

## Original Article

# Effect of balance taping on trunk stabilizer muscles for back extensor muscle endurance: A randomized controlled study

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## Abstract

**Objective:** The purpose of this study was to investigate the difference in back extensor muscle endurance before and after kinesiology tape application to all back stabilizer muscles and to the erector spinae alone. **Methods:** We assessed 32 adults (16 men and 16 women), randomly divided into two groups. In the erector spinae taping (EST) group, kinesiology tape was applied only to the erector spinae, and in the total muscle taping (TMT) group, kinesiology tape was applied to the erector spinae, latissimus dorsi, lower trapezius, internal oblique abdominis, and external oblique abdominis. **Results:** Both groups showed significant difference in terms of back extensor muscle endurance after kinesiology tape application ( $p < 0.05$ ). Between-group comparison revealed that the TMT group had more back extensor muscle endurance than the EST group ( $p < 0.05$ ) after kinesiology tape application. **Conclusions:** These findings indicate that, to improve back extensor muscle endurance, kinesiology tape should be applied to all back stabilizer muscles, rather than to the erector spinae muscles alone.

**Keywords:** Back Extensor, Balance Taping, Endurance, Kinesiology Tape, Trunk Stabilization

## Introduction

Trunk stabilization refers to the optimization of posture for conscious and unconscious movements, maintenance of upright posture, and stabilization of arm and head movements<sup>1</sup>. Greater trunk stabilization may be achieved when several muscles are co-activated as a system than when a single muscle is activated<sup>2</sup>. Trunk stabilizer muscles reduce excessive loading between the intervertebral joints and play an important role in maintaining the stability of the

spine<sup>3</sup>. Trunk stabilizer muscles are connected via fascia, and superficial muscles and deep muscles control the positions of the trunk to facilitate trunk stabilization<sup>4</sup>.

Muscle endurance refers to the ability of a muscle to maintain a posture or perform movements. The weakening of the endurance of trunk stabilizer muscles may result in back dysfunction and chronic low back pain<sup>5</sup>. However, prolonged activity of trunk stabilization muscles gives rise to fatigue in one or more muscles, which may lead to the loss of neuromuscular control and cause tissue damage and back pain from uncontrolled movements<sup>6</sup>. Individuals with weakened trunk extensor muscle endurance experience lumbar and pain, which are caused by strain, dysfunction, and inhibition of the erector spinae<sup>7</sup>.

Muscle fatigue is defined as a reduction in the maximal force or force capacity of muscles after sustained physical activity<sup>8</sup>. Muscles with pain or weakness tend to be fatigued more quickly, resulting in a decline in the ability to perform physical activities<sup>9,10</sup>. When the endurance of the trunk stabilizer muscles decreases due to muscle fatigue, concentric

