

## Star Excursion Balance Test (SEBT): Comparison of Results with and without Neuromuscular Ankle Bandage

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### Abstract

**Study design:** Prospective study, simple crossover design.

**Background:** Proprioception is a cornerstone for maintaining joint and postural stability. Dynamic stability is particularly emphasized within these components. This feature is important in the rehabilitation field. Therefore, the quest for elements to improve these values can bring advantages in sports.

**Objectives:** Evaluate if there are advantages in the performance of a Star Excursion Balance Test (SEBT) using Kinesio taping.

**Methods:** We evaluated 10 professional soccer players from the Chilean women's national team. They were randomly divided into 2 groups. One group had Kinesio taping and their SEBT performance was evaluated. The other group performed the measurements without the use of Kinesio Taping. Afterward, each group performed the evaluation they did not do during the first stage. We then compared the performance achieved with and without the use of Kinesio Taping

**Results:** There were significant differences in the performance achieved by the players who had the SEBT bandage applied in comparison to the players that did no. This was confirmed by using the non-parametric Wilcoxon test for each of the SEBT positions.

**Conclusions:** Kinesio taping has positive implications in the SEBT. We can extrapolate that its use can improve the dynamic balance and thus become an important pillar in sports rehabilitation.

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## Introduction

Proprioception is the ability to identify the spatial position and movement of various parts of the body<sup>1</sup>. This is achieved through stimulation of the peripheral mechanoreceptors located in joints, muscles, and skin that send information of the location and movement of the limbs to the central nervous system<sup>2</sup>. This information is essential in order to maintain joint and postural stability<sup>3</sup>. These factors are significantly relevant in high-performance sports, where proper management of the body is key when performing movements requiring high accuracy.

Within the literature, different methods have been described to measure the different components of proprioception such as determining the balance or postural control on stable or unstable surfaces. These devices can be associated with computer systems that record slight changes in joint ranges or other parameters that may be used to improve the objectivity of the system<sup>4</sup>.

There are also evaluation systems requiring less complex techniques allowing wider dissemination. Among them, we found the Star Excursion Balance Test. This method seeks to evaluate the stability of the lower extremity, the progress of rehabilitation and the deficit caused by the injury thus identifying athletes who have a greater risk of subsequent injuries<sup>5</sup>.

There are different methods for improving proprioception after an injury. Emphasis is placed on the repetition of various exercises aimed at improving postural balance, usually performed on unstable surfaces in monopodestation, with varying levels of difficulty, while increasing the speed of the repetitions or by performing the exercises with the eyes open and then closed<sup>4</sup>.

Another method is the use of the Kinesio Taping, generally located on the affected joint before performing any movement or exercise<sup>4</sup>.

The objective is to re-educate the proprioceptive and neuromuscular system, improve posture, facilitate lymphatic drainage, reduce pain, accelerate injury repair, give support and provide joint stability. To show these properties, we conducted a study in selected women's football national players measuring the changes in the performance of the Star Excursion

Balance Test. We compared the results with and without Kinesio Taping.

## Materials and methods

We performed a prospective, single crossover design study. The study was approved to be implemented by the National Professional Football Association of Chile. The observation period was 2 weeks. In this study, 16 players participated between the ages of 14 and 21, all of them belonging to different Chilean national women's soccer team divisions.

Informed consent was applied to all participants prior to the start of the study. Within this group 6 players did not complete the study because they did not attend the second part of the evaluation, leaving 10 participants in the evaluative final group.

They were divided randomly into 2 homogeneous groups, where one of them performed the first evaluation with Kinesio Taping in both ankles and the second assessment without it (Figure 1). The other group performed in reverse order.

The evaluation method used was the Star Excursion Balance Test (SEBT). This evaluation consists in placing on a flat surface, a central point, and as of that point, lines are drawn forming an eight-pointed star (each line is born from the center point with 45° of difference with regards to the next line).

The subject to be evaluated, initially standing on the central point with both legs, must be kept standing on one leg in it, while reaching with the contralateral leg as far as possible along the vector corresponding to different directions. The subject must then return to a neutral position after each reach. The examiner manually measures the distance from the center of the star to the point that was reached with a tape measure in centimeters.

