Journal of Back and Musculoskeletal Rehabilitation 00 (2013) 1–6
DOI 10.3233/BMR-130427
IOS Press

Postural control and low back pain in elite athletes comparison of static balance in elite athletes with and without low back pain

Claudio A. Oyarzo[a], Claudio R. Villagrán[a], Rony E. Silvestre[b], Pedro Carpintero[c,*] and Francisco J. Berral[d]
[a] *Universidad Finis Terrae, Santiago, Chile*
[b] *Centro de Alto Rendimiento, Santiago, Chile*
[c] *Universidad de Córdoba, Córdoba, Spain*
[d] *Universidad Pablo de Olavide, Seville, Spain*

Abstract. Although current research findings suggest that postural control or static balance is impaired in subjects with low back pain, few studies have specifically addressed the effect of low back pain on static balance in elite athletes. Forty-four athletes belonging to Chilean national teams took part in this study; 20 had low back pain and the remaining 24 were healthy controls. Displacement of the centre of pressure was analyzed by computerized platform posturography, using a standardized protocol; subjects were required to stand upright on both feet, with eyes first open then closed. The results showed that, athletes with low back pain used significantly more energy (p 0.0182) and had a greater displacement of the centre of pressure (p 0.005) with open eyes to control posture than healthy athletes. It may be concluded that static balance is impaired in elite athletes with low back pain and that analysis of two-footed stance provides a sensitive assessment of static balance in athletes.

Keywords: Postural control, balance, posturography, stabilometry, low back pain

1. Introduction

Postural control (PC), also known as balance control, is an integral aspect of motor control [1] and is broadly defined as a complex motor response involving the integration of a range of sensory information and the planning and execution of movement patterns aimed at maintaining a normal posture [2,3]. It has been suggested that good postural control requires an input system for collecting information, an integration centre to receive and interpret that information and prepare a response, and an effector system to execute the response correctly [3]. Any impairment in one or more of these components may give rise to poor balance.

Impaired postural control has been reported in a number of disorders [3,4] including low back pain (LBP) [5–14]. The subjects of published studies range widely in age and – although physical status is not always indicated – mostly appear to display considerable deterioration in flexibility, strength and overall physical resistance [16,17,19] due to chronic pain. Indeed, this physical deterioration has been suggested as a possible cause of impaired PC [7,8,11]. Low back pain is common in athletes [14,19], despite their well-developed physical status, but few studies have addressed PC in this group [14]. Comparative studies of postural control in healthy athletes and those with LBP provide useful information on balance behaviour, enabling assessment of the effect of back pain alone on balance and eliminating the bias entailed in studying subjects with differing physical status.

*Corresponding author: Pedro Carpintero, Universidad de Córdoba, Mejorana 45. 14012, Córdoba, Spain. Tel.: +34 957279299; Fax: +34 957218248; E-mail: pcarpinterob@medynet.com.

ISSN 1053-8127/13/$27.50 © 2013 – IOS Press and the authors. All rights reserved

Table 1
Characteristics of healthy elite athletes and with LBP

	Age (X/DS)	Men	Women	BMI (X/DS)
Healthy athletes (n 24)	21.9/4.15	15	9	24/4
Athletes LBP (n 20)	20.4/4.17	11	9	22/3

Table 2
Differences in Total Energy and Displacements means between healthy elite athletes and elite athletes with low back pain, eyes open

	Healthy athletes	Athletes LBP	P
Total energy (AU)	0.014/0.01	0.020/0.01	*
Displacement (mm)	2.72/0.79	3.57/1.01	**

2. Material and methods

2.1. *Subjects*

A total of 44 volunteers elite athletes aged 16–33 (mean age 21) were studied during the first half of 2011; 20 had LBP (11 men, 9 women) and 24 were healthy (15 men, 9 women) (Table 1). The non-random sample comprised members of national sports teams. All recruited athletes signed written informed-consent forms prior to enrolment in the study. The study protocol, which was followed throughout, complied with the provisions of the Helsinki Declaration on human experimentation, was approved by the ethic committee of our institution.

