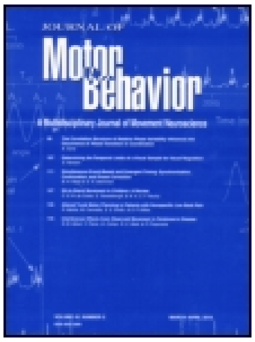

Journal of Motor Behavior

ISSN: 0022-2895 (Print) 1940-1027 (Online) Journal homepage: http://www.tandfonline.com/loi/vjmb20

Laughing: A Demanding Exercise for Trunk Muscles

Heiko Wagner , Ulrich Rehmes , Daniel Kohle & Christian Puta

To cite this article: Heiko Wagner , Ulrich Rehmes , Daniel Kohle & Christian Puta (2014) Laughing: A Demanding Exercise for Trunk Muscles, Journal of Motor Behavior, 46:1, 33-37, DOI: 10.1080/00222895.2013.844091

To link to this article: http://dx.doi.org/10.1080/00222895.2013.844091

Published online: 18 Nov 2013.

Journal of Motor Behavior, Vol. 46, No. 1, 2014

RAPID COMMUNICATION

Laughing: A Demanding Exercise for Trunk Muscles

Heiko Wagner[1,2], Ulrich Rehmes[1], Daniel Kohle[1], Christian Puta[2,3]
[1]Motion Science, Westfälische Wilhelms-Universität Münster, Germany. [2]Center for Interdisciplinary Prevention of Diseases Related to Professional Activities, Friedrich Schiller Universität Jena, Germany. [3]Department of Sports Medicine and Health Promotion, Friedrich Schiller Universität Jena, Germany.

ABSTRACT. Social, psychological, and physiological studies have provided evidence indicating that laughter imposes an increased demand on trunk muscles. It was the aim of this study to quantify the activation of trunk muscles during laughter yoga in comparison with crunch and back lifting exercises regarding the mean trunk muscle activity. Muscular activity during laughter yoga exercises was measured by surface electromyography of 5 trunk muscles. The activation level of internal oblique muscle during laughter yoga is higher compared to the traditional exercises. The multifidus, erector spinae, and rectus abdominis muscles were nearly half activated during laughter yoga, while the activation of the external oblique muscle was comparable with the crunch and back lifting exercises. Our results indicate that laughter yoga has a positive effect on trunk muscle activation. Thus, laughter seems to be a good activator of trunk muscles, but further research is required whether laughter yoga is a good exercise to improve neuromuscular recruitment patterns for spine stability.

Keywords: laughing, motor control, EMG, Exercise, muscles, trunk

Laughing is one of the basic capacities that sets humans apart from most animals (Askenasy, 1987). Laughter has been investigated concerning social, psychological as well as physiological aspects (e.g., the positive effects on the hormonal, pulmonary, and cardiovascular systems; Askenasy, 1987; Bennett & Lengacher, 2008; Filippelli et al., 2001; Miller & Fry, 2009) and the muscular activity of facial and laryngeal muscles (Bloch, Lemeignan, & Aguilera, 1991; Hoit, Plassman, Lansing, & Hixon, 1988; Luschei, Ramig, Finnegan, Baker, & Smith, 2006). To our knowledge, there are no studies that investigated the trunk muscle activations during laughter.

Given that the local and global trunk muscles have a stabilizing effect on the spine (Bergmark, 1989; El-Rich, Shirazi-Adl, & Arjmand, 2004; Gardner-Morse & Stokes, 1998; Granata & Wilson, 2001; Grenier & McGill, 2007; Kavcic, Grenier, & McGill, 2004a; Liebetrau, Puta, Anders, de Lussanet, & Wagner, 2013; McGill, Grenier, Kavcic, & Cholewicki, 2003; Panjabi, 1992a; 1992b; Richardson, Jull, Hodges, & Hides, 1999; Wagner et al., 2005; Wagner, Liebetrau, Schinowski, Wulf, & de Lussanet, 2012), we expect that laughing may be beneficial to stimulate trunk muscles during physiotherapy and rehabilitation especially in cases where traditional exercises can not be applied (e.g., due to physical handicaps).