This movement indicates the distance of excursion. To normalize the different distances depending on the anatomical characteristics of each subject, we performed the following calculation: excursion distance [cm] / height lower extremity [cm] x 100 = Percentage of normalized excursion distance.

The nomenclature of the various movements is based on the relationship of the movement made with the anatomical position of the subject, going clockwise, which is anterior, anteromedial, medial, posteromedial,

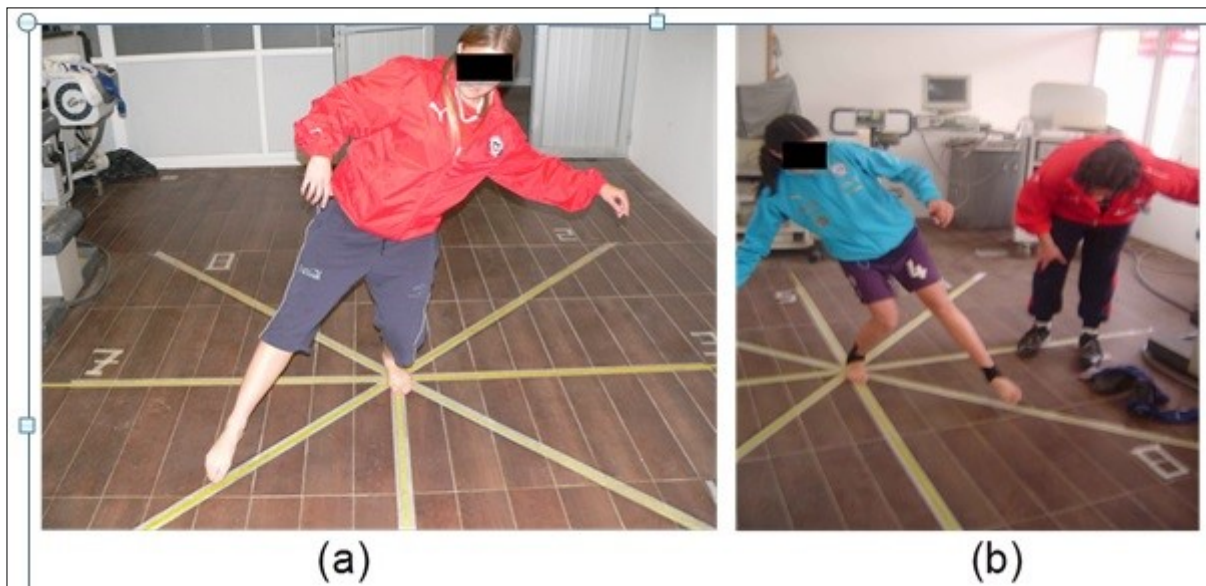


Figure 1. Start excursion balance test (SEBT), without neuromuscular taping (a) and with neuromuscular taping (b).

posterior, posterolateral, and anterolateral side.

If the examiner determines that the participant changes the position of the foot located at the center point, or is unable to maintain postural control during the test, the score achieved will be discarded and repeated.

Prior to measurement, participants are given the opportunity to perform 6 movements in each direction in order to minimize the learning effect, which could affect the results. After 5 minutes of rest, participants must make 3 attempts in each of the 8 directions, beginning with the previous position.

All participants must begin the exercise with their right leg on the center and after completing all 8 positions with the right leg, the participant performed another rest period of 5 minutes. Then, the same protocol was repeated with the left lower extremity. Kinesio Taping was applied to all the players with the same technique and by the same examiner. It starts with the foot in 90 ° of plantar dorsiflexion (Figure 2a). Bandaging is begun without tension at the medial border of the foot between the heel and the arch (Figure 2b). It continues along the plantar region until it reaches the lateral edge and the maximum tension is applied between lateral edges and the medial malleolus of the ankle (Figure 2c). Afterward, it is passed by the Achilles tendon following the line between the medial and lateral malleolus without tension (Figure 2d). From the lateral

malleolus to the medial border of the foot once again maximum tape tension is applied. The tape goes around the sole of the foot again without any tension between the medial and lateral border. (Figure 2e). Between the lateral edge of the foot and the lateral malleolus, 100% tension should be applied. From the lateral malleolus upward, 25% tension should be applied (Figure 2f). The last 5-7 inches are without tension. The R Project for Statistical Computing data analysis program was used.