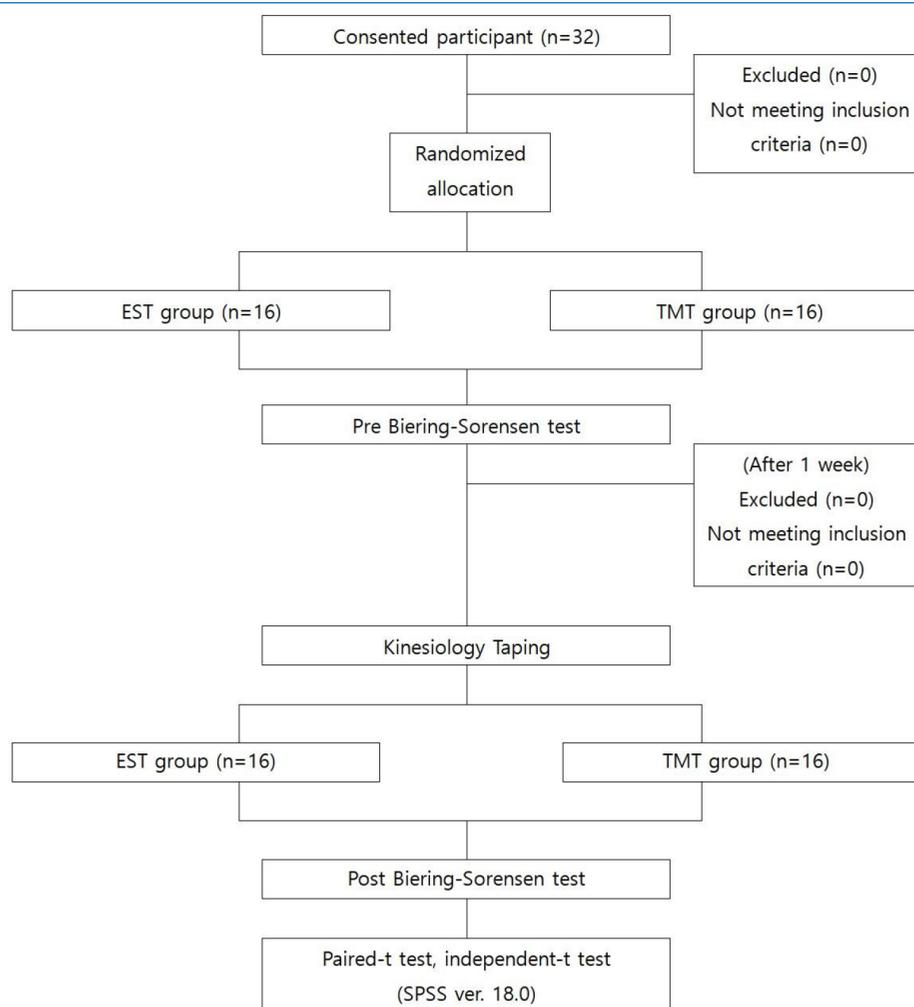
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**Figure 1.** Flowchart for the study.

and eccentric signal patterns are disturbed, leading to a decline in the response rate of muscles<sup>11</sup>. Muscle fatigue also reduces exercise performance and increases the risk of pain and injury<sup>12,13</sup>. As such, in cases of spinal instability, increasing muscle endurance may be more important than muscle strength training<sup>3</sup>.

Recently, kinesiology tape has been used in the treatment of muscle fatigue<sup>14</sup>. It has been reported that tactile stimulation from kinesiology tape application on the skin stimulates the skin receptors<sup>15</sup>, leading to pain reduction<sup>16</sup> and increased joint range of motion<sup>17,18</sup> and muscle strength<sup>19</sup> and pelvic alignment<sup>20</sup>. However, the effect of kinesiology tape on back muscle strength is controversial. Knapman et al. reported that the peak torque of maximal lumbar extension increased when kinesiology tape was applied to the erector spinae of asymptomatic subjects<sup>21</sup>. In contrast, Lee and Kim reported no significant difference in the maximal power of trunk extensors and in muscle activity when kinesiology tape was applied to the erector spinae in asymptomatic subjects<sup>22</sup>.



**Figure 2.** Application of the kinesiology tape on erector spinae muscle.



**Figure 3.** Application of the kinesiology tape on erector spinae, latissimus dorsi, lower trapezius, internal oblique abdominal, external oblique abdominal muscle. (A) Erector spinae (B) Latissimus Dorsi (C) Lower Trapezius (D) Internal Oblique Abdominis (E) External Oblique Abdominis.

In addition, kinesiology tape was applied only to the erector spinae, and no significant difference in back function and pain was found after such application<sup>23-25</sup>. Hagen et al. reported no significant difference in back muscle endurance when kinesiology tape was applied to the erector spinae in subjects with nonspecific low back pain<sup>26</sup>.

As such, most previous studies that used kinesiology taping as an intervention for increasing trunk muscle strength<sup>21,22</sup> and for improving pain applied kinesiology tape only to the erector spinae<sup>23-27</sup>, and very few studies attempted the application of kinesiology tape to other trunk stabilizer muscles in addition to the erector spinae in healthy subjects.

