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Effect of kinesio taping on standing balance in subjects with multiple sclerosis: A pilot study[1]

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Abstract. *Objective:* The aim of this study was to assess the effect of Kinesio Taping on body stability in subjects with MS.
Study design: Non controlled intervention study in a Rehabilitation Unit.
Intervention: A consecutive convenience sample of 15 individuals with multiple sclerosis was assessed. Kinesio Tex Tape was applied directly to the skin of both calves and kept for the next two days.
Main outcome measures: Clinical and stabilometric assessments were performed at baseline, immediately after application of the tape and the day after its removal. To control for learning effect 10 subject with multiple sclerosis were tested repeatedly under the same conditions without tape.
Results: No statistically or clinically relevant differences were observed among conditions in the mediolateral plane. In the AP plane Friedman's ANOVA showed statistically significant differences between baseline and taping condition with respect to length of sway. A trend towards statistically relevant differences were found also with respect to mean sway and velocity of sway. No learning effect was found for repeated testing within the no treated group.
Conclusions: These preliminary results suggest that the use of ankle taping may be useful in immediately stabilising body posture.

Keywords: Taping, standing balance, multiple sclerosis, rehabilitation, posture

1. Introduction

Balance impairments and falls are frequent in subjects with multiple sclerosis (MS) [1,2] and are likely due to the combined effects of a lack of adequate postural control strategies, weakness and ataxia, and a lack of reliable sensory information.

Balance control relies on a complex interaction of sensory and motor systems. An accurate perception of physical stimuli by sensory receptors of the visual, somatosensory and vestibular systems and the integration of these inputs is essential for good standing balance [3–5]. Disorders in the sensory system can lead to inadequate motor responses [6] which are frequently observed in individuals with MS [7]. A recent study addressing sensory disorders in a sample of MS subjects [8] showed the strong effects of the pathology on balance control and the difficulty of subjects with MS in controlling balance when the reliability of sensory information was reduced. More than 2/3 of the subjects showed increased postural sway in quiet standing with eyes closed on the antero-posterior axis.

In standing, it has become common to study the body as an inverted pendulum pivoting at the ankles where the body is balanced by the ankle musculature with primary role of the calf muscles [9]. The ankle has the double role of sway detection by somatosensory input and sway control by feedforward and stiffness control systems [10]. We hypothesized that for individuals with MS an improvement of the quality of somatosensory information could be achieved by the application of a tape across the posterior part of the ankle joints.

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The use of taping could also potentially increase ankle stiffness thus facilitating the role of the postural control system in controlling body sway. The Kinesio Taping Method^{TM}, has different types of applications and different elastic characteristics. It may facilitate or inhibit muscle function in terms of muscle [11] recruitment and it may increase range of motion and joint stability [12]. Similarly to other taping techniques (sport taping, McConnell taping) it can be used to support joints and reduce pain [13] and change peripheral blood flow [14]. In literature there are a couple of studies about application of tape to adults with neurological diseases. In one study improved upper limb function was reported after taping [15] and it was suggested that Kinesio Taping might provide proprioceptive feedback useful for correcting body alignment. In the other study taping on the gluteus muscles proved effective in increasing hip extension during gait of persons with hemiplegia following stroke [16]. In that study it was hypothesised that taping might have: increased the overlap between the actin and myosin filaments and their interaction or that it might have improved muscle activation through cutaneous stimuli [17]. Alternatively, it was suggested that improvement in performance could be due to increased proprioceptive perception because of the pull of the tape on the skin or that taping might simply have given a physical limitation or stability to the joint [18].

The aim of the present study was to assess the effect of Kinesio Taping applied to the back of the ankles in improving body stability in quiet standing with eyes closed in individuals with MS.

2. Materials and methods

A consecutive convenience sample of 15 subjects with multiple sclerosis was assessed at [MASKED] from 01/02/08 to 10/01/09. All inpatients or outpatients who met the following inclusion criteria were enrolled in the study: clinically or laboratory definite relapsing–remitting, primary or secondary progressive multiple sclerosis [19], ability to stand independently in upright position for 30 seconds, ability to walk for 6m even with an assistive device, ability to passively dorsiflex the ankle to the neutral position (0 degrees), no allergy to the tape. The sample consisted of 9 males and the mean age (Standard Deviation) was 49.0 (10.4) years. The average onset of the pathology was 16 (10.8) years before the start of the study. The median (range) EDSS score was 5.5 (3.5–7.5). 6 (40%) subjects had a relapsing remitting sub type of MS; 4 (26.6%) subjects had a primary progressive sub type of MS; 5 (33.3%) subjects had a secondary progressive sub type of MS. Three (20%) subjects used an assistive device (cane).