## Results

The demographic characteristics of the study population are presented in Table 1. We performed data standardization based on the percentage of excursion for each of the movements of the Star Excursion Balance Test (Table 2 and 3).

We present a box plot (Figure 3) which shows the performance gap between the test with Kinesio Taping (neuromuscular bandage), and the one did without it. The hypothesis is that the performance achieved with the application of the bandage should be higher than when the bandage is not used.

The positive values are on the red dotted line, reflecting improved performance achieved with the bandage. If the value is reflected directly on the line, it means that there is no difference between the performances achieved, with or without a bandage. On the contrary, when these values are lower than 0, the performance achieved without bandage was superior to

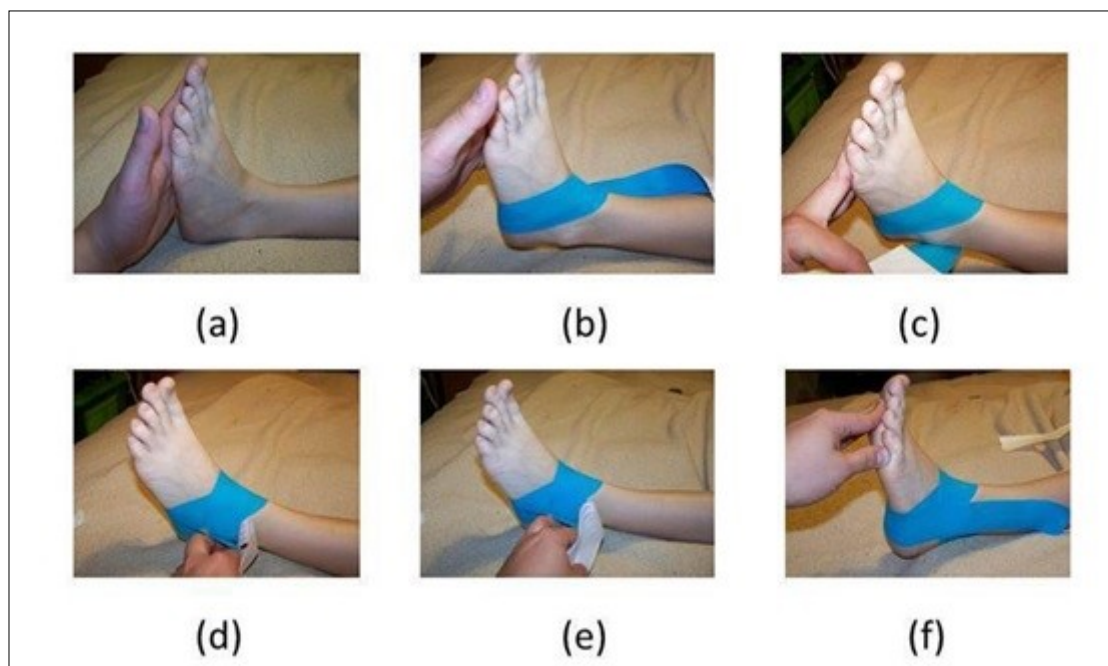


Figure 2. Neuromuscular taping technique. (a) initial position, (b) non-tension taping, (c) tension taping, (d) Aquile's heel part, (e) non tension plantar taping and (f) final taping.

Table 1. Demographic characteristics

Player	Age (year)	Weight	Left leg length (cm)	Right leg length (cm)
1	16,41	52	86,5	86,5
2	16,07	49	75	74,5
3	16,60	56	86	86
4	16,36	46	82	82
5	15,77	54	91	90,5
6	14,78	49	87	87
7	15,93	52	91	90,5
8	20,77	55	80,5	81
9	16,70	56	84,5	84,5
10	17,86	53	78	78
Mean	16,72	52,20	84,15	84,05