Thus, the present study aimed to compare the effects of kinesiology taping on back extensor muscle endurance when kinesiology tape is used only for the erector spinae and when it is used for all trunk stabilizer muscles (erector spinae, latissimus dorsi, lower trapezius, internal oblique abdominis, and external oblique abdominis) in healthy participants.

## Materials and methods

### Participants

To calculate the sample size for each group, G-Power 3.1 (University of Dusseldorf, Dusseldorf, Germany) was used. Assuming a significance level (alpha level) of 0.05, a statistical power of 80%, and an effective size of 0.90, the sample size was calculated to be 15 participants for each group<sup>28</sup>. We enrolled 32 adults (16 men and 16 women) who agreed to participate in our study. The eligibility criteria were the following: no medical history of musculoskeletal disorders of the spine in the past 6 months; no current neurological or orthopaedic contractures; no diagnosis of scoliosis or



**Figure 4.** Biering-Sorensen test.

disc herniation by a medical doctor in the past 6 months; no history of contact dermatitis or cutaneous adverse reaction to kinesiology tape. The present study was approved by the Institutional Review Board of Dong-eui University (DIRB-201806-HR-R-023).

### Study design

This was a randomized controlled study. An examiner who did not participate in the measurement used computer-generated random numbers for the randomization sequence

**Table 1.** General characteristics of participants.

	EST (n=16)	TMT (n=16)	p
Sex (male/female)	8/8	8/8	1.0
Age (years)	37.88±4.19 <sup>†</sup> (28-50) <sup>†</sup>	38.94±5.61 (28-48)	0.70
Height (cm)	168.50±8.23 (158-180)	164.87±5.35 (158-182)	0.80
Weight (kg)	63.87±10.86 (52-85)	67.49±10.87 (50-79)	0.94

<sup>†</sup>Values are presented as mean±standard deviation (range). \*p<0.05. EST, Erector spinae taping; TMT, total muscle taping.

generation process, and the allocation sequence was concealed until the participants were recruited and assigned to each group. Thirty-two participants were randomly assigned to either the erector spinae taping (EST) group (control group) or the total muscle taping (TMT) group (experimental group) using envelopes. All measurements were carried out by the same examiner, who had 15 years of experience. The kinesiology tape was applied to both the EST and TMT groups by a single physical therapist with more than 10 years of experience in kinesiology taping. All participants underwent the Biering-Sorensen test (BST) 1 week before and immediately after the kinesiology tape application. The flowchart representing the steps followed in this study is presented in Figure 1.

#### Instrument

We used the KOD Slant SR-90 (Japan), with a precision of 0.5°, weight of 110 g, and dimensions of 95×95×30 mm (length×width×height). This instrument, which measures the angle against the horizontal plane, was secured to the lumbar region of the participants with an elastic strap to assess the trunk horizontality maintained by the participants and measure the changes in the angle from trunk flexion.

#### Kinesiology tape application

The physical therapist applied the kinesiology tape (BB Tape; WETAPE Inc., Pyeongtaek, Korea) with stretch of approximately 20-25% to the trunk muscles of the participants while they were in relaxed standing position<sup>29</sup>. In the EST group, the kinesiology tape was applied to the erector spinae along both sides of the transverse process from the sacroiliac joint to the eighth or ninth rib (Figure 2)<sup>29</sup>. In the TMT group, balance taping using kinesiology tape was applied to all trunk stabilizer muscles (erector spinae, latissimus dorsi, lower trapezius, internal oblique abdominis, and external oblique abdominis). Balance taping is a taping method that can provide balance to the body through the application of tape on the cause of the symptoms based on an understanding of the anatomical structure of the muscles, joints, and nerves and using a neurophysiological approach<sup>29</sup>. For the erector spinae, kinesiology tape (BB Tape; WETAPE Inc.) was applied along both sides of the transverse process from the sacroiliac joint to the eighth or ninth rib (Figure 3A)<sup>29</sup>. For the latissimus dorsi, kinesiology tape was applied

