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The efficacy of derotation taping in femoral internal rotation deformity of children with cerebral palsy: a randomized controlled trial

Serebral palsili çocuklarda femoral iç rotasyon deformitesinde derotasyon bantlamasının etkinliği: randomize kontrollü çalışma

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ABSTRACT

Aim: The present study aimed to investigate the effect of the derotation method of Kinesio Taping in addition to conventional rehabilitation in children with hemiplegic cerebral palsy with femoral internal rotation deformity.

Materials and Methods: A total of 30 children with unilateral hemiplegic spastic cerebral palsy were randomized into the Kinesio Taping and control group (Conventional Rehabilitation). All included participants have spasticity-related rotation deformity and in-toeing gait. Kinesio Taping group was treated with derotation-tape in addition to conventional rehabilitation. Data was collected before and immediately after the intervention, and also 3 days after the first assessment. The 6-Meter Walk Test, Pediatric Berg Balance Test, Modified Ashworth Scale, Edinburgh Visual Gait Score and Generic Quality-of-Life Instrument for Children were used to assess the children.

Results: There was no significant difference between the groups regarding spasticity scores ($p>0.05$). Spasticity was decreased in hip internal rotators and knee flexors in immediate and acute periods after the intervention in the Kinesio Taping group ($p<0.05$). There was no difference between the two groups regarding balance, walking, and quality-of-life ($p>0.05$). Post-intervention improvement in 6-Meter Walk Test, Pediatric Berg Balance Test and Edinburgh Visual Gait Score scores was significant only in the Kinesio Taping group ($p<0.05$). Quality-of-life increased significantly after treatment in both groups.

Conclusion: The results revealed that derotation Kinesio Taping reduces spasticity in the hip internal rotator and knee flexor muscles in the immediate and acute period in children with spastic hemiplegic cerebral palsy. Besides, Kinesio Taping improved balance and walking in the acute period.

Keywords: Cerebral palsy, derotation, in-toeing gait, kinesio taping.

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ÖZ

Amaç: *Bu çalışmanın amacı femoral internal rotasyon deformitesi olan hemiplejik serebral palsili çocuklarda konvansiyonel rehabilitasyona ek olarak Kinesio Bantlama ile derotasyon yönteminin etkisini araştırmaktı.*

Gereç ve Yöntem: *Tek taraflı hemiplejik spastik serebral palsili toplam 30 çocuk Kinesio Bantlama ve kontrol grubuna (Konvansiyonel Rehabilitasyon) randomize edildi. Tüm katılımcılar spastisiteye bağlı rotasyon deformitesine ve "in-toeing" yürüyüşe sahipti. Kinesio Bantlama grubu konvansiyonel rehabilitasyona ek olarak derotasyon bandı ile tedavi edildi. Veriler müdahaleden önce ve hemen sonra ve ayrıca ilk değerlendirmeden 3 gün sonra toplanmıştır. Çocukları değerlendirmek için 6 Metre Yürüme Testi, Pediatrik Berg Denge Testi, Modifiye Ashworth Ölçeği, Edinburgh Görsel Yürüme Skoru ve Çocuklar için Genel Yaşam Kalitesi Ölçeği kullanılmıştır.*

Bulgular: *Spastisite skorları açısından gruplar arasında anlamlı fark yoktu ($p>0.05$). Kinesio Bantlama grubunda müdahaleden hemen sonra ve akut dönemde kalça iç rotator kaslarında ve diz fleksörlerinde spastisite azaldı ($p<0.05$). Denge, yürüme ve yaşam kalitesi açısından iki grup arasında fark yoktu ($p>0.05$). Müdahale sonrası 6 Metre Yürüme Testi, Pediatrik Berg Denge Testi ve Edinburgh Görsel Yürüme Skoru skorlarındaki iyileşme sadece Kinesio Bantlama grubunda anlamlıydı ($p<0.05$). Yaşam kalitesi her iki grupta da tedavi sonrasında anlamlı olarak artmıştı.*