Any member of a national sports team with medically-diagnosed LBP was deemed eligible for inclusion, although athletes who had sustained foot, ankle, knee or hip injuries in the past twelve months were excluded, on the grounds that such injuries might influence static balance.

Healthy members of any national team were eligible, provided that they attended a check-up during the study period. Exclusion criteria were: an episode of low back pain in the past twelve months; low back pain lasting over six weeks at any point in the past; and foot, ankle, knee or hip injuries in the past twelve months.

Low back pain was caused by facet syndrome in fourteen subjects, stress fracture in three, discal herniation (DH) in one, and unspecified causes in the remaining two subjects. LBP was acute in eighteen subjects and chronic in two.

2.2. *Instrument and procedure*

The study was performed on a computerized posturographic platform previously validated, using an evaluation protocol comprising three thirty-second subtests, supplied with the platform.

Subjects were tested at the Kinesiology Unit, in a room designed to standardize noise, light, temperature and visual references. All tests were performed in the same way, in the evenings. Subjects were tested on admission as patients. Only the subject and the tester were in the room when the tests were performed and the same instrument-trained kinesiologist carried out all the tests. All subjects were given the same oral instructions. After explaining the test, subjects were given a preliminary dummy run. For the standardized posturographic test, subjects were asked to stand upright, barefoot, on both feet, with heels 2 cm apart, feet at an angle of 30°, arms by their sides and at ease. The point of visual reference was placed at eye level at a distance of 50 cm and the test was carried out in silence to avoid distraction. The two-footed stance was recorded for 90 seconds, this being considered a comfortable interval for maintaining stability. For the first 30 seconds, the subject was asked to look at the posturograph and minimize the central vector on the screen, i.e. centre of pressure (CoP) and individual displacement. After 30 seconds, the subject was asked to look straight ahead and remain standing on both feet, receiving only environmental information. For the last 30 seconds, the subject was asked to remain in the same position with his/her eyes closed. Data were captured and stored on computer. In other words, subjects stood on both feet looking straight ahead for only 60 seconds, with eyes open for 30 and closed for 30 seconds.

Posturographic signals were examined to measure the amount of energy used in the following frequency bands: 4 Hz, 2 Hz, 1 Hz, 0.5 Hz, 0.25 Hz, 0.125 Hz y 0.0625 Hz. Frequency bands were matched to eyes-open and eyes-closed tests. This enabled the relative contribution of each subsystem to motor control of posture to be determined in the two groups.

2.3. *Data analysis*

The hypothesis that LBP influences in static balance in elite athletes was tested by comparing the two groups, with eyes both open and closed, measuring values of total energy (ET), i.e. the sum of the 7 frequency bands squared, and the radius of centre of pressure. Variables did not follow normality criteria according to the Kolmogorov-Smirnoff test, and was applied the non-parametric Mann-Whitney test. Difference were considered statistically significant at $p < 0.05$). The GraphPad Prism Version 5.0. statistical software package was used for statistical analysis

Table 3
Differences in Total Energy and Displacements means between healthy elite athletes and elite athletes with low back pain, eyes closed

	Healthy athletes	Athletes LBP	P
Total Energy (AU)	0.029/0.02	0.036/0.03	–
Displacement (mm)	4.01/1.07	4.39/1.18	–

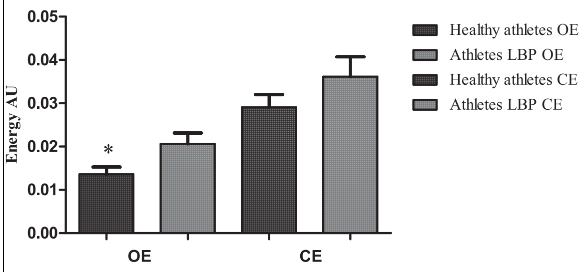


Fig. 1. Comparison of Total Energy means between healthy and LBP athletes. Open and closed eyes. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/BMR-130427)