along the axillary border from the intertubercular groove on the humerus to the spinous process of the sacrum (Figure 3B)<sup>29</sup>. For the lower trapezius, kinesiology tape was applied from the root of the scapular spine to the 12<sup>th</sup> thoracic spinous process (Figure 3C)<sup>29</sup>. For the internal oblique abdominis, kinesiology tape was applied between the xiphoid process and the 11<sup>th</sup> or 12<sup>th</sup> rib to the posterior superior iliac spine (Figure 3D)<sup>29</sup>. For the external oblique abdominis, kinesiology tape was applied along the iliac crest to the abdominal aponeurosis (Figure 3E)<sup>29</sup>.

#### Biering-Sorensen test

The BST, first described by Hansen in 1964 and popularized by Biering-Sorensen, is a method for assessing the endurance of back extensor muscles<sup>30</sup>. Its reliability as a test for endurance has been proven in previous studies using electromyography (ICC=0.83)<sup>31</sup>. In BST, the participants were in the prone position with the anterior superior iliac spine on the edge of a bed<sup>30,32</sup>, and their legs were tightly bound and secured to the bed with straps across the greater trochanter of the femur, popliteal fossa, and Achilles tendon region about 1 to 2 cm above the ankle joints<sup>30</sup>. A towel was placed beneath the ankle straps so that the ankle joints were not strained<sup>30</sup>. When the BST started, the participants had their arms crossed in front of the chest so that the spine was held in the neutral position, and the duration when the spine was held in the neutral position was measured using a stopwatch<sup>30,32</sup>.

The time was measured immediately after the trunk was in the horizontal position until the trunk was ≥10° downslope from the horizontal plane. During the experiment, trunk extension or flexion movement within 5° of the slant level needle was allowed<sup>30</sup>. In BST, a shorter time in the horizontal position indicates low trunk muscle endurance and high muscle fatigue (Figure 4)<sup>30</sup>.

#### Statistical analysis

To assess the general characteristics of the participants, descriptive statistics were used to compare means and standard deviations of age, height, and weight. A paired samples t-test was performed to investigate the effect of kinesiology tape application on the back extensor endurance in the EST and TMT groups. An independent sample t-test was performed to compare the effect of kinesiology tape

**Table 2.** Change in endurance time (seconds) of the back extensor muscles after kinesiology tape application.

Variables	Pre	Post	Effect size	p
EST group (n=16)	70.93±26.23 (28.40-113.22) <sup>†</sup>	84.36±26.25 (38.39-121.35)	0.61	0.000*
TMT group (n=16)	66.87±21.37 (36.79-118.77)	110.71±25.64 (57.32-152.22)	1.06	0.000*

<sup>†</sup>Values are presented as mean±standard deviation (range). \*p<0.05. EST, Erector spinae taping; TMT, total muscle taping.

**Table 3.** Comparison of difference in endurance time (seconds) before and after kinesiology tape application between the EST and TMT groups.

EST	TMT	Effect size	P
13.43±4.46 (5.58-46.78) <sup>†</sup>	43.84±11.67 (4.58-60.95)	0.77	0.000*

<sup>†</sup>Values are presented as mean±standard deviation (range). \*p<0.05. EST, Erector spinae taping; TMT, total muscle taping.

application in the EST and TMT groups. SPSS version 18.0 Windows (IBM, Armonk, NY, USA) was used for the statistical analysis of the data, and a statistical significance level of 0.05 was used.

## Results

### General characteristics of the participants

There were no significant differences in general characteristics of the participants in the two groups (Table 1).

### Change in back extensor endurance after kinesiology tape application

The endurance time in the horizontal position during the BST significantly increased in both the EST and TMT groups after kinesiology tape application (p<0.05) (Table 2).

### Change in back extensor endurance depending on the tape application technique

The endurance time in the horizontal position during the BST significantly increased in the TMT group compared with that in the EST group (p<0.05) (Table 3).