Sonuç: *Sonuçlar derotasyon yöntemi ile Kinesio Bantlamanın spastik hemiplejik serebral palsili çocuklarda acil ve akut dönemde kalça iç rotator ve diz fleksör kaslarındaki spastisiteyi azalttığını ortaya koymuştur. Ayrıca, Kinesio Bantlama akut dönemde denge ve yürümeyi geliştirmiştir.*

Anahtar Sözcükler: *Serebral palsi, derotasyon, ayak içi yürüyüş, kinesio bantlama.*

INTRODUCTION

Hypotonus, hypertonus or dystonia are frequently encountered in neurological problems (1, 2). Internal femoral rotation (IFR) deformity due to hypertonus is a fundamental cause of in-toeing gait in children with Cerebral Palsy (CP). Symptoms including pain, knocking or rubbing at the knees, stumbling or falling due to altering foot plantar pressure distribution are among the IFR results (3). The mechanism of IFR in children with CP includes "dynamic and static" elements. Dynamic aspects are hypertonus in the adductors, hamstrings, gluteals, tensor facia latae muscles, contracture, and muscle imbalance. The static characteristic is an extreme femoral "anteversion angle" that relieves the mechanical benefit of the muscles that strike the hip joint (i.e., abductors and gluteals) and leads to more inefficient energy use in the forward thrust phase of gait (4, 5).

The primary treatment goal is to improve gait capacity to lead a more self-reliant daily life. Given the essence of the hip joint role in gait ability and the insufficiencies in hip function related to CP, there is a sufficient reason to target this joint to improve gait capacity. General approaches ("e.g., orthotics, botulinum toxin A, forced movement therapy and neurodevelopmental therapy") focus on increasing posture and muscle and activity in the extremities, and enhancing gait (6, 7). In recent years, the use of evidence-based therapies in treatment has been increasing (8). Researchers are performing to develop more efficient treatments to increase the quality of life of children with CP and their families. Recent studies have reported that motor learning-based treatments improve activity degree in CP (9). Therefore, Kinesio Taping in CP may be a practical technique to achieve essential improvement (10, 11).

The Kinesiology Taping (KT) technique was developed in 1973 by Dr Kenzo Kase and has recently been used as a supportive method in physiotherapy, orthopedics, pediatrics and sports injuries (12-14). KT is a thin, cotton, porous fabric with a drug-free, latex-free and heat-activated acrylic adhesive. Cotton fibers allow for evaporation and faster drying, providing a longer wear time of up to 4-5 days. KT on the knee joint is believed to relieve pain by improving the alignment and draining inflamed soft tissues. KT technique can support the painful tissue, create a specific anatomical alignment, provide ease of movement, increase stability and protect the joint (15, 16).

There is no randomized controlled study on the effects of KT on internal femoral rotation in children with CP. The present study aimed to investigate the effect of the derotation method of

KT in addition to conventional rehabilitation in children with hemiplegic cerebral palsy with femoral internal rotation deformity. We hypothesized that derotation purposed Kinesio Taping could improve balance, quality of life, performance testing, spasticity level and gait in children with unilateral hemiplegic spastic CP.

MATERIALS and METHODS

Participants and Study Design

A total of 30 children with unilateral hemiplegic spastic CP were randomized into the KT group (KT plus conventional rehabilitation) and control group (conventional rehabilitation). All included participants have spasticity-related rotation deformity and in-toeing gait. "CONsolidated Standards of Reporting Trials (CONSORT)" were used during all trial phases (17). The inclusion criteria of the participants were as follows: (1) unilateral hemiplegic spastic children with CP, (2) Gross Motor Functional Classification < 3, (3) no mental retardation and cooperation to understand the verbal comments. Exclusion criteria of the study were as follows; (1) a static cause of femoral internal rotation deformity, (2) the presence of lower extremity surgery or botulinum toxin administration in the last six months, (3) development of an allergic reaction on the skin. The CONSORT flowchart of the study is given in Figure-1.