All subjects consented to participate in the study and signed an informed consent form.

Since we were investigating the effect of the kinesiotape on improving the somatosensory information in the absence of other sensory information only the eyes closed condition (EC) on firm surface was assessed.

2.1. Clinical assessment

A clinical assessment of static balance and the assessment of calf muscles strength was carried out at the beginning of the study. The Berg Balance Scale (BBS) was used to assess static balance. This scale rates balance skills from 0 (cannot perform) to 4 (normal performance) on 14 items with a maximum total score of 56 [20]. The assessment of strength was obtained by the Medical Research Council (MRC) scale where 0 means no muscle contraction and 5 means normal force [21].

The visual analogic scale (VAS) was administered to assess patient's walking perception at pre test and at follow up. The VAS queries the subject's perception of his/her walking skill. The subject has to tick a mark on a 10 cm segment with higher value meaning better perception of walking skills. The 10 meters Timed Walking Test (TWT) was administered at pre test and at follow up always without tape. Mean speed is reported as meters/second (m/s).

2.2. Instrumental assessment

The stabilometric assessment was carried out with a monoaxial platform. The Technoboby® stabilometric platform consists of three string gauges placed under a circular surface of 50 cm of diameter at 120 degrees. The sampling frequency was at 20 Hz. Accuracy and reliability of stabilometric data has already been published elsewhere: the Intraclass Correlation Coefficients ranged between 0.77 to 0.93 for the variables included in the present study. The standard error of measurements were 2.27, 6.04, 250.95 respectively for sway (SWAY), velocity of sway (VEL), and length of sway in 30 seconds (LENGTH) in antero-posterior plane; Description of feet position and experimental set-up have been provided elsewhere [8].

The subjects were tested for 30 seconds in two experimental conditions on firm surface: EC: eyes closed and KTM: Kinesio taping applied, eyes closed. All subjects were assessed in the morning. The subjects then wore the tape for 2 days. The day after removal of the tape the subjects were retested in the eyes closed condition (RET). No treatment was allowed between assessments. During platform assessment subjects were told to stay as still as possible, an operator stood behind the subject to prevent falls. Subjects were tested wearing their normal shoes and clothes. For the follow up assessment subjects were asked to use the same shoes worn during the first assessment.

The instant positions of the centre of pressure (COP) were computed to calculate the following parameters:

SWAY AP (and ML) [mm]: mean sway in the anterior-posterior (AP) and medio-lateral (ML) axis. Calculated as the standard deviation of raw AP and ML COP position.

VEL AP (and ML) [mm/s]: velocity of oscillations in the AP and ML axis. Computed as the first time derivative of COP displacements.

LENGTH [mm]: length of COP trajectory. Computed as the sum of the displacement of COP on the platform surface for each frame.

2.3. Intervention

After the first EC stabilometric assessment Kinesio Tex Tape® was applied directly to the skin of both calves (see Fig. 1). The second stabilometric assessment was done immediately after tape application (KTM). The tape was then kept on for a couple of days and was removed at the end of the second day, the third stabilometric assessment was done the day after tape removal (RET).

During the application of the tape the subject was seated on a chair, the ankle was held slightly dorsiflexed and the knee was bent at about 90 degrees. The tape was cut in an "I" shape, 40 cm in length. First, the base of the tape was applied on the plantar surface of the heel about 5 cm from the posterior aspect of the calcaneous. Second, the band was stretched along 50% to 75% of the length of the Achilles tendon reaching the first third of the calf. The last part of the tape was applied as an anchor to dissipate forces.