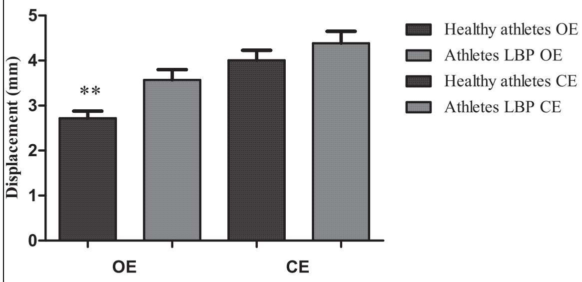


Fig. 2. Comparison of Displacement means between healthy and LBP athletes. Open and closed eyes. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/BMR-130427)

3. Results

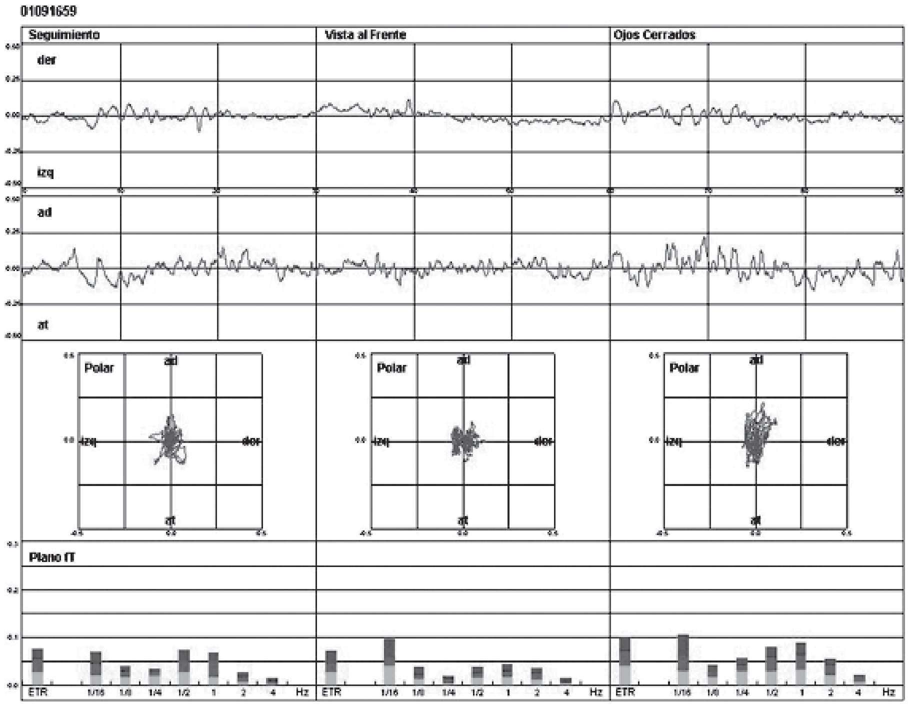
Athletes with LBP utilized significantly more energy (p 0.0182) and had a greater displacement of the centre of pressure (p 0.005) than healthy subjects for controlling balance; both with eyes open (Table 2 and Figs 1 and 2). With eyes closed we not found differences statistically significant between both groups (Tables 2 and 3).

