in extension provides more grip strength than the other two modes (flexors, extensors/flexors) (63). When KT apply without tension (as placebo), not provide the necessary stimulation; and this stimulate is not comparable to KT with proper tension (62).

We used KT without tension in control group and there was no significant difference in results from these group and could not interfere with the result, so our results were in the same direction; KT without tension (as sham) is not effective.

In conclusion, KT in neurorehabilitation of children with CP can be a useful option to promote power or grip strength and AROM of wrist and thumb. Therefore, KT provides easy and effective way to improve function in children with CP and neuromotor impairments.

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Author’s contribution
Alireza Shamsoddini, Zabih Allah Rasti and Sina Labaf: Study concept and design. Alireza Shamsoddini and Zabih Allah Rasti: Acquisition of data. Alireza Shamsoddini, Zabih Allah Rasti: Analysis and interpretation of data. Alireza Shamsoddini, Zabih Allah Rasti: Drafting of the manuscript. Hamid Dalvand: Editing of the manuscript. All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of Interest
The authors declare that there is no conflict of interest.

References
1. Shamsoddini A, Amirsalari S, Hollisaz M-T, Rahimnia A, Khatibi-Aghda A. Management of Spasticity in Children with Cerebral Palsy. Iran J Pediatr 2014;24(4):345-51.
2. Shamsoddini A. Comparison between the effect of neurodevelopmental treatment and sensory integration therapy on gross motor function in children with cerebral palsy. Iran J Child Neurol 2010;4(1):31-8.
3. Gage J. Analysis in cerebral palsy. London: Clinics in developmental medicine; 1991.P.213-24.
4. da Costa CS, Rodrigues FS, Leal FM, Rocha NA. Pilot study: Investigating the effects of Kinesio Taping(R) on functional activities in children with cerebral palsy. Dev Neurorehabil 2013;16(2):121-8.
5. Amirsalari S, Dalvand H, Dehghan L, Feizy A, Hosseini SA, Shamsoddini A. The efficacy of botulinum toxin type A injection in the hamstring and calf muscles with and without serial foot casting in gait improvement in children with cerebral palsy (in person). Tehran Univ Med J 2011;69(8):509-17.
6. Yasukawa A, Patel P, Sisung C. Pilot study: investigating the effects of Kinesio Taping in an acute pediatric rehabilitation setting. Am J Occup Ther 2006;60(1):104-10.
7. Burtner PA, Poole JL, Torres T, Medora AM, Abeyta R, Keene J, et al. Effect of wrist hand splints on grip, pinch, manual dexterity, and muscle activation in children with spastic hemiplegia: a preliminary study. J Hand Ther 2008;21(1):36-42; quiz 3.
8. Sadeghi Moghadam R, Lavjadi L. effect of wrist kinesio taping on hand function in children with diplegic spastic cerebral palsy (in person). J Novin Rehabil 1391;6(1):26-31.
9. Pfeifer LI, Santos TR, Silva DB, Panuncio Pinto MP, Caldas CA, Santos JL. Hand function in the play behavior of children with cerebral palsy. Scand J Occup Ther 2014;21(4):241-50.
10. Beckung E, Hagberg G. Neuroimpairments, activity limitations, and participation restrictions in children with cerebral palsy. Dev Med Child Neurol 2002;44(5):309-16.
11. Keklicek H, Uygur F, Yakut Y. Effects of taping the hand in children with cerebral palsy. J Hand Ther
12. Bhardwaj P, Nayak SS, Kiswar AM, Sabapathy SR. Effect of static wrist position on grip strength. Indian J Plast Surg 2011;44(1):55-8.
13. O’Driscoll SW, Horii E, Ness R, Cahalan TD, Richards RR, An KN. The relationship between wrist position, grasp size, and grip strength. J Hand Surg Am 1992;17(1):169-77.
14. Parvatikar V, Mukkannavar P. Comparative study of grip strength in different positions of shoulder and elbow with wrist in neutral and extension positions. J Exe Sci Phys 2009;5(2):67-75.
15. case-Smith J, O’Brien J. Occupational therapy for children. Maryland: Mosby Elsevier; 2010.p.155-175.
16. Kalantari M, Hasani M, Hasani K, Taghizade G. Evaluation of Hand Stereognosis Level in 3-6 years Old Children with Spastic Hemiplegia and Diplegia (in persion). J Rehabil 2013;14(2):93-101.
17. Steultjens EM, Dekker J, Bouter LM, van de Nes JC, Cup EH, van den Ende CH. Occupational therapy for stroke patients: a systematic review. Stroke 2003;34(3):676-87.
18. Löwing K, Thews K, Haglund-Åkerlind Y, Gutierrez-Farewik EM. Effects of Botulinum Toxin-A and Goal-Directed Physiotherapy in Children with Cerebral Palsy GMFCS Levels I & II. Phys Occup Ther Pediatr 2016:1-15.
19. Cao J, Khan B, Hervey N, Tian F, Delgado MR, Clegg NJ, et al. Evaluation of cortical plasticity in children with cerebral palsy undergoing constraint-induced movement therapy based on functional near-infrared spectroscopy. J Biomed Opt 2015;20(4):046009-.
20. Dalvand H, Dehghan L, Feizi A, Amir Ss, Hosseini S, Shamsoddini A. The effect of foot serial casting along with botulinum toxin type-a injection on spasticity in children With Cerebral Palsy (in persion). J Kerman Uni Med Sci 2012;19(4):562-73.
21. Mazzone S, Serafini A, Iosa M, Aliberti MN, Gobbetti T, Paolucci S, et al. Functional taping applied to upper limb of children with hemiplegic cerebral palsy: a pilot study. Neuropediatr 2011;42(6):249-53.
22. Wong EC, Man DW. Gross motor function measure for children with cerebral palsy. Int J Rehabil Res 2005;28(4):355-9.
23. Basu AP, Pearse J, Kelly S, Wisher V, Kisler J. Early intervention to improve hand function in hemiplegic cerebral palsy. Improving outcomes in cerebral palsy with early intervention: new translational approaches. Front Neurol 2015:147.
24. Novak I, McIntyre S, Morgan C, Campbell L, Dark L, Morton N, et al. A systematic review of interventions for children with cerebral palsy: state of the evidence. Dev Med Child Neurol 2013;55(10):885-910.