2.4. Learning effect

Randomization of experimental conditions was avoided since taping applied as a first experimental condition might have interfered with the experimental condition (EC) without taping because of carry over effect. Thus the EC condition was always assessed first

Fig. 1. Application of taping.

and used as baseline to understand what might be the effect of the taping. Since it is possible that the lack of randomization could have led to improvement of performance due to a learning effect, another group of subjects was tested repeatedly in baseline conditions (that did not include taping). In this way we could verify that a change of performance was likely to be due to the intervention rather than to repeated exposure to testing procedures (learning effect). For this purpose a convenience sample of 10 subjects with MS that met the study inclusion/exclusion criteria were recruited and tested. The sample consisted of 6 males, the mean age was 56.5 years (5.7). The median (Range) EDSS score was 5.75 (4–6); The onset of the pathology was 17.4 (10.3) years before the start of the study. 4 (40%) subjects had a relapsing remitting sub type of MS; 3 (30%) subjects had a primary progressive sub type of MS; 3 (30%) subjects had a secondary progressive sub type of MS. 2 (20%) subjects used an assistive device (cane). All participants were assessed in the morning. Three conditions were tested: condition EC as baseline, as described for the experimental sample; a second condition eyes closed, after a pause of 10 minutes, (EC2) that substituted the KTM condition of the experimental sample; and the RET condition assessed three days later, as described for the experimental sample.

2.5. Data analysis

A box plot was used to verify the presence of outliers. The Shapiro-Wilk test was used in testing for normality of distributions. Due to the small number of subjects in the sample and lack of normal distribution of data a Friedman's ANOVA was used to assess the differences between experimental conditions. Since this is a non controlled pilot study it is important to note that the alpha levels reported below have to be considered only indicative.

We considered a difference between baseline and KTM condition significant if its magnitude was higher than the minimally detectable change (MDC). The MDC shows which changes fall outside the measurement error. It is represented by the following formula: MDC = 1.96 * $\sqrt{2}$ * SEM, where SEM is the standard error of measurement [22]. These differences were: 2.26 mm, 6.03 mm/s and 250.9 mm respectively for SWAY AP, VEL AP and LENGTH [8].

Spearman correlation coefficient was calculated between the performance in the EC condition and the difference between the EC and the KTM conditions for each variable to understand whether the effect of taping was influenced by the original performance.

To calculate the required sample size for a future random controlled study a sample size estimation was run. T test for independent sample was chosen to assess statistically significant differences between groups of change scores (post-pre). A power of 0.8 and an alpha level of 0.05 were chosen.

3. Results

The group of subjects scored on the average 45.8 (8.7 SD) points on the BBS which indicated a mild to moderate balance disorder. VAS scale scored 4.7 cm (2.4) out of 10, implying that subjects perceived their walking impairments as being from moderate to heavy. The average strength of calf muscles was 3.8 (0.94) and 3.6 (0.72) out of 5 points respectively for right and left lower limb.

No statistically or clinically significant differences were observed among conditions in the mediolateral axis for SWAY ML (P = 0.89) and VEL ML (P = 0.42). Thus the following analysis refers to the AP axis and to the experimental group.

Table 1 reports the results for Sway AP, VEL AP and Length variables.

For SWAY AP overall differences among conditions approached significance (P = 0.12). A statistically significant difference was found between SWAY AP EC and SWAY AP RET (P = 0.02). Five out of 15 subjects showed an improvement (above MDC) while three subjects showed a decrement of performance (below MDC). The performances of the other subjects did not change.

With respect to the VEL AP variable overall differences among conditions approached significance(P = 0.09). A statistically significant difference was found between VEL AP EC and VEL AP KTM (P = 0.02). Six out of 15 subjects showed an improvement while one subject showed a decrement of performance. The performances of the other subjects did not change.

With respect to LENGTH ANOVA showed statistically significant differences among conditions (P = 0.01). Statistically significant differences were found between LENGTH EC and LENGTH KTM (P = 0.004). Five out of 15 subjects showed a relevant improvement. The performances of the other subjects did not change.

A statistically significant correlation was found between the LENGTH in the EC condition and the changes in LENGTH obtained with the application of the tape ($r = 0.57$; $p = 0.03$). The same was true for the SWAY AP ($r = 0.63$; $p = 0.01$) and VEL AP ($r = 0.64$; $p = 0.01$). Thus subjects with worse performance on the initial assessment had better outcome from the application of the tape. Conversely, no statistically significant correlations were found between clinical baseline measures (BBS and strength of calf muscles) and improvement in stabilometric measure.

With respect to the VAS scale subjects reported a slight increase in walking confidence from 4.7 (2.4) to 5.9 (2.5) cm ($p < 0.04$) from the first assessment to the retest 3 days later. The same was true for the TWT test: increment of speed was seen from 0.80 (0.36) to 0.90 m/s (0.41), ($P < 0.01$) from the first assessment to the retest 3 days later.

