The effect of motor control exercises versus back muscle endurance training with kinesio taping on the balance indices in patients with nonspecific chronic low back Pain

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ABSTRACT:
Aims and Background: In patients with low back pain, postural sway is more than normal people. The aim of this study was to compare the effect of motor control exercises (MCE) and back muscle endurance training with kinesio taping (BMET&KT) on the on the balance indices in patients with nonspecific chronic low back Pain (NCLBP).

Methods and Materials: For this single-blind randomized controlled trial, 33 patients with NCLBP were selected through convenience sampling and randomly divided into two groups of the MCE and BMET&KT. Exercises of the both groups were performed 3 times per week for 5 weeks. Before and after the treatment, overall, Anteroposterior and lateral stability indices were measured by Biodex Balance System in both static and dynamic conditions with the eyes open and closed on both legs. Paired t-test and independent sample t-tests were used for analyzing the data.

Results: In the MCE group, the overall stability index (OSI) and anteroposterior stability index (APSI) in static condition with eyes closed and lateral stability index (LSI) in static condition with open eyes reduced from 1.01 ± 0.35 to 0.71 ± 0.36 (P = 0.003), 0.84 ± 0.35 to 0.57 ± 0.32 (P = 0.008) and 0.14 ± 0.07 to 0.10 ± 0.04 (P = 0.020) respectively. In the BMET&KT group, the OSI and APSI in static condition with eyes open and LSI in dynamic condition with eyes open reduced from 0.35 ± 0.15 to 0.24 ± 0.10 (P = 0.009), 0.25 ± 0.09 to 0.18 ± 0.08 (P = 0.003) and from 0.63 ± 0.28 to 0.44 ± 0.20 (P = 0.008) respectively. Except APSI in static condition with eyes open, there wasn’t significant difference between the two groups (P > 0.05). Conclusion: The MCE were more effective on the static balance in eyes closed condition. While, BMET&KT were more effective on the static balance in the eyes open condition. But there wasn’t any difference between the two treatment methods in terms of the improvement of the postural stability.

Keywords: Low back pain, back muscle endurance training, kinesio taping, motor control exercises, balance indices
INTRODUCTION
Low back pain is considered worldwide as a major problem (1). It is highly prevalent in adolescence, but in the middle age which is considered as a part of the most productive years of a person’s working life, is most prevalent (1). This can result a large economic impact on individuals, families, businesses and governments (1-4). Based on duration of symptoms, low back pain is divided into three categories: acute, sub-acute and chronic (5). There are many challenges associated with chronic low back pain, because it does not tend to improve over time and also consumes more financial resources(5). Except for 5% to 10% of the low back pain cases that have specific cause, the rest of the low back pain cases have no specific cause and are classified in non-specific group (6). People who suffer from chronic low back pain compared to healthy people have more postural sways, so these people have impaired postural control (7-14). Postural control is controlling the body position in space for the dual purposes of stability and orientation. The ability to maintain a proper relationship between body segments and between the body and environment for a task, called postural orientation. The ability to control center of mass (COM) in relation to base of support called balance or postural stability. The ability to control the position of our body in the space is fundamental to everything we do. All tasks need postural control (15). The optimal control of the balance in an upright position and postural stability are the essential items for daily activities and also prevent musculoskeletal injuries (16). The results of many studies show that people with low back pain compared to healthy people have more speed average and total displacement at the center of pressure and greater fall risk. In addition, people with low back pain have less limits of stability compared to healthy people. Also in people with low back pain, hip strategy is reduced and dependency on eyes is increased. The analysis of shifting the center of pressure also showed their inability to start and control the hip strategy. Therefore, as the evidences shows, people with low back pain compared to healthy people have postural inability (7-14). So far, many interventions have been conducted with the aim of influencing the balance. Salehivand and Meamār showed that the core stability training programs with the Swiss ball and without the Swiss ball in people with non-specific chronic low back pain improves the static and dynamic balance (17). Nikbiz and ibeygi showed that 6 weeks of core stability training increases dynamic balance among females with CLBP (18). Karimi and et al showed that all the indices of the dynamic balance with eyes closed (standing on both feet) and LSI in dynamic condition with open eyes (standing on both feet) after conduction of a stabilization program (10 consecutive days) in people with CLBP reduced (19). Andrusaitis and et al showed that in women with non-specific CLBP, stabilization exercises and trunk strengthening exercises have no effects on static balance in eyes open and closed condition (20). If we consider the motor control exercises or specific spinal stabilization or core stabilization exercises or the protocols targeting specific muscles of body to improve the control and coordination of the spine and pelvis as motor control exercise (21), Review the above studies show that MCE are effective on balance of people with low back pain. The perception of a person’s body position and movement in space is part of the complex motor control task of the balance. This perception of the body position and movement needs a combination of information obtained from peripheral receptors within various sensory systems including vision, somatosensory (proprioceptive receptor, joints and skin receptors) and vestibular system (22). Information obtained from receptors in the muscles, skin and joints forms proprioceptive system (23). In people with LBP lumbar proprioception is impaired (24-28). Paoloni et al showed that the use of kinesio taping in people with non-specific CLBP leads to lumbar muscle function normalization immediately after it is...
used. This effect of kinesio taping also was stable until a short period of time (29). Voglar and Sarabon showed that lumbar region kinesio taping have beneficial effects on the anticipatory postural adjustments in young people without pain (30). Bae et al showed that kinesio taping have positive effects on the anticipatory postural control in people with CLBP (31). Another factor that can have a significant impact on postural control in healthy individuals is back muscles fatigue (32). On the other hand the back muscles endurance in people with LBP is impaired (33, 34). Bala et al showed that back muscle endurance training reduces pain and increases back muscles endurance level in patients with sub acute non-specific LBP (35).