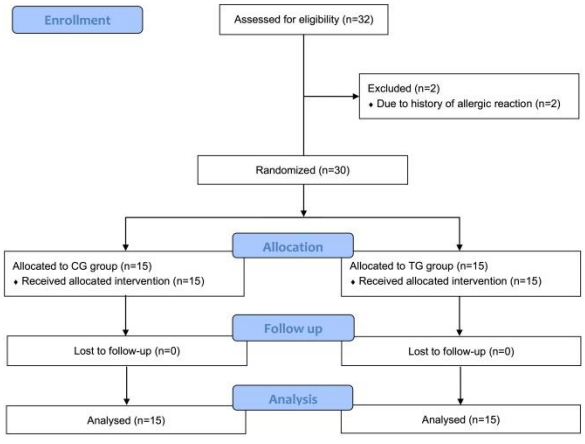

Figure-1. CONSORT Flow chart of the study.

"The study was carried out following the ethical principles and the Helsinki Declaration. Informed consent from the patients and their families was obtained. The study protocol was approved by the clinical research ethics committee of "Muğla Sıtkı Koçman University" University (No: 5/II, Date: 02/03/2022). The study protocol was registered (ClinicalTrials.gov Identifier: "NCT05251519")."

Figure-2. Distortion taping application using kinesio taping

Sample Size

G-Power 3 (version 3.1.9.7, Heinrich-Heine-Universität, Düsseldorf, Germany) was used to calculate the sample size. Regarding the previous similar study values (18), the effect size was encountered as 1.03. The power (1-ß error probability) and confidence level were fixed as 80% and 0.05, respectively. Output parameters yielded 13 individuals for each group. Finally, a minimum of 26 patients were considered the adequate sample size for the study.

Recruitment, Blinding and Randomization

A two-armed trial was conducted in "Fethiye Özel Son Atılım special education and rehabilitation center. Participants were children with CP who received rehabilitation at the rehabilitation center. First, detailed information about the study was presented, and consent was obtained from the families of the children. The possible benefits and side effects of KT were explained. Intervention and evaluation practices were carried out in the treatment room of the rehabilitation center. Throughout these practices, the physiotherapist responsible for the child's treatment followed up on possible unexpected effects and complaints.

Randomization was performed with web-based computer software. Thirty individuals were included in KT and CG with the asymptotic maximal procedure (19). Considering pragmatic reasons, blinding could not be accomplished.

Interventions

For spasticity management, stretching exercises for spastic muscles and cold therapy were applied to CG. Strengthening exercises applied the antagonist of spastic muscles, and joint range of motion movements were used. In addition to traditional treatment for the KT group, derotation tape was applied (20). Firstly, the relevant lower extremity of the participant is placed in external rotation. An I-shaped tape is cut in sizes suitable for the applied area. The beginning of the tape is fixed to the foot, and the therapist dragged the tape "superiorly and laterally", spiralling up the hip and "diagonally crossing" the gluteal region; then landed the base of the "I-tape" at the "ipsilateral posterior superior iliac spine" (Figure-2).

Outcome Measures

Data was collected before and immediately after the intervention, and also 3 days after the first assessment. The immediate and acute effects of the KT application was observed during the second and third evaluation. The 6 Meter Walk Test (6MWT), Pediatric Berg Balance Test (PBBT), Modified Ashworth Scale (MAS), Edinburgh Visual Gait Score (EVGS), and Generic Quality of Life Instrument for Children (KINDL) were used to assess the clinical status of the children.

6 Meter Walk Test (6MWT)

Unsupported GAİT along a six-meter pathway was evaluated. Individuals performed the walking task in a setting of 10 meters. The first and last 2 meters were used to eliminate the acceleration bias (21).

Pediatric Berg Balance Test (PBBT)

PBBT is a comprehensive task-based tool for static and dynamic balance assessment. A total of 14 items evaluates balance-related tasks (e.g., sitting, standing, transferring). Each item is scored between 0-4 (22).

Modified Ashworth Scale (MAS)

MAS was used to assess the muscle tonus of the participants. Spastic lower extremity muscles were evaluated regarding a standardized protocol. MAS is scored between 0-4. Higher scores indicate higher spasticity (23).