3.1. Learning effect

With respect to the learning effect Table 2 shows the results of the control group obtained after repeated assessments without taping (EC, EC2, RET). No statistically significant differences were found among conditions. In contrast to the taped group this group tended to perform a little worse on the second assessment (EC2). None of the control subjects showed improvement above MDC.

3.2. Sample size calculation

Finally, a sample size calculation, based on the criterion reported in the Method Section, was done to estimate the sample size needed for a future RCT. The analysis revealed that 74 subjects per group will have to be recruited.

Table 1
Length, Sway, and Velocity of sway in antero-posterior axis [mm]

Variable	Condition	n	Median	Range	25–75th percentile
SWAY AP [mm]	EC	15	11.20	5.60–24.25	7.25–14.55
	KTM	15	9.20	5.30–22.15	6.60–11.00
	RET	15	8.03	5.30–17.50	7.20–11.10
VEL AP [mm/s]	EC	15	32.57	14.90–57.05	19.65–42.80
	KTM	15	25.60	16.30–50.45	18.67–33.83
	RET	15	27.00	16.35–48.16	18.80–39.80
LENGTH [mm]	EC	15	894.33	468.00–1572.00	554.50–1423.00
	KTM	15	697.50	471.50–1426.00	550.50–951.00
	RET	15	751.50	508.00–1544.60	597.50–1092.00

SWAY AP: mean sway in antero – posterior axis; VEL AP: velocity of sway in antero – posterior axis;
LENGTH: length of sway.
EC: eyes closed condition. KTM: eyes closed condition, Kinesio Tape applied. RET: eyes closed condition, retest 1 day after removal of tape.

Table 2
Length, Sway, and Velocity of sway in antero-posterior axis [mm]

Variable	Condition	n	Median	Range	25–75th percentile
SWAY AP [mm]	EC 1	10	10.73	4.90–19.45	7.30–12.30
	EC 2	10	11.05	4.70–25.55	8.08–12.05
	RET	10	10.63	5.25–26.45	7.85–14.45
VEL AP [mm/s]	EC 1	10	22.47	13.75–58.55	16.65–31.60
	EC 2	10	22.75	13.50–56.15	16.50–37.40
	RET	10	24.65	15.35–57.80	17.70–43.75
LENGTH [mm]	EC 1	10	702.75	396.00–1633.00	520.50–920.00
	EC 2	10	789.50	436.00–1566.50	498.25–1050.50
	RET	10	693.25	433.50–1522.00	545.50–1329.50

SWAY AP: mean sway in antero – posterior axis; VEL AP: velocity of sway in antero – posterior axis;
LENGTH: length of sway.
EC1: eyes closed condition baseline. EC2: eyes closed condition second assessment. RET: eyes closed condition, retest 3 days after baseline assessment.

4. Discussion

In this paper we investigated the effect of Kinesio taping® applied on the posterior part of the ankle joint on body sway in individuals with MS in quiet standing with eyes closed.

The preliminary results of this study showed that subjects with MS have relevant balance disorders and that taping may improve quiet standing posture with eyes closed. In general no adverse events were observed and subjects reported no discomfort during the treatment. The effects of taping were specific and axis dependent: reduction of sway was seen only in the antero-posterior axis. This was expected since the application of the tape acted primarily on the flexio-extension movement of the ankle joints.

The results of this study showed a trend towards a reduction of amplitude and velocity of sway in the antero-posterior axis with the application of kinesio tape. For the SWAY AP variable a reduction of 21% and 15% of sway was observed from baseline to the second (with tape) and third assessment (RET). These changes were relevant (above MDC) for one third of subjects. In general positive effects were seen in subjects showing higher sway values at baseline. For the VEL AP variable a reduction of 27% and 21% of velocity of sway was observed from baseline to the second and third assessment, these changes were above MDC for 40% of subjects. Traditionally, the amount of motion and velocity of the center of pressure have been assumed to be a reflection of the degree of instability and are considered controllable variables in the regulation of upright posture [23]. The reduction of amplitude of those two variables can thus be considered indicative of a better control of balance in the antero-posterior axis in this group of subjects.