Although the balance is a complex motor control task and various factors and systems affect its performance (22). However, no study has compared the effects of motor control exercises and extensor muscles endurance exercises combined intervention method with kinesio taping on the balance in people with non-specific CLBP. Comparison of their effects to choose an appropriate treatment for the patient with LBP is a scientific challenge and interesting for physiotherapists. Therefore, the aim of this study was to investigate the effect of motor control exercises and back muscle endurance training with kinesio taping on the balance indices in people with non-specific CLBP. The assumption was that the both treatment methods of motor control exercises and back muscle endurance training with kinesio taping increase postural stability and the influence of motor control exercises in increasing postural stability will be more compared to other group.

METHODS AND MATERIALS

Study plan: This single-blind randomized clinical trial was conducted in 2016 at the Zahedan University of Medical Sciences. Thirty-three people with NCLBP were classified randomly into two groups of motor control exercises (n = 17) and back muscle endurance training with kinesio taping (n = 16). The subjects were unaware of the existence of two training groups; so this study was single-blind. Motor control exercises for 5 weeks, 3 sessions per week at the clinic and 3 sessions at home and back muscle endurance training with kinesio taping like the first group were conducted. Study variables were measured before and after treatment.

The study population and patients screening: For this study, thirty-three patients with NCLBP were selected by convenience sampling. Inclusion criteria were: age between 18-58 years, patients with non-specific CLBP who their pain was relieved with rest and exacerbated with activity (19). no vestibular, hip musculoskeletal and lower extremity disorders (20), no history of radicular pain, spinal stenosis, any neurologic signs, systemic infection, cardiovascular and balance disorders, uncorrected vision problems, severe deformity of musculoskeletal and injury to the extremities or taking medication a week before the test (19), no pregnancy (36), no history of diabetes, respiratory disorders, spinal surgery, nerve root pain, severe spinal deformity or disease (37), no history of metabolic, systemic, inflammatory, arthritis and malignancy diseases . The exclusion criteria were: patients who were absent more than three consecutive treatment sessions (20), patients who exercises exacerbated their pain and discomfort (20) and receiving or doing other medical procedures during the study. The patients were enrolled in the study after reading and signing the informed consent tab. This study was approved by the scientific and ethics committee of Zahedan University of Medical Sciences. Rights of the patients were retained during the all study periods.