4. Discussion

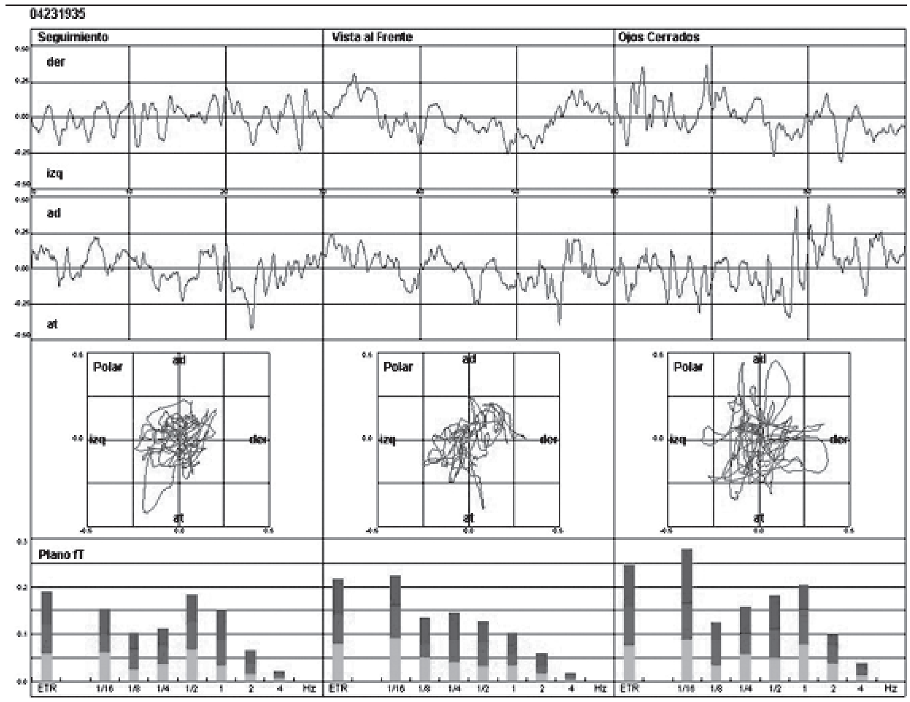
Previous studies of the relationship between LPB and impaired PC report a significant link, although results are somewhat contradictory [5–9]. The results obtained here suggest impaired two-footed balance, with eyes open. Similar findings were reported by Byl and Sinnot [4] for a study population similar to this one, though their subjects varied more in age and no reference was made to individual physical status. They measured two-footed and one-footed support, with eyes open and closed, on different surfaces and with the head positioned differently, and found a significant correlation only for one footed support and eyes closed. Mientjes [8] studied 8 patients with chronic LBP in two-footed stance and reported similar results, with eyes closed; changes in PC with eyes open were found only for variables not tested here, such as change of surface, body inclination and head-turning. Bouche [17], in a study of subjects who had undergone discectomy, noted impaired balance only with eyes closed; these subjects, whose pain had been relieved, displayed improved balance control with eyes open. In our study we do not found significant differences with closed eyes. Perhaps because in our study group were individuals of both genders, and according to Luoto [7] the balance in men was only impaired in one-footed stance [8], where a strong association was apparent between severe LBP and one-footed postural control regardless of sex or dominant side. Luoto suggested that the reasons for sex-related differences were unclear, but pointed to differences in pelvic structure and in levels of strength. Leinonen [12] also reported greater sway in two-footed support with eyes both open and closed in patients programmed for surgery for lumbar disk herniation, in comparison to healthy controls. The clinical status of these patients, however, was clearly more complicated than that of the athletes studied here. Harringe [14], in a study restricted to young female gymnasts, noted significantly-impaired balance in subjects standing with eyes closed on a foam surface and found that LBP caused greater displacement of the centre of pressure than leg injuries.

Comparison of these findings with the results obtained here suggests that athletes with LBP are more sensitive than the general population, since PC is impaired even with eyes open and two-footed support on a stable surface.