Table 2. Performance achieved with neurotape and without neurotape

Position	Anterior		Anterior right		Anterior left		Right		Posterior right		Posterior left		Left		Posterior	
	With	Without	With	Without	With	Without	With	Without	With	Without	With	Without	With	Without	With	Without
Group	Taping	Taping	Taping	Taping	Taping	Taping	Taping	Taping	Taping	Taping	Taping	Taping	Taping	Taping	Taping	Taping
	85,55	87,86	95,95	98,27	87,86	85,55	98,27	98,27	100,58	98,27	94,80	97,11	91,33	87,86	101,73	102,89
	101,33	98,67	98,67	102,67	86,67	84,00	105,33	109,33	110,67	110,67	96,00	97,33	93,33	88,00	110,67	112,00
	80,23	84,88	91,86	93,02	79,07	81,40	94,19	95,35	103,49	102,33	94,19	96,51	88,37	96,51	104,65	104,65
	89,02	90,24	93,90	96,34	82,93	85,37	97,56	93,90	93,90	93,90	80,49	82,93	68,29	70,73	97,56	98,78
	83,52	82,42	91,21	93,41	74,73	76,92	89,01	91,21	97,80	98,90	82,42	81,32	78,02	76,92	92,31	97,80
	86,21	86,21	90,80	91,95	78,16	80,46	93,10	94,25	102,30	101,15	93,10	95,40	87,36	95,40	103,45	103,45
	86,81	89,01	94,51	94,51	84,62	82,42	95,60	98,90	109,89	109,89	96,70	98,90	82,42	85,71	108,79	110,99
	86,96	89,44	99,38	99,38	70,81	73,29	116,77	118,01	104,35	106,83	104,35	109,32	96,89	99,38	108,07	108,07
	99,41	98,22	99,41	101,78	87,57	85,21	108,88	107,69	115,98	113,61	108,88	107,69	95,86	97,04	117,16	119,53
	103,85	105,13	107,69	106,41	91,03	91,03	110,26	111,54	114,10	114,10	103,85	105,13	96,15	96,15	119,23	120,51
	90,29	91,21	96,34	97,77	82,34	82,56	100,90	101,85	105,31 104,96		95,48	97,16	87,80	89,37	106,36	107,87
Mean																

Table 3. Performance achieved with and without neurotape. Normalized score in SEBT left leg.

Position	Anterior		Anterior right		Anterior left		Right		Posterior right		Posterior left		Left		Posterior	
	With Taping	Without Taping	With Taping	Without Taping	With Taping	Without Taping	With Taping	Without Taping	With Taping	Without Taping	With Taping	Without Taping	With Taping	Without Taping	With Taping	Without Taping
Group	85,55	87,86	95,95	98,27	87,86	85,55	98,27	98,27	100,58	98,27	94,80	97,11	91,33	87,86	101,73	102,89
	101,33	98,67	98,67	102,67	86,67	84,00	105,33	110,67	110,67	109,33	96,00	97,33	93,33	88,00	110,67	112,00
	80,23	84,88	91,86	93,02	79,07	81,40	94,19	102,33	103,49	95,35	94,19	96,51	88,37	96,51	104,65	104,65
	89,02	90,24	93,90	96,34	82,93	85,37	97,56	93,90	93,90	93,90	80,49	82,93	68,29	70,73	97,56	98,78
	83,52	82,42	91,21	93,41	74,73	76,92	89,01	97,80	97,80	91,21	82,42	81,32	78,02	76,92	92,31	97,80
	86,21	86,21	90,80	91,95	78,16	80,46	93,10	102,30	101,15	94,25	93,10	95,40	87,36	95,40	103,45	103,45
	86,81	89,01	94,51	94,51	84,62	82,42	95,60	109,89	109,89	98,90	96,70	98,90	82,42	85,71	108,79	110,99
	86,96	89,44	99,38	99,38	70,81	73,29	116,77	104,35	106,83	118,01	104,35	109,32	96,89	99,38	108,07	108,07
	99,41	98,22	99,41	101,78	87,57	85,21	108,88	115,98	113,61	107,69	108,88	107,69	95,86	97,04	117,16	119,53
	103,85	105,13	107,69	106,41	91,03	91,03	110,26	114,10	114,10	111,54	103,85	105,13	96,15	96,15	119,23	120,51
Mean	90,29	91,21	96,34	97,77	82,34	82,56	100,90	105,31	104,96	101,85	95,48	97,16	87,80	89,37	106,36	107,87