For a scientific investigation of laughter, a standardized exercise was necessary where laughing can be stimulated reliably. Based on the scientific research in gelotology (the science of laughter), laughter yoga was invented as a method to attain an authentic laughing through artificial laughing exercises, under the aphorism “Fake it until you make it!”

The aim of this study was to quantify the activation of trunk muscles during laughter yoga in comparison to crunch and back lifting exercises regarding the mean levels of trunk muscle activity.

Method

Participants

Seven male and seven female students participated in this study, with an average age of 24.9 ± 1.3 years and an average body mass index of 21.5 ± 2.5 kg/m^2. Average weight and body height was 66 ± 12.19 kg and 174.3 ± 7.4 cm, respectively. Prior to the study, all participants gave written informed consent.

Laughter Yoga

Because laughter yoga should be performed in groups, additional subjects attended the sessions, when the subjects were recorded. During the laughter yoga recording session, several different standardized laughter exercises were performed. For statistical analysis, the climax laughter exercises were chosen because here laughing increases gradually from lowest to strongest level. All attendees stood in a circle and after a deep intake of breath everybody started to laugh. This exercise was divided into five levels, growing from one to five, while level five was selected for statistical analysis. Laughing yoga was compared with five traditional trunk stabilization exercises (i.e., forearm bridge, side bridge, back-lifting, abdominal curl, back-lifting, and abdominal crunch).

Crunch and Back-Lifting Exercises

To evaluate muscular activation, traditional low back stabilization exercises were used as references, which have become a standard therapy in rehabilitation and prophylactic care (Kavcic et al., 2004a, 2004b; Stevens & Hall, 1998). For statistical analysis, the symmetric abdominal crunch and the back-lifting exercise were chosen as references for the abdominal and back muscles because they showed the highest muscular activations of the five traditional exercises.

Correspondence address: Heiko Wagner, Motion Science, Westfälische Wilhelms-Universität Münster, Horstmarer Landweg 62b, D-48149 Münster, Germany. e-mail: heiko.wagner@uni-muenster.de

Experimental Setup

During the experiment one or two subjects performed stabilization exercises and laughter yoga successively, while the sequence was randomized. The five stabilization exercises were performed in the same order, three times for 10 s each, with a break of 10 s between each exercise.

Surface Electromyography

The muscular activation during laughter yoga and the traditional exercises was measured by surface electromyography (SEMG; Biovision, Wehrheim, Germany; 5–700 Hz, AD conversion rate 2000 Hz, gain 2500; Superlogics, Natick, MA, PCM12 Card: 12-bit, 16 channels) from three abdominal muscles (cf. Table 1; rectus abdominis [RA], obliquus internus abdominis [OI], obliquus externus abdominis [OE]) and two back muscles (cf. Table 1; erector spinae pars longissimus [ES], multifidus pars lumbalis superficial [MF]).

Intervals of 10 s for each stabilization and laughter exercise and each muscle were analyzed and displayed by MATLAB (The Mathworks, Natick, MA). The raw surface electromyography data were centered by subtracting the mean over each trial followed by rectification and smoothing using a moving average filter with a window size of 100 ms. For statistical analysis, the average activations for each muscle and exercise interval were calculated.

Data Evaluation

According to our aim, we tested for significant differences for the level of muscle activation between laughter yoga and classical exercises. Using the average rectified filtered SEMG levels, repeated measures analyses of variance (ANOVAs) were calculated. The ANOVAs for trunk muscles were performed separately for the abdominal and back muscles. For the abdominal muscles, we used the within-subject factors exercise (abdominal crunch, climax laughter yoga level 5) and muscle (RA, OI, OE). For the back muscles, a similar ANOVA with the within-subjects factor exercise (back-lifting, climax laughter level 5) and muscle (ES, MF) were used. Results were corrected for violations of sphericity using the Greenhouse-Geisser approach for ε-correction of degrees of freedom. Post hoc analyses were performed using Duncan's post hoc test (abdominal muscles) and multiple t tests corrected for multiple comparisons (paraspinal muscles).