Data Collection: Individuals were interviewed to ensure compliance with inclusion and exclusion criteria of the study. Meter with accuracy of centimeters to measures the height of the patients, digital scale to measure the weight (to calculate body mass index) and Biodex Balance System for
measurement of balance indices were used to collect data.

**Randomization:** Randomization into two groups was done by clinical physiotherapist and through replacing triple blocks.

**Assessment of balance indices:**
OSI, APSI and LSI were measured by SD Biodex Balance System. (Balance System SD 950-304Inc., Shairly, N Y, USA). Biodex Balance System consists of a circular moving force disc, 55 cm in diameter at a height of 20 cm from the ground within the body of the device. This force disc is able to rotate in different directions up to 20 ° relative to the horizontal plane (38-41). In this device, there is a small computer with a keyboard and display on a stand, vertically, to when the subject is standing on the force disc is in front of him. The hardship of the force is adjustable; this means that the system is capable of changing the difficulty from 1 (least stable status) to 12 (most stable status) (38, 41). To assess the balance of the subjects in static and dynamic condition, postural stability test of the Biodex stability system was used. This test indicates the subject’s ability to maintain the center of balance. This test has three OSI, APSI and LSI parameters (38). Overall stability index represents the variance of device disc displacement on the degree relative to the horizontal plane. APSI reflects the variance of the device disc displacement on degree relative to the horizontal plane for the sagittal plane movements. Lateral stability index reflects the device disk’s displacement variance in degrees relative to the horizontal plane for the frontal plane movements. Individual score in this test shows the deviation from the center. Therefore, the lower scores indicate better balance (38-41). To test the postural stability in dynamic situation, the degree of difficulty for the device was 8 (42). During the postural stability test hands were crossed on the chest (38). During the postural stability test subjects were taught that when they are balancing on the platform maintain the cursor directly in the center of the screen. During the test, subjects were trying to maintain their balance by looking at a target on the screen and maintaining a certain point in the center of the target (9). During the test, the subjects were not allowed to touch the devices guards (37). In this study, postural stability test was conducted in dynamic and static condition and with eyes open and closed on the both feet. Every test consists of three trials and each trial lasted 20 seconds. 10 seconds rest between each trial was given. There was also a 5 minutes interval between each test (38).

**Treatment:**
After the first session that the balance of the subjects was measured, both groups received their exercises three times a week and for five weeks under the supervision of a physiotherapist (the physical therapist who evaluated the balance). In addition, the patients were asked to do their exercises three times a week (days do not exercise in clinic) at home. It should be noted that patients of the each groups received Burst TENS and Hot Pack modalities for 20 min at the beginning of each session at the clinic.

**Motor control exercises group:**
Exercises of the motor control group was established based on the treatment method reported by Richardson et al (43, 44) and as well as previous studies conducted in this field (45-47). These exercises consist of three general steps:
First step: At first local stabilizing muscles with minimal power and isometric were active in positions where the amount of force was minimum, meaning in supine, and quadruped, sitting and standing positions. Clinical physiotherapist taught the patients how to contract the muscles independent of the superficial muscles. Gradually, the contraction time was added until the patient was able to repeat 10 contractions with maintaining it for 10 seconds during normal respiration rhythm. Then the patient progressed to the next step (43, 45, 46).
The next step consists of: Closed chain exercises, low speed and low load: The purpose of this step was to maintain the contraction of the deep stabilizing muscles, while gradually the load cues
were progressed through the body using weight-bearing closed chain exercises. Weight bearing load was added very slowly. The focus was on activation of the local stabilizing muscles and weight-bearing muscles of the lumbar spine and pelvis and their ability to maintain static lumbopelvic posture for weight-bearing (47).

Third step consists of: Open chain exercises, high speed and high load: The purpose of this step was that while continuing to hold the segmental control, the load was added through the open kinetic chain movement of adjacent segment. The main focus of this step was integration of all the muscles (deep stabilizing, bearing and non-weight bearing) into functional movement tasks (44, 47).