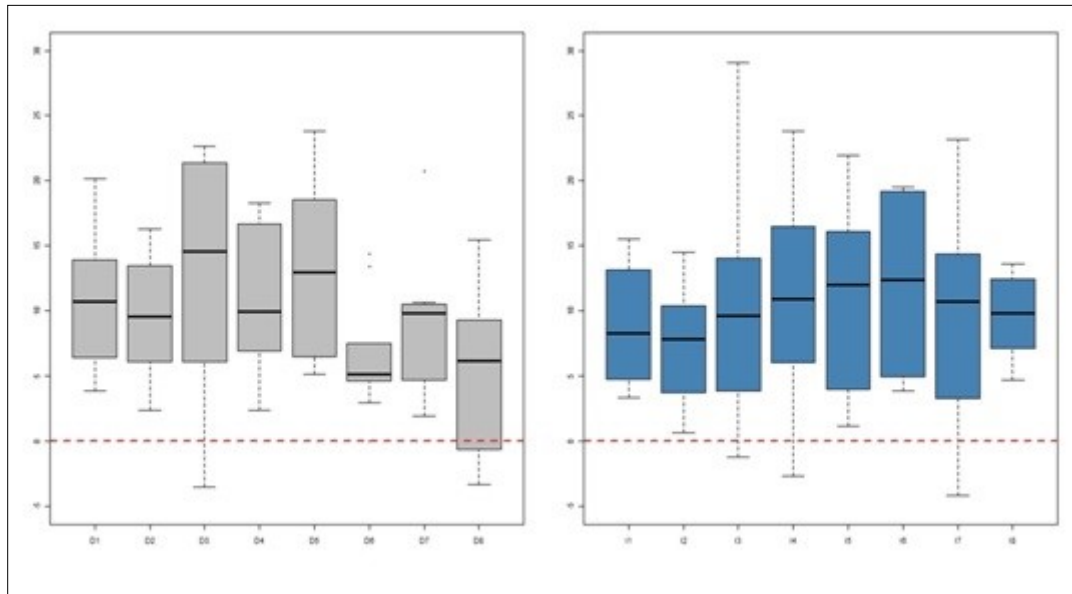


Figure 3. Boxplot showing the normalized scores for each evaluated SEBT position, for the right foot (grey) and left one (blue). They show the difference between the group using the neuromuscular taping and the one without it. Above the red dotted line the scores are a positive value which means a better achievement with the neuromuscular taping.

Table 4. Wilcox Test

Right leg		Left leg	
Position	Value	Position	Value
D1	99,90	I1	99,90
D2	99,90	I2	99,90
D3	99,80	I3	99,71
D4	99,90	I4	99,80
D5	99,90	I5	99,90
D6	99,54	I6	99,90
D7	99,90	I7	99,78
D8	98,15	I8	98,90
Mean	99,63	Mean	99,73

that achieved with a bandage. (The black lines show the average yield).

Each box plot represents one of the 8 positions evaluated for the right foot (gray) or left foot (blue). This demonstrates that higher yields are greater with the presence of Kinesio Taping than without it.

In addition, non-parametric tests were applied to each of the different positions in the SEBT. The results statistically confirm what is appreciated in the diagrams. The null hypothesis: is rejected in all cases to 2% level (98% confidence). That the averages SEBT yield with Kinesio Taping is the same or below the performance achieved without bandage this data is presented in Table 4.

### Discussion

Among the different sports, there is always the risk of injury, to a greater or lesser degree, and within this risk, the most commonly affected area is the ankle. In the United States, ankle injuries reach 2 million cases annually, corresponding to 20% of all injuries associated with sports<sup>5</sup>. In Chile, there are no large studies of incidence nationwide. Dysfunction caused by a sprained ankle can be very severe and can generate in up to 40% of patients a dysfunction that persists for at least 6 months<sup>8</sup>. Moreover, athletes with multiple episodes of ankle sprains presented a significant decrease in proprioceptive function, which in turn is a potential risk factor for re-injury<sup>7</sup>.

Within the context of a high incidence of injury, other global studies have focused on posing methods designed to improve proprioception, as a part of the rehabilitation of an ankle injury.