## Discussion

The results of the study showed that the endurance time of the back extensor muscles during the BST increased in both the EST and TMT groups after kinesiology tape application. Yeung et al. found that isometric muscle strength temporarily increased with kinesiology tape application and explained that this may be due to the stimulation of the spindles of the striated muscles by the kinesiology tape application, promoting muscle contractions via the cutaneous mechanoreceptor<sup>33</sup>. According to the cutaneous fusimotor reflex theory, skin stimulation by tactile stimuli induces relaxation and contraction of the underlying muscles

through gamma motor neuron reflex and improves muscle strength<sup>34</sup>. Konishi stated that kinesiology tape application improves muscle endurance through activation of gamma motor neurons by tactile stimulation of the skin<sup>15</sup>. These mechanisms might have contributed to the muscle endurance increase noted in both groups following kinesiology tape application. According to Choi and Lee, quadriceps muscle strength increased after kinesiology tape was applied to fatigued quadriceps muscle in athletes<sup>14</sup>. Álvarez-Álvarez et al. showed that the endurance of the lumbar extensor increased when kinesiology tape was applied to erector spinae in asymptomatic participants<sup>35</sup>.

In a few systematic review studies, Kinesio Taping was used as a treatment tool for musculoskeletal rehabilitation, but it showed no beneficial effect in patients with low back pain and had low quality evidence<sup>36,37</sup>. Most previous studies have suggested an inefficacy of applying kinesiology tape to the erector spinae of patients with low back pain<sup>23-26</sup>. Luz Júnior et al. showed that Kinesio Taping to the erector spinae of patients with chronic low back pain had no effect on pain and disability compared to placebo taping<sup>27</sup>.

Trunk stabilizer muscles are connected via fascia, and the superficial muscles, together with the deep muscles, provide trunk stabilization<sup>38</sup>. Vleeming et al. stated that the hips, pelvis, and legs interact with the arm and spinal muscles via the thoracolumbar fascia, and the superficial trunk muscles work together with the deep and core muscles during dynamic movements<sup>38</sup>. A study by Allison and Henry, using electromyography, reported that other trunk muscles, in addition to the back extensor, are activated even for static postures<sup>39</sup>. They also stated that the activation of a single muscle cannot affect the overall trunk stability, and all muscles involved in the trunk work as a corset and thus affect trunk stabilization<sup>40</sup>. The erector spinae, which plays an important role in trunk stabilization, is attached to the sacrum and pelvis and increases the anterior tilt of the lumbar spine by inducing forward tilt of the pelvis, and contraction of both sides extends the trunk, neck, or head<sup>41,42</sup>. Moreover,

the extensor muscles of the trunk are co-activated in order to reduce the strong flexion function of the oblique abdominal muscles, and an increase in the angle of pelvic inclination increases the activation of the oblique abdominal muscles, which are opposite to the direction of the pelvic inclination. Similarly, during back extension, the back extensor and flexor muscles are co-activated<sup>43</sup>. It has been reported that the erector spinae and abdominal muscles interact during pelvic movement and trunk extension and flexion<sup>43</sup>.

The latissimus dorsi is attached to the thoracolumbar fascia and transfers forces from the spine to the pelvis and to the legs. Its coupled function with the trunk assists in trunk rotation<sup>38</sup>. The latissimus dorsi simultaneously stabilizes the lower lumbar spine and the sacroiliac joints, and its co-contraction with the lower trapezius depresses the scapulothoracic joint and stabilizes the trunk<sup>38,42</sup>. As such, back extension requires a combined action of several muscles that are connected, rather than that of a single muscle, to maintain stability<sup>38,44,45</sup>. In the present study, it is believed that the application of kinesiology tape to the erector spinae, latissimus dorsi, lower trapezius, internal oblique abdominis, and external oblique abdominis worked like a corset and thus resulted in greater improvement of back extensor endurance in the TMT group than that in the EST group, because the trunk stabilizer muscles do not provide trunk stabilization through the action of a single muscle.