**Back muscle endurance training with kinesio taping group:**

BMET&KT group program was the following:

Patients in each session did the extension exercises first, and then kinesio taping was done for people. The extension exercises protocol was performed as the following:

The beginning of all exercises was like this: the subject was laid to the prone position. Pillows that supported the hip/upper thigh and the legs without using the holder belt were used. This protocol has five different exercises. All subjects began the exercise from the first training position. When subjects could hold a given position for 10 seconds and perform 25 repetitions (10 second rest between each attempt), were progressed to the next step of the exercises. Five steps of the exercises were as following:

1. The subject laid to prone position while his hands were beside him. Then, he raised the head and the trunk from neutral to the extension position from the table.
2. The subject laid to prone position while his hands interlocked at the occiput (shoulders were in abduction 90 and the elbows were in flexion position). Then, he raised the head, trunk from neutral to the extension position from the table.
3. The subject laid to prone position while brought his hands elevated forward. Then, he raised the head, trunk and the elevated arms from neutral to the extension position from the table.
4. The subject laid to prone position. Then he raised the head, trunk and the contralateral arm and leg from the neutral position to the extension from the table.
5. The subject laid to prone position while his shoulders and elbows were in abduction 90 and flexion position, and lifting the head, trunk and both legs (with knees extended) off the table (48).

**Kinesio taping:**

Three strips of 20 cm × 5 cm kinesio tape (DARCO(Europe)GmbH, Raising, Germany) was put at the lumbar spine between the fifth lumbar vertebrae and twelfth thoracic vertebrae (were diagnosed by hand by physiotherapist). One of the strips was placed on the midline (the line that is coinciding to the spinouts processes). Two other strips were placed by a distance of 4 cm from the first strip on the left and right erector spine muscles. The patients were asked to lean forward in the process of kinesio taping. No tension, except to cover the lumbar in the bent forward position, was applied (29). A physiotherapist taped all patients in this group.

**Sample size determination:**

The number of samples was determined based on the pilot study. In the first 10 patients were selected and classified randomly into two study groups and the main stage of the study was performed on them. Based on the obtained mean and SDs from these two groups, the number of needed sample for the main study was estimated with a confidence level of 95% and 90% power of test.

**Statistical analysis:**

Data were analyzed by spss 16 after collecting. Normal distribution of data was evaluated by K-S test. Levine s test was used to test for equality of variances. For normally distributed data, paired t-test was used for comparing the results before and after intervention of each group (within group) and independent t-test was used to compare results before and after intervention between the two.
groups (between groups). For non-normal distributed data, Wilcoxon and Mann-Whitney U tests were used respectively for comparison of the results before and after interventions within group and between groups. α level was less than 5%.

RESULTS:
The mean and SD of age, weight, height and BMI for motor control exercises group was 24.41 ± 4.28 years, 63.23 ± 10.92 kg, 1.71 ± 0.06 m and 21.56 ± 3.04 kg/m² respectively. The mean and SD of age, weight, height and BMI for back muscle endurance training with kinesio taping group was 26. 26 ± 5.77 years, 66 ± 14.09 kg, 1.70 ±0.08 m and 22.62 ± 4.08 kg/m² respectively (Table 1). Sample size of 30 patients for two groups (15 per group) was estimated by using the pilot study. 33 eligible patients completed the study. Compliance of distribution of data with normal distribution was assessed by K-S test. The results showed that the distribution of all data was normal. Mean and standard deviation of the data related with overall, anteroposterior and lateral stability indices while standing on both feet in both static and dynamic conditions with eyes open and closed, comparison of the results of after treatment than before of each group and p-value related to them and comparison of the results of after treatment between groups and p-value related to them are summarized in Table 2.

Within group comparison: In MCE group, OSI and APSI in static condition with eyes closed and LSI in static condition with eyes open showed significant decrease in comparison with the before intervention (P < 0.05). LSI in static condition with eyes closed, OSI and APSI in static condition with eyes open, OSI and APSI and LSI in dynamic condition with eyes open and closed did not show significant difference in comparison with before the intervention (P > 0.05) (Table 2).