25. Choi YK, Nam CW, Lee JH, Park YH. The Effects of Taping Prior to PNF Treatment on Lower Extremity Proprioception of Hemiplegic Patients. J Phys Ther Sci 2013;25(9):1119-22.
26. Labaf S, Shamsoddini A, Hollisaz Mt, Sobhani V, Shakibaee A. Effects of Neurodevelopmental Therapy on Gross Motor Function in Children with Cerebral Palsy. Iran J Child Neurol 2015;9(2):36.
27. Shamsoddini A, Hollisaz M. Effect of sensory integration therapy on gross motor function in children with cerebral palsy. Iran J Child Neurol 2009;3(1):43-8.
28. Lee SH, Shim JS, Kim K, Moon J, Kim M. Gross Motor Function Outcome After Intensive Rehabilitation in Children With Bilateral Spastic Cerebral Palsy. Ann Rehabil Med 2015;39(4):624-9.
29. Shamsoddini A, Holisaz M. Comparison of immediate effect of taping technique and counterforce brace on muscle strength and range of motion of wrist extension and forearm supination of patient’s with tennis elbow. Ann Mill Health Sci Res 2006;4(3):873-6.
30. Zabih Allah Rasti Mk, Alireza Shamsoddini. Effects of Kinesio Taping Technique in children with Cerebral Palsy: review. J Rehabil Med 2016;5(1):235-43.
31. Shamsoddini A, Hollisaz MT, Hafezi R, Amanollahi A. Immediate Effects of Counterforce Forearm Brace on Grip Strength and Wrist Extension Force in Patients With Lateral Epicondylitis. Hong Kong J Occup Ther 2010;1(20):8-12.
32. Taylor RL, O’Brien L, Brown T. A scoping review of the use of elastic therapeutic tape for neck or upper extremity conditions. J Hand Ther 2014;27(3):235-46.
33. Mackin E, Callahan A, Skirven T, Schneider L. Rehabilitation of the hand and upper extremity. United States of America: Mosby; 2002. P.1796-1806.
34. Jaraczewska E, Long C. Kinesio taping in stroke: improving functional use of the upper extremity in hemiplegia. Top Stroke Rehabil 2006;13(3):31-42.
35. Shamsoddini A, Hollisz M, Azad A, Keyhani M. Comparison of initial effect of taping technique and Counterforce brace on pain and grip strength of patients with lateral epicondylitis. J Rehabil 2006; 7(1): 38-42. (In Persion)
36. Yi-Liang K, Yueh-Chu H. Effects of the Application Direction of Kinesio Taping on Isometric Muscle Strength of the Wrist and Fingers of Healthy Adults — A Pilot Study. J Phys Ther Sci 2013;25(3):287–91.
37. Shamsoddini A, Hollisaz MT. Effects of Taping on Pain, Grip Strength and Wrist Extension Force in Patients with Tennis Elbow. Trauma Mon 2013;18(2):71.
38. Shamsoddini A, Hollisaz MT, Hafezi R. Initial effect of taping technique on wrist extension and grip strength and pain of Individuals with lateral epicondylitis. Iran Rehabil J 2010;8(11):24-8.
39. Simsek TT, Turkucuoglu B, Cokal N, Ustunbas G, Simsek IE. The effects of Kinesio(R) taping on sitting posture, functional independence and gross motor function in children with cerebral palsy. Disabil Rehabil 2011;33(21-22):2058-63.
40. Cepeda J, Fishweicher A, Gleeson M, Greenwood S, Motyka-Miller C. Does Kinesio Taping of the abdominal muscles improve the supine-to-sit transition in children with hypotonia. https://www.kinesiotaping.com/console/uploads/material_document/2008-3.pdf Retrieved on April 2008;12:2011.
41. Irwin CB, Sesto ME. Reliability and validity of the multiaxis profile dynamometer with younger and older participants. J Hand Ther 2010;23(3):281-8; quiz 9.
42. Molenaar HM, Zuidam JM, Selles RW, Stam HJ, Hovius SE. Age-specific reliability of two grip-strength dynamometers when used by children. J Bone Joint Surg Am 2008;90(5):1053-9.
43. Mitchell J. A measurement of hand function in the normal child and the cerebral palsied child. Australia J Phys 1976;22(4):161-5.
44. Lee J-h, Yoo W-g, An D-h. The Effects of Extensor Pattern Position and Elastic Taping of Non-Dominant Hand on the Grip Strength of Dominant Hand. Phys Ther Korea 2009;16(4):8-15.
45. Gajdosik RL, Bohannon RW. Clinical measurement of range of motion. Review of goniometry emphasizing reliability and validity. Phys Ther 1987;67(12):1867-72.
46. Pendleton H, Schultz-Krohn W. Occupational therapy practice skills for physical dysfunction. California: Mosby;2006.P.456-8.
47. Pendleton H, Schultz-Krohn W. Occupational therapy practice skills for physical dysfunction. California: Mosby;2006.P.461.
48. Herrero P, Carrera P, Garcia E, Gomez-Trullen EM, Olivan-Blazquez B. Reliability of goniometric measurements in children with cerebral palsy: a comparative analysis of universal goniometer and electronic inclinometer. A pilot study. BMC Musculoskeletal Disord 2011;12:155.
49. Mutlu A, Livanelioglu A, Gunel MK. Reliability of goniometric measurements in children with spastic cerebral palsy. Med Sci Monit 2007;13(7):CR323-9.
50. Speth LA, Leffers P, Janssen-Potten YJ, Vles JS. Botulinum toxin A and upper limb functional skills in hemiparetic cerebral palsy: a randomized trial in children receiving intensive therapy. Dev Med Child Neurol 2005;47(7):468-73.
51. Demirel A, Tunay Bayrakci V. The effect of kinesio tape on active wrist range of motion in children with cerebral palsy: a pilot study. J Orthop2014;6(2):69-74.
52. National Collaborating Centre for Women’s and Children’s Health (UK). Spasticity in children and young people with non-progressive brain disorders: Management of spasticity and co-existing motor disorders and their early musculoskeletal complications. NICE Clinical Guidelines, 2012, No. 145.
53. Pendleton H, Schultz-Krohn W. Occupational therapy practice skills for physical dysfunction. California: Mosby; 2006.P.1011.
54. Eliasson AC, Ekholm C, Carlstedt T. Hand function in children with cerebral palsy after upper-limb tendon transfer and muscle release. Dev Med Child Neurol 1998;40(9):612-21.