Most of earlier studies focused on chronic LBP patients, whose physical status was probably impaired. Poor physical status may have a direct influence on PC; Luoto showed that both deterioration in physical status and stronger pain were associated with increased posture-control impairment [21]. However, though Luoto fails to indicate the physical status of healthy controls, it may be assumed – since the comparison was with patients with chronic LBP – that controls were also sedentary. The present study addressed elite athletes, with a view to ensuring – among other things –



A



B

Fig. 3. A: Healthy elite athlete. The graph of mediolateral and anteroposterior activity is shown in the upper part of the figure, followed by CoP displacement (X-axis = m ediolateral displacement; Y-axis = anteroposterior displacement). Here, activity is concentrated around zero. B: Results for an athlete with LBP show evident displacement and greater energy use. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/BMR-130427)

the similar physical status of healthy subjects and LBP patients; it was thus possible to investigate changes in PC due to pain alone, without needing to take into account the possible influence of poor physical status. The results suggest that PC is affected by low back pain even in optimally-fit athletes. Indeed, it would appear that, due to the need to achieve highly-precise PC, athletes with LBP expend more energy for this purpose than sedentary subjects.

Most of the elite athletes studied here had acute LBP, since chronic back pain is not generally compatible with elite sporting activity. The two cases of chronic back pain (i.e. pain lasting over three months) were of mild intensity (Table 2), thus allowing at least some physical activity. It may thus be postulated that pain in itself may impair PC, due to inhibitory or compensatory processes involving alterations in proprioceptive information processing [22]. Thus, delayed activation of the tranversus abdominis muscle in the presence of back pain prevents correct stabilization of the spine, which in turn complicates posture correction strategies [23]. Pain-induced inhibition of the multifidus muscles [24] renders trunk stabilization more difficult [25]. Proprioceptive changes [17,24,26] and compensatory muscle responses [11,12] hinder the regulation of postural tone. Information-processing difficulties delay the motor response required for PC [22]. Finally, new strategies and postural adjustments need to be developed, which limit trunk amplitude and speed [12].

Although the poor PC found here in subjects with LBP was clearly not due to poor baseline physical status, it is nonetheless likely that improved physical status may have a positive effect on postural control in healthy subjects.

Posturographic examination, though lacking uniform analytical criteria, provided information on normal conditions and on changes caused by LBP which could not have been gained by clinical assessment alone. Wavelet analysis [22] enabled clear visualization of PC behaviour at various frequencies, including a proportional increase in energy expenditure over all frequency bands – and especially in total energy – in athletes with LBP. This tool may provide enhanced sensitivity in the detection of impaired balance in athletes.

The approach used here yielded data essential to improved assessment and monitoring of athletes with LBP and may also prove a useful tool for preventing LBP, given its potential predictive value as outlined by Takala [10].

Balance control should be taken into account in physiotherapy programs for athletes, not only because balance is evidently impaired by LBP, but also because there is a risk of exacerbating the injury if the athlete resumes normal sporting activity before he/she has fully recovered normal sensorial-motor capacity. Since subjects with poor PC may display impaired dynamic stability of the spine and articular displacement from the neutral zone [10,11], as well as limited trunk amplitude and especially trunk speed [12], the lumbar spine is exposed to more serious injury.

The results obtained indicate that both evaluation of PC and a balance-training program may be of value in athletes with LBP. Future research could usefully include larger athlete sample sizes, with a view to identifying differences between sports specialties and gender as well as comparing findings with those recorded for sedentary subjects. This approach may also be useful in evaluating other clinical conditions including ankle instability, which has also been found to affect PC [27].

In conclusion, this study suggests that static balance is impaired in elite athletes with low back pain, tested both with eyes open.

References

[1] Ebenbichler G. Sensory-motor control of the lower back: implications for rehabilitation. *Medi Sci Sports Exerc* **98** (2001), 1889-98.

[2] Winter DA. Human balance and posture control during standing and walking. *Gait Posture* **3** (1995), 193-214.

[3] Luoto S, Aalto H, Taimela S, et al. One-footed and externally disturbed two-footed postural control in patients with chronic low back pain and healthy control subjects. A controlled study with follow-up. *Spine* **23** (1998), 2089-2090.

[4] Byl N, Sinnott P. Variations in balance and body sway in middle-aged adults. Subjects with healthy backs compared with subjects with low back dysfunction. *Spine* **16** (1991), 325-30.