Results

Abdominal Muscles

Figure 1 shows the average rectified filtered SEMG levels. The ANOVA did not reveal a significant main effect of the factor Exercise, $F(1, 13) = 0.48$, $p = .5$. The main effect of factor muscles was significant, $F(2, 26) = 4.83$, $p = .021$, $\varepsilon = .9$. The main effect of the factor muscle resulted from the significant higher activation for the OI in comparison to the RA (Duncan post hoc test: $p = .006$). Furthermore, there was a significant interaction between exercise and muscle, $F(2, 26) = 5.6$, $p = .025$, $\varepsilon = .6$ (Figure 1A). Duncan's post hoc test revealed that the intensity of the RA during laughter yoga was lower than during abdominal crunch ($p = .03$), but still reached 45%. There were no significant differences between the abdominal crunch and the intensive laughter yoga exercise for the activation of OE ($p = .5$). Remarkably, the mean activation of OI during intense laughter yoga exceeded the activation during abdominal crunch by more than 150%. This latter finding was marginally significant ($p = .05$).

Paraspinal Muscles

The ANOVA revealed a significant main effect of the factor exercise, $F(1, 13) = 40.5$, $p < .0001$. For the paraspinal muscles (MF and ES) the activation during laughter yoga reached 48% compared with the back-lifting exercise for both back muscles separately. There was no main effect of the factor muscle, $F(1, 13) = 0.99$, $p = .3$, and no significant interaction between exercise and muscle, $F(1, 13) = 0.01$, $p = .9$. However, when ES and MF SEMG was analyzed separately,

TABLE 1. Electrode Placement for Surface Electromyography

Muscle	Electrode position and orientation
M. rectus abdominis (upper part, RA)	4 cm lateral navel, caudal electrode at navel level, vertical
M. obliquus internus abdominis (OI)	1 cm medial to inguinal ligament, along horizontal line between both anterior superior iliac spines
M. obliquus externus abdominis (OE)	Cranial electrode directly below most inferior point of costal margin, on line to opposite pubic tubercle
M. multifidus (lumbalis, MF)	Caudal electrode at L_4 level, 1 cm medial from line between posterior superior iliac spine and 1st lumbar palpable spinous process, parallel to line
M. erector spinae (longissimus, ES)	Approx. 3 cm lateral midline over palpable bulge of muscle, lower electrode at L_1 level, vertical

Sources. Hermens et al., 1999; Ng, Kippers, & Richardson, 1998.