However, this study has some limitations. First, the participants of the study were healthy individuals aged 20 years or older, and the results cannot be generalized to the entire population. Second, it was not possible to control the physical activity of each participant because the kinesiology tape application experiment was performed a week after the initial assessment in order to minimize the effect of muscle fatigue. Third, we were not able to use instruments, such as isokinetic machines, that can provide objective quantitative measurements. Fourth, we did not verify the placebo effects. Fifth, psychometric properties, which can influence the duration time during the BST,<sup>46</sup> was not evaluated. Further studies that address these limitations are warranted. Additionally, studies on the effect of kinesiology tape application to trunk stabilizer muscles on pain, disability, and muscle strength of patients with nonspecific low back pain are needed.

## Conclusion

In the present study, the endurance of the back extensor muscles significantly increased in the participants of both the EST group, in whom kinesiology tape was applied to the erector spinae alone, and the TMT group, in whom kinesiology tape was applied to all trunk stabilizer muscles (erector spinae, latissimus dorsi, lower trapezius, internal oblique abdominis, and external oblique abdominis). Comparison of the groups showed that the increase was greater when the kinesiology tape was applied to all trunk stabilizer muscles than when applied only to the erector

spinae. Therefore, kinesiology tape application to all back stabilizer muscles (erector spinae, latissimus dorsi, lower trapezius, internal oblique abdominis, and external oblique abdominis), rather than to the erector spinae alone, may be more helpful in improving back extensor muscle endurance in healthy participants.

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## References

1. McNeill W. Core stability is a subset of motor control. *J Bodyw Mov Ther* 2010;14(1):80-3.
2. McGill SM. *Back Mechanic: The Secrets to a Healthy Spine Your Doctor Isn't Telling You: The Step by Step McGill Method to Fix Back Pain*. Seoul, Korea: Yeongmun; 2017.
3. Barr KP, Griggs M, Cadby T. Lumbar stabilization: a review of core concepts and current literature, part 2. *Am J Phys Med Rehabil* 2007;86(1):72-80.
4. Barker PJ, Briggs CA, Bogeski G. Tensile transmission across the lumbar fasciae in unembalmed cadavers: effects of tension to various muscular attachments. *Spine (Phila Pa 1976)* 2004;29(2):129-38.
5. Villafañe JH, Gobbo M, Peranzoni M, Naik G, Imperio G, Cleland JA, Negrini S. Validity and everyday clinical applicability of lumbar muscle fatigue assessment methods in patients with chronic non-specific low back pain: a systematic review. *Disabil Rehabil* 2016; 38(19):1859-71.
6. Correia JP, Oliveira R, Vaz JR, Silva L, Pezarat-Correia P. Trunk muscle activation, fatigue and low back pain in tennis players. *J Sci Med Sport* 2016;19(4):311-6.
7. Yoshida A, Kahanov L. The effect of Kinesio Taping on lower trunk range of motions. *Res Sports Med* 2007; 15(2):103-12.
8. Emmanuel C, Ayanniyi O. Relations between back muscles' endurance capacity and risk of low-back pain. *TAF Prev Med Bull* 2010;9:421-6.
9. Allen DG, Lamb GD, Westerblad H. Skeletal muscle fatigue: cellular mechanisms. *Physiol Rev* 2008;88(1): 287-332.
10. Enoka RM, Duchateau J. Muscle fatigue: what, why and how it influences muscle function. *J Physiol* 2008; 586(1):11-23.
11. Reimer RC, Wikstrom EA. Functional fatigue of the hip and ankle musculature cause similar alterations in single leg stance postural control. *J Sci Med Sport* 2010;13(1):161-6.
12. Allen TJ, Peoske U. Effect of muscle fatigue on the sense of limb position and movement. *Exp Brain Res* 2006;170(1):30-8.
13. Björklund M, Crenshaw AG, Djupsjöbacka M, Johansson H. Position sense acuity is diminished following repetitive low-intensity work to fatigue in a simulated occupational