Edinburgh Visual Gait Score (EVGS)

EVGS is a video-based gait analysis and assessment tool. It examines the pathological gait characteristics of 6 anatomical regions in three different planes with 17 items. In our study, patient images were recorded from three different angles. The videos were reviewed with slow-motion technology and scored by an experienced physiotherapist (24).

Generic Quality of Life Instrument for Children (KINDL)

The KINDL evaluates the “quality of life, psychological well-being, social relationships, physical function and everyday life activities” of children. KINDL is scored between 0 to 100. A high score shows more pleasing quality of life (25).

Statistical Analysis

“Statistical Package for Social Sciences (SPSS) Version 25.0 (SPSS inc, Chicago, IL, USA) was used for the analysis of clinical data. Statistical significance (p) was accepted as 0.05. Continuous variables were presented as mean ± standard deviation. Categorical variables were given as numbers and percentages. One-Sample Kolmogorov-Smirnov Test and Histogram were used to determine the data distribution. Regarding the normality, parametric or non-parametric statistical significance tests were considered the between-group or in-group differences.”

RESULTS

The baseline characteristics, including age, BMI, gender, hemiplegic side and presence of other musculoskeletal disease, were similar between the groups (p>0.05) (Table-1).

Table-1. Characteristics of the participants

	KT (n=15)	CG (n=15)	p
Age (years, mean±SD)	9.86±1.59	9.80±2.33	0.870[a]
BMI (kg/m^2, mean±SD)	17.02±2.86	19.66±4.59	0.174[a]
Gender (female/male, n)	9/6	8/7	0.500[b]
Hemiplegic side (right/left, n)	8/7	5/10	0.462[b]
Other musculoskeletal disease (yes/no)	0/15	0/15	1.000[b]

“**BMI:** Body Mass Index, **a:** Mann–Whitney U test, **b:** Pearson Chi-Square test”

Table-2. The effect of KT on spasticity between groups and in-group analysis

		KT (n=15)	CG (n=15)	p (between group)
MAS hip flexor	**Baseline**	1.73±0.79	1.66±0.72	0.870[a]
	1st day	1.73±0.79	1.66±0.72	0.870[a]
	3rd day	1.66±0.72	1.66±0.72	1.000[a]
	p (within group)	0.368[b]	1.000[b]	
MAS hip adductor	**Baseline**	1.93±0.96	1.60±0.73	0.389[a]
	1st day	1.93±0.96	1.60±0.73	0.389[a]
	3rd day	1.86±0.91	1.60±0.73	0.486[a]
	p (within group)	0.368[b]	1.000[b]	
MAS hip internal rotator	**Baseline**	2.13±0.91	1.60±0.73	0.126[a]
	1st day	2.06±0.88	1.60±0.73	0.174[a]
	3rd day	1.73±0.59	1.60±0.73	0.512[a]
	p (within group)	**0.006[b]**	1.000[b]	
MAS knee flexor	**Baseline**	2.46±0.74	2.46±0.74	0.838[a]
	1st day	2.46±0.74	2.46±0.74	0.838[a]
	3rd day	2.26±0.70	2.46±0.74	0.567[a]
	p (within group)	**0.049[b]**	1.000[b]	
MAS plantar flexor	**Baseline**	3.06±0.59	2.66±1.23	0.089[a]
	1st day	3.06±0.59	2.66±1.23	0.089[a]
	3rd day	3.06±0.59	2.66±1.23	0.089[a]
	p (within group)	1.000[b]	1.000[b]	

"**n:** number of patients, **MAS:** Modified Ashworth Scale, **a:** Mann–Whitney U test, **b:** Friedman test"

Table-3. The effect of KT on balance, gait and quality of life between and in-group analysis