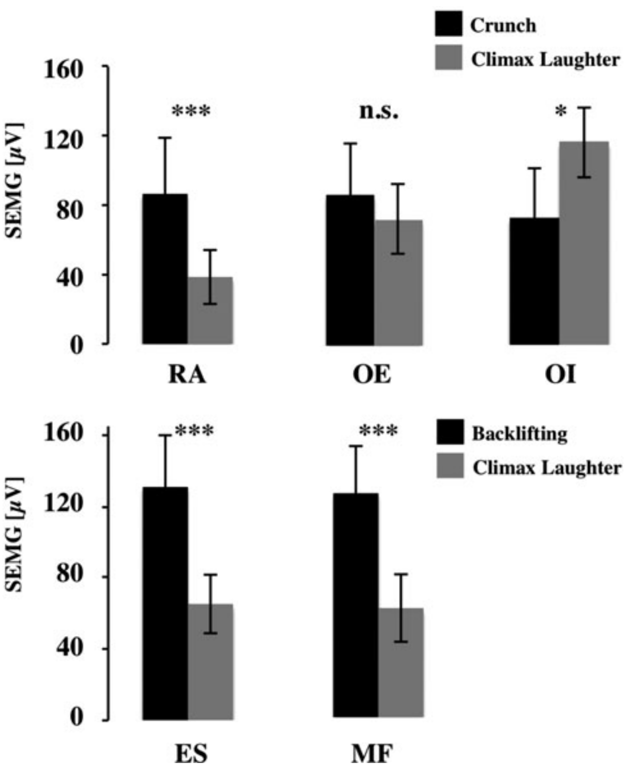

FIGURE 1. Average rectified filtered SEMG levels of abdominal (**A**) and paraspinal muscles (**B**) during a traditional stabilization exercise (crunch and back lifting) and climax laughter yoga (level 5). Vertical bars show 95% confidence intervals. Significant differences are marked: $^{*}p \leq .05$; $^{***}p < .001$. RA = m. rectus abdominis; OE = m. obliquus externus abdominis; OI = m. obliquus internus abdominis; ES = m. erector spinae; MF = m. multifidus pars lumbalis superficialis.

SEMG levels for the back lifting exercise were greater than laughter yoga (t tests corrected for multiple comparisons; significance level was set on $p = .0125$: MF, $p < .0001$; ES, $p < .0001$; see Figure 1B).

Discussion

The aim of this study was to quantify the trunk muscle activation during laughter yoga in comparison to the levels of activity reached by conventional training exercises (crunch and back lifting) regarding the mean levels of trunk muscle activity. Our results show that the overall mean activity of the measured trunk muscles during the highest intensity of laughter yoga was comparable to that during traditional exercises. Remarkably, the mean activation of OI during intense laughter yoga exceeded the activation during abdominal crunch by more than 150%.

As stated in the introduction, laughter has many positive physiological and psychological side effects and is generally a pleasant activity, so it may have potential as a trunk muscle exercise (Cholewicki and vanVliet, 2002). However, laughter yoga is a very different kind of exercise than the traditional abdominal crunch and back-lifting movements. For example, the higher activity of the OI during laughter yoga compared to stability exercises may be an indication of the specific breathing-related aspect during laughter yoga. Another striking difference is the nature of muscular control. Whereas the traditional exercises are controlled in a cognitive manner, the laughter yoga exercises enable a high degree of internal, self-organized muscular control. However, it may be expected that the stronger emphasis of self-organization may be advantageous if the goal is to focus on neuromuscular contributions to spinal stability (Liebetrau, et al., 2012; van Dieën, Selen, & Cholewicki, 2003; van Dieën, Cholewicki, & Radebold; 2003). The presence or absence of muscular coactivation has influence on spinal stability (Reeves & Cholewicki, 2003; Zeinali-Davarani, Hemami, Barin, Shirazi-Adl, & Parnianpour, 2008).

Laughter yoga seems to be associated with the presence of the co-activation for abdominal and back muscles (Figure 2). This is exemplified by a detailed look at an exemplary 10-s interval during one of the tests. The recorded SEMG traces indicate that a qualitative difference may exist between the activation characteristics. Typically SEMG activation characteristic was a slow change in the activation during the abdominal crunch and the back lifting, whereas the laughter yoga exercises were typically modulated at higher frequencies showing an irregular, phasic pattern (Figure 2). Whereas the traditional physical exercises evoke highly regular and stereotypical muscular activities the patterns recorded during the laughter yoga are rhythmic at higher frequencies and much less stereotypical. Given this difference in activation characteristics and given the different relative mean activation between the performed exercises it will be interesting to test whether the laughter yoga training might have lasting influences on motor control, such as spinal stability. However, in the sense of the movement characteristics, the exercises used in the present study are not optimally comparable, because of the differences in rhythmic characteristics. Instead, if interested in investigating the frequency characteristics, other exercises may be better suited for comparisons to laughter yoga exercises, such as the cyclic upper body movements caused by an oscillating might pole (Anders, Wenzel, & Scholle, 2008; Moreside, Vera-Garcia, & McGill, 2007).

The potential therapeutic value (Granacher, Gollhofer, Hortobágyi, Kressig, & Muehlbauer, 2013; Navalgund, Buford, Briggs, & Givens, 2013) must be investigated in more detail. In this respect the present study is to be regarded as a preliminary result. We expect that further research have promising potential, given the very different activation patterns that occur during the laughter yoga and traditional exercises.