[5] Leinonen V. Impaired lumbar movement perception in association with postural stability and motor-and somatosensory-evoked potentials in lumbar spinal stenosis. *Spine* **27** (2002), 975-983.

[6] Luoto, BM. Psychomotor speed and postural control in chronic low back pain patients. *Spine* **21** (1996), 2621-2627.

[7] Luoto BM. One-footed and externally disturbed two-footed postural control in patients with chronic low back pain and healthy control subjects. *Spine* **23** (1998), 2081-2089.

[8] Mientjes M, Frank J. Balance in chronic low back pain patients compared to healthy people under various conditions in upright standing. *Clin Biomech* **14** (1999), 710-716.

[9] Mok NW, Brauer SG, Hodges PW. Hip strategy for balance control in quiet standing is reduced in people with low back pain. *Spine* **11** (2004), 107-112.

[10] Takala EP. Do functional tests predict low back pain? *Spine* **25** (2000), 2126-2132.

[11] Moseley GL, Hodges PW. Are the changes in postural control associated with low back pain caused by pain interference? *Clin J Pain* **21** (2005), 323-329.
[12] Bouche K, Stevens V, Cambier D, et al. Comparison of postural control in unilateral stance between healthy controls and lumbar discectomy patients with and without pain. *Eur Spine* **15** (2006), 423-432.
[13] Della Volpe R, Popa T, Ginanneschi F, et al. Changes in coordination of postural control during dynamic stance in chronic low back pain patients. *Gait Posture* **24** (2006), 349-355.
[14] Harringe ML, Halvorsen K, Renstrom P, et al. Postural control measured as the center of pressure excursion in young female gymnasts with low back pain or lower extremity injury. *Gait Postur* **28** (2008), 38-45.
[15] Brumagne S, Janssens L, Knapen S, et al. Persons with recurrent low back pain exhibit a rigid postural control strategy. *Eur Spin* **17** (2008), 1177-1184.
[16] Biedermann H, Shanks G, Forrest W, et al. Power spectrum analysis of electromyographic activity discriminators in the differential assessment of patients with chronic low back pain. *Spin* **16** (1991), 1179-1184.
[17] Cassisi J, Robinson M, O'Conner P, et al. Trunk strength and lumbar lumbar paraspinal muscle activity during isometric exercise in chronic low back pain patients and controls. *Spine* **18** (1993), 245-251.
[18] King J, Goddard M. Pain Rehabilitation. Chronic pain syndrome and myofascial pain. *Arch Phys Med Rehabil* **75** (1994), S 9-S 14.
[19] Congeni J, Mc Culloch J, Swenson K. Lumbar espondylolysis. A study of natural progression in athletes. *Am J Sports Med* **25** (1997), 248-253.
[20] Samar VJ, Bopardikar A, Rao R, et al. Wavelet analysis of neuroelectric waveforms: A conceptual tutorial. *Brain Lang* **66** (1999), 7-60.
[21] Luoto BM. Mechanisms explaining the association between low back trouble and deficits in information processing. *Spine* **24** (1999), 255-261.
[22] Mense S. Nociception from skeletal muscle in relation to clinical muscle pain. *Pain* **54** (1993), 241-289.
[23] Hodges P. Changes in motor planning of feedforward postural responses of the trunk muscles in low back pain. *Exp Brain Res* **141** (2001), 261-266.
[24] Cholewicki J, Panjabi M, Khachatryan A. Stabilizing function of trunk flexor-extensor muscles around a neutral spine posture. *Spine* **22** (1997), 2207-2212.
[25] Wilke HJ, Wolf S, Claes LE, et al. Stability increased of the lumbar spine with different muscle groups. A biomechanical in vitro study. *Spine* **20** (1995), 192-198.
[26] Newcomer KL. Differences in repositioning error among patients with low back pain compared with control subjects. *Spine* **25** (2000), 2488-2493.
[27] Riemann B. Is there a link between chronic ankle instability and postural instability? *J Athl Train* **37** (2002), 386-393.