		KT (n=15)	CG (n=15)	p (between group)
6MWT	**Baseline**	12.10±4.40	10.96±3.73	0.325[a]
	1st day	11.62±4.74	10.90±3.62	0.567[a]
	3rd day	11.07±4.31	10.98±3.74	0.838[a]
	p (within group)	**0.0001[b]**	0.802[b]	
PBBS	**Baseline**	31.46±14.23	35.60±15.86	0.202[a]
	1st day	32.06±14.35	35.73±15.89	0.267[a]
	3rd day	34.53±15.08	35.86±15.91	0.683[a]
	p (within group)	**0.0001[b]**	0.082[b]	
EVGS	**Baseline**	20.20±4.87	8.86±4.28	**0.0001[a]**
	1st day	20.20±4.87	8.80±7.67	**0.0001[a]**
	3rd day	14.60±5.80	15.20±24.64	0.106[a]
	p (within group)	**0.0001[b]**	0.670[b]	
KINDL	**Baseline**	59.51±15.89	66.87±15.04	0.367[a]
	1st day	59.51±15.89	66.87±15.04	0.367[a]
	3rd day	72.63±18.06	70.96±15.62	0.539[a]
	p (within group)	**0.0001[b]**	**0.0001[b]**	

"**n:** number of patients, **6MWT:** 6 Meter Walk Test, **PBBT:** Pediatric Berg Balance Test, **MAS:** Modified Ashworth Scale, **EVGS:** Edinburgh Visual Gait Score, **KINDL:** Generic Quality of Life Instrument for Children, **a:** Mann–Whitney U test, **b:** Friedman test"

The mean age of the participants was 9.86±1.59 and 9.80±2.33 for the KT and CG, respectively. There was no significant difference between the groups regarding spasticity scores ($p>0.05$). Spasticity was decreased in hip internal rotators and knee flexors in immediate and acute periods after the intervention in the KT group ($p<0.05$). No significant change was observed in spasticity score in all other in-group changes ($p>0.05$) (Table-2).

There was no difference between the two groups regarding balance, walking, and quality of life ($p>0.05$). Post-intervention improvement in 6MWT, PBBS and EVGS scores was significant only in the KT group ($p<0.05$). Improvements were observed for 6MWT and PBBS, both in the immediate and acute periods. For EVGS, a positive change was seen in the acute period. Quality of life, as assessed by KINDL, increased significantly after treatment in both groups. These improvements were in the 3-day acute period (Table-3)

DISCUSSION

The results of the present study revealed that derotation KT reduces spasticity in the hip internal rotator and knee flexor muscles in the immediate and acute period in children with spastic hemiplegic CP. On the other hand, KT improved balance and gait in the acute period. Deration KT application has not been discussed in any trial in children with CP. Considering the unique aspect of the intervention of the current study, the results provided guiding data for further long-term follow-up studies.

Spasticity is the most common symptom affecting balance and gait in children with CP during activities of daily living. Various static and dynamic deformities cause gait disorders by negatively affecting the balance of individuals (26). In particular, correcting malformations that cause joint deformity should be started from the distal parts of lower extremity towards the proximal region due to a collective clinical approach (27). In-toeing gait deformity is a holistic internal rotation malformation of the lower extremity that does not solely originate from the ankle. A more holistic approach may be required in treating CP with in-toeing gait conditions (28). Based on this hypothesis, we investigated the spiral-shaped derotation method that travels the lower extremity by two joints (ankle and knee). Since the short-term effects of KT are more pronounced (29), we focused on symptomatic effects with immediate and acute-term follow-up. The study's results positively affected spasticity, especially in the hip and knee joint muscles, and improved gait and balance. In addition, these developments may also lead to improvements in quality of life.

Our analysis results with MAS in the evaluation of spasticity provided improvements in the hip internal rotator and knee flexor muscles in both immediate and acute periods in the KT group. We interpreted that the primary purpose of the derotation KT application is to provide rotational strength and proprioception gain and corrections in the in-toeing gait deformity of the children. Notably, the decreased tone of the hip internal rotator muscles revealed this situation more clearly. On the other hand, spiral-shaped KT, which also crosses the knee joint, was also influential on hamstring muscle tone and was able to reduce knee flexor contracture, particularly in the acute period after three days of application. Supporting our results with classification systems and radiological imaging methods that reveal the degree of improvement in in-toeing gait would construct the advancements that can be achieved in clinical practice more meaningful (30).