Our results indicate that a positive effect of laughter yoga may exist for quantitative and qualitative trunk muscle

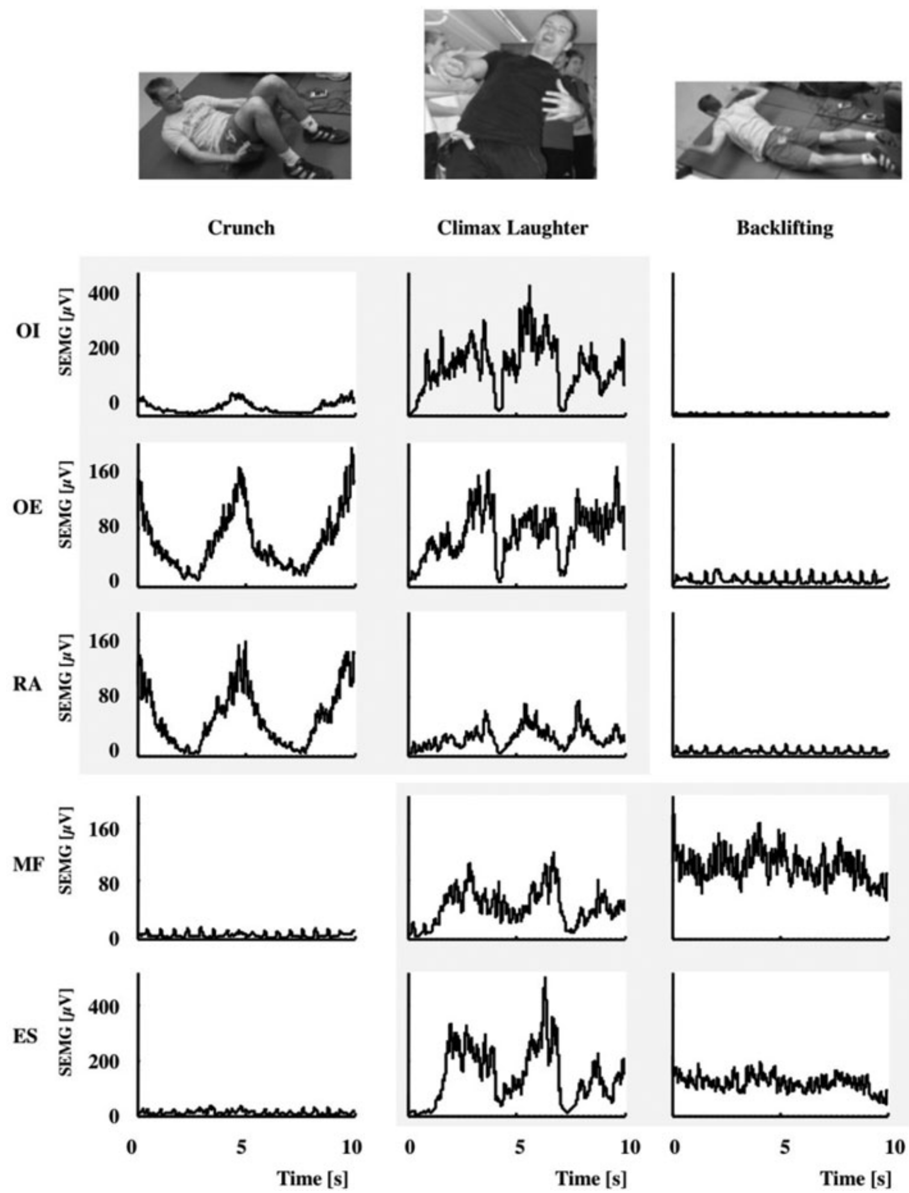

FIGURE 2. Exemplary trials of a representative subject produced by stabilising exercises and laughter yoga, showing SEMG activity from the abdominal (RA = m. rectus abdominis; OE = m. obliquus externus abdominis; OI = m. obliquus internus abdominis) and paraspinal muscles (ES = m. erector spinae; MF = m. multifidus pars lumbalis superficialis). Note the qualitative differences in the muscle activation characteristics.

activation besides the many positive social, psychological and hormonal effects that have been reported in the literature. Laughter yoga seems to be a good activator of muscles, but not necessarily a good exercise for neuro-musculo-skeletal problems in spine, spine stability, or for improving neuro-muscular recruitment patterns. This requires further research.