In back muscle endurance training with kinesio taping group, OSI and APSI in static condition with eyes open and LSI in dynamic condition with eyes open showed significant decrease in comparison with the before intervention (P < 0.05). OSI and APSI and LSI in static condition with eyes closed, LSI in static condition with eyes open, OSI and APSI and LSI in dynamic condition with eyes closed and OSI and APSI in dynamic condition with eyes open did not show significant difference in comparison with before the intervention (P > 0.05) (Table 2).

Between group comparison: To determine the correct randomization process, we compared the pre-treatment data of two groups with each other. The results showed that there is no significant difference between the two groups in terms of the studied variables and patients were matched in two groups in terms of the studied variables (P > 0.05). Comparing the after treatment results between the two groups showed that except for APSI variable (in static condition with eyes open) there was no statically significant difference between the two groups (Table 2). Review of data showed that the mentioned index showed significant decrease after treatment comparing with the before treatment in back muscle endurance training with kinesio taping group, but it was not in motor control exercises group (Table 2).

DISCUSSION:
The results of this study supported part of the first hypothesis that MCE and BMET&KT increase postural stability. But unlike the second hypothesis, there was no difference between the two treatment methods in terms of the improvement of the postural stability.

Our results indicated that motor control exercises improve overall and anteroposterior stability indices in static condition with eyes closed and medial-lateral stability index in static condition with eyes open; But these exercises had no effect on medial-lateral indices in static condition with eyes closed, overall and anteroposterior stability index in static condition with eyes open and overall, anteroposterior and medial-lateral stability indices in dynamic condition with eyes open and closed. Back muscle endurance training with kinesio taping exercises improved overall, anteroposterior stability indices in static condition
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with eyes open and medial-lateral stability index in dynamic condition with eyes open. While it had no effect on overall, antroposterior and medial-lateral stability indices in static condition with eyes closed, medial-lateral stability index in static condition with eyes open, overall and antroposterior and medial-lateral stability indices in dynamic condition with eyes closed and overall and antroposterior stability indices in dynamic condition with eyes open. Only, improvement of the antroposterior stability variable in static condition with eyes open in Back muscle endurance training with kinesio taping exercises group was more than motor control exercise group.

Andursaitis et al showed that stabilization exercises don’t have influence on the static balance in both eyes open and closed condition (20). The results of our study did not agree with these results. Maybe this difference was due to low sample size of their study compared to our study. Karimi et al showed that 10 consecutive days of supervised stability exercises improve most of the dynamic stability indices in people with LBP (19). Nikbin and Ilbeygi showed that 6 weeks of core stability exercise increases dynamic balance of girls with CLBP (18). However, our study did not confirm these results. Maybe, the lack of motor control exercises effect on dynamic balance is because of this that a key aspect of balance during locomotion is the control of the mass of head, trunk and arms with respect to the hips. Since this is a large load to keep upright (49). Winter et al hypothesized that dynamic balance of head, trunk and arms is controlled by hip muscles and approximately without interference of leg muscles (49). However, invention of motor control exercises was based on the principle that people with LBP have lack of the trunk muscles control. The idea is to use a motor learning approach to retrain the optimal control and coordination of the spine. Therefore, motor control exercises includes the training of reactivation of deep trunk muscles with progress towards static, dynamic and functional tasks in order to integrate activation of deep trunk muscles with global trunk muscles (21).

Our results showed that back muscle endurance training with kinesio taping exercises improve static balance in sagittal plane with eyes open and dynamic balance in frontal plane with eyes open.

In healthy men, there is a positive relation between trunk muscles endurance level (flexors, extensors and lateral flexors of the trunk) and static balance (50). Parreira et al showed that in healthy people trunk extensor muscles fatigue has a substantial effect on the postural control in static condition (eyes open) (32). In the other hand, Adegoke and Babatunde showed that following the back muscle endurance training, endurance level of the back muscles improves (48). So maybe this improved static balance in BMET&KT group is because of back muscle endurance trainings.