There was a statistically significant reduction of the length of the path in the taped condition and at retest. A reduction of 28% and 19% was observed in LENGTH from baseline to the second and third assessment, these changes were above MDC for one third of subjects. This finding is interesting because length of the path is mechanically related to energy expenditure. A reduction of energy expenditure is important because of the high incidence of fatigue in this population of subjects [24].

It was possible that observed improvement, or lack of improvement, was related to baseline level of strength of calf muscles or balance performance rated by Berg Balance Scale; however, no correlations were found between improvement observed on stabilometric platform and baseline level of balance disorders and strength.

The improvement in gait speed and in perception of walking skills (VAS) suggested a clinical and functional effect of taping. However, it is important to note that those positive effects may be due to patient's compliance since subjects knew that the taping was applied. In fact, other studies have suggested that application of taping may improve perceived joint stability and confidence [25].

In order to improve outcome and methods of applying the tape it is important to understand the mechanism that led to improved upright balance. The effect of treatment on quiet standing was clinically relevant in one third of the subjects immediately after the application of the taping which implies that the changes are not due to long term learning. This may imply that taping acts to modify the physical characteristic of the ankle segments.

The modification of the balance control system may be explained by two hypotheses addressing the mechanical and/or the sensory effect of taping.

With respect to the first hypothesis several authors have stressed the role of the stiffness of the ankle as one of the mechanism used to stabilize posture. The combination of tendons, muscles and joint capsule determines the intrinsic stiffness of the ankle. Weakness of lower limb has been reported in subjects with MS [26] and taping may have a role in increasing plantarflexor force as the centre of the mass moves forward during oscillatory swaying. Taping, because of its mechanical characteristics, may reduce joint movement and increase the overlap of muscular filaments thus increasing muscle recruitment [16,27] and may restrict the excessive movement in the ankle [28].

With respect to the second hypothesis the role of the input from skin receptors of the sole of the feet has been advocated [29]. These inputs are used to promote feedforward active control system of body sway. In feedforward control an internal model is formed, mapping body state and muscle activations, which allows the nervous system to predict the muscle activation needed to stabilize the posture [30]. It has been stressed that the reliability of information is a key issue in the use of this mechanism since reliable information is necessary to develop an effective internal model of body posture to feed the predictive process [29]. The mechanical effect of taping on the skin of the feet and calf may increase the stress on skin receptors thus increasing their output stimulating sopraspinal centres thus enhancing kinestesic and joint position sense [28]. This effect is amplified by closure of the eyes where the weight of somatosensory and vestibular inputs is increased. Delwaide and Crenna suggested that it is possible to activate the supraspinal centre by exteroceptive afferents [31]. They reported an increased excitability in the soleus motor nucleus with high-intensity stimulation of the sural nerve (conduction of sensitive information).

Although the role of taping in increasing peripheral informations seems plausible other studies have to be implemented since the two papers [32,33], that have addressed the effect of ankle taping on proprioception in healthy subjects found no evidence of increased proprioception.

The assessment the day after the removal of the tape made it possible to verify short term adaptation. Improved stability was observed the day after the removal of the tape indicating that short term learning had occurred. This could mean that the internal model was modified following taping and that the CNS was better able to control body sway even without the facilitation of the tape.

The effects observed are not likely due to the repetitive exposition to the assessment. The group assessed without application of tape showed that no learning effect occurred: the performance did not improve from the first condition to the other two conditions.

The data presented in this paper warrants further studies with higher methodological quality and so the present results should be interpreted with caution. There are several limitations to this preliminary study. The sample of subjects was small and did not cover a wide range of balance disorders, also a recruitment bias could have occurred since a convenience sample was recruited. The low power of the statistical analysis may have increased the likelihood of Type II error. Moreover, the lack of statically significant differences may be due to the lack of the effect of taping on some subjects with low level of sway.

A follow-up study with a control group matched for age, length of disease and type of balance disorder is necessary to reduce placebo effects and bias; in this perspective a sham treatment is necessary to blind subjects to treatment allocation and reduce the risk of compliance. An extensive platform assessment in different sensory contests should be added. The effect of taping in other tasks such as tandem stance and sit to stand should be assessed and the impact of taping in activities of daily living should be studied. Finally, a theory about the neurophysiological effect of taping would facilitate the generation of experimental hypotheses.

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All subjects signed an informed consent to the protocol. The study has been approved by local ethical committee.

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