The specific and typical activation of trunk muscles that we found during laughter evoked by laughter yoga might enable young and old people irrespective of their liking of physical and sports exercises to engender in regular trunk muscle activity.

ACKNOWLEDGMENTS

The authors thank Marc de Lussanet, Arne Wulf, and Thomas Wulf for critical discussions and reading of the manuscript; and V. Spogis for performing the laughter yoga sessions.

FUNDING

Drs.Wagner and Puta were supported by grants of the German Federal Ministry of 250 Education and Research BMBF [01EC1003A, B].

REFERENCES

Anders, C., Wenzel, B., & Scholle, H. C. (2008). Activation characteristics of trunk muscles during cyclic upper-body perturbations caused by an oscillating pole. *Archives of Physical Medicine and Rehabilitation*, *89*, 1314–22.

Askenasy, J. J. (1987). The functions and dysfunctions of laughter. *The Journal of General Psychology*, *114*, 317–334.

Bennett, M. P., & Lengacher, C. (2008). Humor and laughter may influence health: III. Laughter and health outcomes. *eCAM*, *5*, 37–40.

Bergmark, A. (1989). Stability of the lumbar spine. A study in mechanical engineering. *Acta Orthopaedica*, *230*, 1–54.

Bloch, S., Lemeignan, M., & Aguilera, N. (1991). Specific respiratory patterns distinguish among human basic emotions. *International Journal of Psychophysiology*, *11*, 141–154.

Cholewicki, J., & vanVliet, J. J. (2002). Relative contribution of trunk muscles to the stability of the lumbar spine during isometric exertions. *Clinical Biomechanics*, *17*, 99–105.

El-Rich, M., Shirazi-Adl, A., & Arjmand, N. (2004). Muscle activity, internal loads, and stability of the human spine in standing postures: Combined model and in vivo studies. *Spine*, *29*, 2633–2642.

Filippelli, M., Pellegrino, R., Iandelli, I., Misuri, G., Rodarte, J. R., Duranti, R., . . . Scano, G. (2001). Respiratory dynamics during laughter. *Journal of Applied Physiology*, *90*, 1441–1446.

Gardner-Morse, M. G., & Stokes, I. A. (1998). The effects of abdominal muscle coactivation on lumbar spine stability. *Spine*, *23*, 86–91.

Granacher, U., Gollhofer, A., Hortobágyi, T., Kressig, R. W., & Muehlbauer, T. (2013). The importance of trunk muscle strength for balance, functional performance, and fall prevention in seniors: A systematic review. *Sports Medicine*, *43*, 627–641.

Granata, K. P., & Wilson, S. E. (2001). Trunk posture and spinal stability. *Clinical Biomechanics*, *16*, 650–659.

Grenier, S. G., & McGill, S. M. (2007). Quantification of lumbar stability by using 2 different abdominal activation strategies. *Archives of Physical Medicine and Rehabilitation*, *88*, 54–62.

Hermens, H. J., Freriks, B., Merletti, R., Stegeman, D. F., Blok, J., Rau, G., & Disselhorst-Klug, C. (1999). *European recommendations for surface electromyography, results of the SENIAM project*. Roessingh, the Netherlands: Roessingh Research and Development b.v.

Hoit, J. D., Plassman, B. L., Lansing, R. W., & Hixon, T. J. (1988). Abdominal muscle activity during speech production. *Journal of Applied Physiology*, *65*, 2656–2664.

Kavcic, N., Grenier, S., & McGill, S. M. (2004a). Determining the stabilizing role of individual torso muscles during rehabilitation exercises. *Spine*, *29*, 1254–1265.

Kavcic, N., Grenier, S., & McGill, S. M. (2004b). Quantifying tissue loads and spine stability while performing commonly prescribed low back stabilization exercises. *Spine*, *29*, 2319–2329.