- setting. *Eur J Appl Physiol* 2000;81(5):361-7.
14. Choi IR, Lee JH. The effect of the application direction of the kinesiology tape on the strength of fatigued quadriceps muscles in athletes. *Res Sports Med* 2019; 27(1):1-10.
  15. Konishi Y. Tactile stimulation with kinesiology tape alleviates muscle weakness attributable to attenuation of Ia afferents. *J Sci Med Sport* 2013;16(1):45-8.
  16. Garcia-Muro F, Rodriguez-Fernandez AL, Herrero-de-Lucas A. Treatment of myofascial pain in the shoulder with Kinesio Taping. A case report. *Man Ther* 2010; 15(3):292-5.
  17. Lee JH, Yoo WG. Treatment of chronic Achilles tendon pain by Kinesio Taping in an amateur badminton player. *Phys Ther Sport* 2012;13(2):115-9.
  18. Lee SM, Lee JH. The immediate effects of ankle balance taping with kinesiology tape on ankle active range of motion and performance in the Balance Error Scoring System. *Phys Ther Sport* 2017;25:99-105.
  19. Wong OM, Cheung RT, Li RC. Isokinetic knee function in healthy subjects with and without Kinesio Taping. *Phys Ther Sport* 2012;13(4):255-8.
  20. Wu YT, Choe YW, Cheng Peng, Kim MK. The immediate effects of posterior pelvic tilt with taping on pelvic inclination, gait function and balance in chronic stroke patients. *J Korean Soc Phys Med* 2017;12(3):11-21.
  21. Knapman HJ, Fallon T, O'Connor M, Titmus LA, Choy ST, Hornsby C, Marsden JF, Shum GL. The effect of elastic therapeutic taping on lumbar extensor isokinetic performance. *Phys Ther Sport* 2017;25:9-14.
  22. Lee MH, Kim SY. The immediate effects of Kinesio Taping on the maximal power and muscle activity of erector spinae in normal subjects. *Int J Contents* 2012; 8(4):69-72.
  23. Added MA, Costa LO, Freitas DG, Fukuda TY, Monteiro RL, Salomão EC, Costa Lda C. Kinesio Taping does not provide additional benefits in patients with chronic low back pain who receive exercise and manual therapy: a randomized controlled trial. *J Orthop Sports Phys Ther* 2016;46(7): 506-13.
  24. Araujo AC, do Carmo Silva Parreira P, Junior LC H, da Silva TM, da Luz Junior MA, da Cunha Menezes Costa L, Pena Costa LO. Medium term effects of Kinesio Taping in patients with chronic non-specific low back pain: a randomized controlled trial. *Physiotherapy* 2018; 104(1):149-51.
  25. Kamali F, Sinaei E, Taherkhani E. Comparing spinal manipulation with and without Kinesio Taping® in the treatment of chronic low back pain. *J Bodyw Mov Ther* 2018;22(2):540-5.
  26. Hagen L, Hebert JJ, Dekanich J, Koppenhaver S. The effect of elastic therapeutic taping on back extensor muscle endurance in patients with low back pain: a randomized, controlled, crossover trial. *J Orthop Sports Phys Ther* 2015;45(3):215-9.
  27. Luz Júnior MA, Sousa MV, Neves LA, Cezar AA, Costa LO. Kinesio Taping is not better than placebo in reducing pain and disability in patients with chronic non-specific low back pain: a randomized controlled trial. *Braz J Phys Ther* 2015;19(6):482-90.
  28. Morita ÂK, Marques NR, Navega MT. Neuromuscular control strategies of the trunk antagonist muscles during the Biering-Sorensen test in individuals with recurrent low back pain and healthy subjects. *Motriz Rev Educ Fís* 2016;22(4):266-71.
  29. Lee JH, Choi SW. Balance Taping: Clinical Application of Elastic Therapeutic Tape for Musculoskeletal Disorders. Paju, Korea: WETAPE; 2016.
  30. Demoulin C, Vanderthommen M, Duysens C, Crielaard JM. Spinal muscle evaluation using the Sorensen test: a critical appraisal of the literature. *Joint Bone Spine* 2006;73(1):43-50.
  31. Latimer J, Maher CG, Refshauge K, Colaco I. The reliability and validity of the Biering-Sorensen test in asymptomatic subjects and subjects reporting current or previous nonspecific low back pain. *Spine (Phila Pa 1976)* 1999;24(20):2085-9.
  32. Umezu Y, Kawazu T, Tajima F, Ogata H. Spectral electromyographic fatigue analysis of back muscle in healthy adult women with men. *Arch Phys Med Rehabil* 1998;79(5):536-8.
  33. Yeung SS, Yeung EW, Sakunkaruna Y, Mingsoongnern S, Hung WY, Fan TL, lao HC. Acute effects of Kinesio Taping on knee extensor peak torque and electromyographic activity after exhaustive isometric knee extension in healthy young adults. *Clin J Sport Med* 2015;25(3):284-90.
  34. Johansson H, Sojka P. Actions on gamma-motoneurons elicited by electrical stimulation of cutaneous afferent fibres in the hind limb of the cat. *J Physiol* 1985; 366:343-63.
  35. Álvarez-Álvarez S, José FG, Rodríguez-Fernández AL, Güeita-Rodríguez J, Waller BJ. Effects of Kinesio® Tape in low back muscle fatigue: randomized, controlled, doubled-blinded clinical trial on healthy subjects. *J Back Musculoskelet Rehabil* 2014;27(2):203-12.
  36. Ramírez-Vélez R, Hormazábal-Aguayo I, Izquierdo M, González-Ruiz K, Correa-Bautista JE, García-Hermoso A. Effects of Kinesio Taping alone versus sham taping in individuals with musculoskeletal conditions after intervention for at least one week: a systematic review and meta-analysis. *Physiotherapy* 2019;105(4):412-20.
  37. Nelson NL. Kinesio Taping for chronic low back pain: a systematic review. *J Bodyw Mov Ther* 2016; 20(3):672-81.
  38. Vleeming A, Pool-Goudzwaard AL, Stoeckart R, Wingerden JP, Snijders CJ. The posterior layer of the thoracolumbar fascia. Its function in load transfer from spine to legs. *Spine (Phila Pa 1976)* 1995;20(1):753-8.
  39. Allison GT, Henry SM. Trunk muscle fatigue during a back extension task in standing. *Man Ther* 2001;6(4):221-8.
  40. McGill SM. *Low Back Disorders: Evidence-based Prevention and Rehabilitation*. Champaign, IL, USA:

- Human Kinetics; 2007.
41. Ekstrom RA, Osborn RW, Hauer PL. Surface electromyographic analysis of the low back muscles during rehabilitation exercises. *J Orthop Sports Phys Ther* 2008;38(12):736-45.
  42. Neumann DA. *Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation*, 2nd Edition. Seoul, Korea: Panmun Education; 2011.
  43. Wilke HJ, Wolf S, Claes LE, Arand M, Wiesend A. Stability increase of the lumbar spine with different muscle groups. A biomechanical *in vitro* study. *Spine (Phila Pa 1976)* 1995;20(2):192-8.
  44. Brown SH, Vera-Garcia FJ, McGill SM. Effects of abdominal muscle coactivation on the externally preloaded trunk: variations in motor control and its effect on spine stability. *Spine (Phila Pa 1976)* 2006; 31(13):387-93.
  45. Tarnanen SP, Ylinen JJ, Siekkinen KM, Mälkiä EA, Kautiainen HJ, Häkkinen AH. Effect of isometric upper-extremity exercises on the activation of core stabilizing muscles. *Arch Phys Med Rehabil* 2008;89(3):513-21.
  46. Mannion AF, O'Riordan D, Dvorak J, Masharawi Y. The relationship between psychological factors and performance on the Biering-Sørensen back muscle endurance test. *Spine J* 2011;11(9):849-57.