But perhaps improved lateral stability in a dynamic condition with eyes open was due to the following: a) Extensor muscles of the hip joints must maintain the pelvis in an extension position than thighs to easily raise the trunk from the prone position by trunk extensor muscles (51). Perhaps these muscles associated with back muscles were involved in the improving the balance. Because a key aspect of balance during locomotion is controlling the head, trunk and arms mass motion is related to the hip joints (49). b) Using of the kinesio taping in people with non-specific CLBP results to the lumbar muscles function normalization immediately after using them. This kinesio taping effect is stable for a short period of time (29). Voglar and Sarabon and Bae et al showed that kinesio taping has positive effects on anticipatory postural control in healthy individuals and people with CLBP respectively (30, 31). Maybe these kinesio taping effects have improved the balance. Maybe all of the above factors had a role in improving the balance. For identifying the role of kinesio taping and endurance training in improving the balance of the people with non-specific CLBP, it is recommended that the role of...
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CONCLUSION

Motor control exercises were more effective on static balance in eyes closed condition. While back muscle endurance training with kinesio taping exercises were more effective on static balance in eyes open condition. But there was no difference between the two treatment methods in terms of the improvement of the postural stability.

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Table 1. Comparing demographics between the two groups

<table>
<thead>
<tr>
<th>variable</th>
<th>MCE group: n = 17</th>
<th>BMET&amp;KT group: n = 16</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>24.41 ± 4.28**</td>
<td>26.26 ± 5.77</td>
<td>0.307</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>63.23 ± 10.92</td>
<td>66 ± 14.09</td>
<td>0.543</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.71 ± 0.06</td>
<td>1.70 ± 0.08</td>
<td>0.814</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>21.56 ± 3.04</td>
<td>22.62 ± 4.08</td>
<td>0.415</td>
</tr>
</tbody>
</table>

*: P< 0.05 significant

**: Data are expressed as mean ± SD

Figure 1. Flow diagram of the progress through the phases of the randomized trial

Table 2. Comparison of the data after and before treatment of the overall, anteroposterior and lateral stability in two groups and comparison of the after treatment results between the two groups.
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<table>
<thead>
<tr>
<th>variable</th>
<th>MCE group n = 17</th>
<th>BMET&amp;KT group n = 16</th>
<th>Comparison of the results after treatment between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before intervention</td>
<td>After intervention</td>
<td>P- value</td>
</tr>
<tr>
<td>SEcOSI</td>
<td>1.01 ± 0.35</td>
<td>0.71 ± 0.36</td>
<td>0.003*</td>
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<tr>
<td>SEcAPSI</td>
<td>0.84 ± 0.35</td>
<td>0.57 ± 0.32</td>
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<td>0.22 ± 0.05</td>
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<td>SEoAPSI</td>
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<td>0.27 ± 0.44</td>
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<td>SEoLSI</td>
<td>0.14 ± 0.07</td>
<td>0.10 ± 0.04</td>
<td>0.020*</td>
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<tr>
<td>DEcOSI</td>
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<tr>
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<tr>
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<td>DEoLSI</td>
<td>0.58 ± 0.25</td>
<td>0.47 ± 0.15</td>
<td>0.069</td>
</tr>
</tbody>
</table>

*: P< 0.05 before and after treatment (within group) is significant

**: P< 0.05 after between group treatment is significant

***: Data are expressed as mean ± SD

SEcOSI: Static Eyes Closed Overall stability index
SEcAPSI: Static Eyes Closed Anteroposterior Stability Index
SEcLSI: Static Eyes Closed Lateral Stability Index
SEoOSI: Static Eyes Open Overall stability index
SEoAPSI: Static Eyes Open Anteroposterior Stability Index
SEoLSI: Static Eyes Open Lateral Stability Index
DEcOSI: Dynamic Eyes Closed Overall stability index
DEcAPSI: Dynamic Eyes Closed Anteroposterior Stability index
DEcLSI: Dynamic Eyes Closed Lateral Stability index
DEoOSI: Dynamic Eyes Open Overall stability index
DEoAPSI: Dynamic Eyes Open Anteroposterior Stability index
DEoLSI: Dynamic Eyes Open Lateral Stability index

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