With regards to the use of proprioceptive exercises, there are some studies that support its use. Bernier and Perrin<sup>8</sup> in 1998 studied 48 subjects with functional ankle instability using progressive weekly proprioceptive exercises (monopedestacion balance on stable surfaces, on inclined surfaces and moving surface with open and closed eyes), for 6 weeks. Compared to the control group, significant improvements were found with regards to the postural balance measured before and after 6 weeks of exercise ( $p < 0.05$ )<sup>9</sup> Eils and Rosenbaum in 2001 studied 30 subjects with functional ankle instability, using weekly exercises (balance and monopedestacion standing on a platform moving on a

cushion of air on an inclined surface, among others) for 6 weeks<sup>9</sup>. Compared to the control group, significant improvements were shown in the reaction time of the long and short peroneus muscles measured by electromyography ( $p < 0.001$ ).<sup>10</sup>

Furthermore, Powers in 2004 studied 38 patients with functional ankle instability and proprioceptive exercises done through the use of Thera-Band for 6 weeks<sup>10</sup>. With regards to the control group, no significant differences before and after 6 weeks of exercise, in terms of postural balance and muscle fatigue as measured by electromyography<sup>11</sup>. Hess in 2001 studied 20 subjects with functional ankle instability<sup>11</sup>, using agility drills, jumps and rotations for 4 weeks. With regards to the control group, there were no significant differences in the postural balance<sup>12</sup>

On the use of Kinesio Taping Karlsson and Andreasson<sup>12</sup> in 1992 studied 20 subjects with functional ankle instability, measured by electromyography muscle reaction time to stimulus; with and without the use of an inelastic tape (Gibney Taping Technique) during the measurement. There was a significant decrease in muscle reaction time ( $p < 0.05$ ) with the use of tape<sup>13</sup>. Refshaug<sup>13</sup> in 2000 studied 25 subjects with recurrent ankle sprains compared to a control group of 18 subjects without injury. Both groups were separated into 2 groups (with and without tape) and measured the angular displacement of flexion and dorsi-plantar flexion, without obtaining significant differences in movement between the experimental and control groups, nor between groups with and without tape<sup>14</sup>. Matsusaka<sup>14</sup> in 2001 studied 22 subjects with functional ankle instability, separated into two groups, where one was subjected to a training monopedestacion balance on an unstable disk, 3 times a week for 10 weeks. The second group was also subjected to this training, but in addition, combined with the use of inelastic tape. Postural balance was measured at 2, 3, 4, 5, 6, 8, and 10 weeks and compared with previous results at the start of training. In the first group, there was a significant improvement in the postural balance after 8 weeks, and in the second group, the improvement was seen 4 to 6 weeks. However, when comparing between groups, there was a significant decrease in the level of postural balance in the second group compared with the first in each measurement performed during the fourth,



fifth and sixth week<sup>15</sup>. Delahunt<sup>15</sup> in 2010 studied 16 subjects with chronic ankle instability. Through the Star Excursion Balance Test, we measured the dynamic postural stability in 3 groups: there was no use of taping however lateral subtalar taping and taping fibular were used. There were no significant differences between groups with regards to the distances achieved, but if they significantly improved the perception of stability, confidence and security in those groups with taping<sup>16</sup>

Aminaka<sup>16</sup> studied 20 subjects with patellofemoral pain syndrome and 18 healthy subjects who underwent the SEBT test, separated into groups with and without the use of patellar taping use. We found significant improvement in the distance achieved in the group with taping, in subjects with patellofemoral pain syndrome, but not in the healthy group<sup>17</sup>

Due to the aforementioned, the results presented in our study do not differ too much from the international series. Multivariate analysis shows the increase in performance in the TBEE through the use of Kinesio taping (Figure 2).

We should note, however, that despite the extensive validation TBEE, is an indirect method of assessing the proprioception of the subject under study. Therefore to improve and validate the results presented, it is necessary to use direct methods of assessment and electromyography. Another important point of analysis is for what period of time the functionality of the Kinesio Taping is maintained, which would have a direct impact on its correct use in sports.

### Conclusion

We can say that the Kinesio Taping has an effect on the Star Excursion Balance Test. Therefore, it could be a factor that improves dynamic balance and thus become a useful tool in therapies aimed at recovering acute ankle injury, both in the primary stage and in the progressive reintegration to the competitive field.

### Conflict of Interest

We declare no conflicts of interest.

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