The present study performed the walking assessment of children using the physical performance test (6MWT) and the video-based gait analysis tool (EVGS). Therefore, we consolidated our results with two different evaluation tools with different concepts. The improvements provided by both assessments after distortion KT may have been accomplished due to the reduction in the hip-knee muscles' spasticity and the somatosensory inputs provided by KT (31). In this context, additional comparisons obtained with technological devices and proprioception and sensory evaluation will provide valuable practical implications compared to our study results. In particular, considering the improvements acquired from EVGS and spatiotemporal data may provide a more extended quantity and quality improvement in walking parameters. On the other hand, our balance evaluation results received with PBBS showed improvements in both static and dynamic balance parameters, primarily in the acute period. It can be predicted that children with CP are more successful in maintaining the center of gravity of the body within the support surface, as the reduced spasticity brings along the improved joint alignment. Supporting this situation with a multi-

sensor measurement may assemble the inferences from the results more transparent (32).

Quality of life is a parameter that changes can be more clearly reflected in longer-term follow-up (33). However, since even acute-term improvements will affect the daily life activities of the children, we provided a KINDL assessment with the idea that it may indirectly bring partial advancements in the quality of life. According to our results, KT does not provide an additional gain in quality of life. In this context, future studies need to investigate the effect of derotation KT application on the quality of life at a minimum of 8 weeks of follow-up.

In the literature, studies investigate the applications of KT to the lower extremity in CP. However, different KT techniques and assessment outputs reduce the comparability of results. One of these studies emphasized that “Y” shaped KT application to the tibialis anterior and gastrocnemius muscles did not affect spasticity in the acute period in children with hemiplegic spastic CP. However, improvements were attained in gait and balance. The similar results obtained except for the spasticity suggest that the spiral-shaped derotation application can be preferred in terms of effectiveness in spasticity (34).

Another similar study showed that “Y” shaped CT in children with spastic diplegic CP improved spatiotemporal parameters, including "gait velocity, step length, stride length, and single support time". Although other KT techniques were used for different muscles, the results supported our EVGS and 6MWT results with more technical data (35). Another trial that applied KT to lower extremity anterior facial muscles reported balance improvements in children with CP (36). The study results, in which these gains were acquired in the long term, support our PBBS data. Moreover, it may provide an observational inference that our acute-term results will be preserved long-term. In this respect, long-term PBBS results may be the subject of further study.

Clinical Implications

Although the study's results emphasize the acute effect of KT as a deficiency in long-term rehabilitation, it reveals the sustainability of KT treatment in terms of regular rehabilitation of individuals with CP in special education centers. Improvements gained even in the walking and balance of individuals with CP will make significant contributions even to the individual's level of independence. Therefore, applying low-cost KT in addition to conventional rehabilitation programs may provide significant gains in patients' motor and sensory functions. Secondary analysis studies focusing on long-term kT efficacy in clinical practice can be used to elaborate the results of the present KT technique.

Study limitations

The most significant limitation of the study is the lack of blinding. Convenient situations and the nature of the research affected this pragmatic situation. Blinding can provide more apparent results to avoid evaluator and practitioner bias. Second, long-term follow-up is not provided. We could not extend our intervention period, mainly due to the necessity of renewing the KT every three days. Third, the evaluation of proprioception and somatosensory gains is essential. Because there is no improvement in balance and gait only due to spasticity, it can be considered insufficient data since proprioceptive inputs of KT are known. Future studies may focus on sensory and proprioceptive assessments with technological devices.

CONCLUSION

The results revealed that derotation KT reduces spasticity in the hip internal rotator and knee flexor muscles in the immediate and acute period in children with spastic hemiplegic CP. On the other hand, KT improved balance and walking in the acute period. Since the deration KT application has not been discussed in any trial in children with CP, our study results provide unique data with a high evidence level. Considering the originality of the intervention of the current study, further studies should investigate long-term follow-up studies on derotation KT in children with CP.

Conflict of interest: No conflict of interest was declared by the authors.

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