Liebetrau, A., Puta, C., Anders, C., de Lussanet, M. H. E., & Wagner, H. (2013). Influence of delayed muscle reflexes on spinal stability. *Human Movement Science*. doi:10.1016/j.humov.2013.03.006

Liebetrau, A., Puta, C., Schinowski, D., Wulf, T., & Wagner, H. (2012). Is there a correlation between back pain and stability of the lumbar spine in pregnancy? A model-based hypothesis. *Schmerz*, *26*, 36–45.

Luschei, E. S., Ramig, L. O., Finnegan, E. M., Baker, K. K., & Smith, M. E. (2006). Patterns of laryngeal electromyography and the activity of the respiratory system during spontaneous laughter. *Journal of Neurophysiology*, *96*, 442–450.

McGill, S. M., Grenier, S., Kavcic, N., & Cholewicki, J. (2003). Coordination of muscle activity to assure stability of the lumbar spine. *Journal of Electromyography and Kinesiology*, *13*, 353–359.

Miller, M., & Fry, W. F. (2009). The effect of mirthful laughter on the human cardiovascular system. *Medical Hypotheses*, *73*, 636–639.

Moreside, J. M., Vera-Garcia, F. J., & McGill, S. M. (2007). Trunk muscle activation patterns, lumbar compressive forces, and spine stability when using the bodyblade. *Physical Therapy*, *87*, 153–163.

Navalgund, A., Buford, J. A., Briggs, M. S., & Givens, D. L. (2013). Trunk muscle Reflex amplitudes increased in patients with subacute, recurrent LBP treated with a 10-week stabilization exercise program. *Motor Control*, *17*, 1–17.

Ng, J. K., Kippers, V., & Richardson, C. A. (1998). Muscle fibre orientation of abdominal muscles and suggested surface EMG electrode positions. *Electromyography and Clinical Neurophysiology*, *38*, 51–581.

Panjabi, M. M. (1992a). The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. *Journal of Spinal Disorders*, *5*, 383–9.

Panjabi, M. M. (1992b). The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. *Journal of Spinal Disorders*, *5*, 390–396.

Reeves, N. P., & Cholewicki, J. (2003). Modeling the human lumbar spine for assessing spinal loads, stability, and risk of injury. *Critical Reviews in Biomedical Engineering*, *31*, 73–139.

Richardson, C. A., Jull, G. A., Hodges, P. W., & Hides, J. A. (1999). *Therapeutic exercise for spinal segmental stabilization in low back pain: Scientific basis and clinical approach*. London, England: Churchill Livingstone.

Stevans, J., & Hall, K. G. (1998). Motor skill acquisition strategies for rehabilitation of low back pain. *Journal of Orthopedic and Sports Physical Therapy*, *28*, 165–167.

Van Dieën, J. H., Selen, L. P., & Cholewicki, J. (2003). Trunk muscle activation in low-back pain patients, an analysis of the literature. *Journal of Electromyography and Kinesiology*, *13*, 333–351.

Van Dieën, J. H., Cholewicki, J., & Radebold, A. (2003). Trunk muscle recruitment patterns in patients with low back pain enhance the stability of the lumbar spine. *Spine*, *28*, 834–841.

Wagner, H., Anders, C., Puta, C., Petrovitch, A., Morl, F., Schilling, N., . . . Blickhan, R. (2005). Musculoskeletal support of lumbar spine stability. *Pathophysiology*, *12*, 257–265.

Wagner, H., Liebetrau, A., Schinowski, D., Wulf, T., & de Lussanet, M. H. E. (2012). Spinal lordosis optimizes the requirements for a stable erect posture. *Theoretical Biology and Medical Modeling*, *9*, 13.

Zeinali-Davarani, S., Hemami, H., Barin, K., Shirazi-Adl, A., & Parnianpour, M. (2008). Dynamic stability of spine using stability-based optimization and muscle spindle reflex. *IEEE Transactions, Neural Systems and Rehabilitation Engineering*, *16*, 106–118.

Received November 10, 2012
Revised May 27, 2013
Accepted September 8, 2013