55. Kaya Kara O, Atasavun Uysal S, Turker D, Karayazgan S, Gunel MK, Baltaci G. The effects of Kinesio Taping on body functions and activity in unilateral spastic cerebral palsy: a single-blind randomized controlled trial. Dev Med Child Neurol 2015;57(1):81-8.

56. Morris D, Jones D, Ryan H, Ryan C. The clinical effects of Kinesio® Tex taping: A systematic review. Physiother Theory Pract 2013;29(4):259-70.

57. Kase K. Until today from birth of Kinesio taping method. Albu-querque, NM: KMS.2001;200:7-30. (in Japanese)

58. Chitaria SB, Narayan A, Ganesan S, Biswas N. Short-Term Effects of Kinesiotaping on Fine Motor Function in Children with Cerebral Palsy− A Quasi-Experimental Study. Crit Rev Phys Rehabil Med 2015;27(1):43-52.

59. Lemos TV, Pereira KC, Protássio CC, Lucas LB, Matheus JPC. The effect of Kinesio Taping on handgrip strength. J Phys Ther Sci 2015;27(3):567-70.

60. Zeynep Bahadır Ağce, Sedef Karayazgan, Özge Müzezzinoğlu MY, Hatice Abaoğlu, Akel S. Effect of wrist correction kinesio taping application on hand span in children with cerebral palsy. Dev Med Child Neurol 2015;57(Supplement S5):30-.

61. Chitaria SB, Narayan A, Ganesan S, Biswas N. Short-Term Effects of Kinesiotaping on Fine Motor Function in Children with Cerebral Palsy− A Quasi-Experimental Study. Crit Rev Phys Rehabil Med 2015;27(1).

62. Chang HY, Chou KY, Lin JJ, Lin CF, Wang CH. Immediate effect of forearm Kinesio taping on maximal grip strength and force sense in healthy collegiate athletes. Phys Ther Sport 2010;11(4):122-7.

63. Kouhzad Mohammadi H, Khademi Kalantari K, Naeimi SS, Pouretzezad M, Shokri E, Tafazoli M, et al. Immediate and delayed effects of forearm kinesio taping on grip strength. Iran Red Crescent Med J 2014;16(8):e19797.