Original research

The effect of a 10-week training regimen on lumbo-pelvic stability and athletic performance in female athletes: A randomized-controlled trial*

Jonathan D. Mills*, Jack E. Taunton, William A. Mills

Faculty of Medicine, Dalhousie University, Room C-132, CRC Building, 5849 University Avenue, Halifax, NS, Canada B3H 4H7

Received 30 July 2004; revised 23 February 2005; accepted 28 February 2005

Abstract

Objective: To evaluate a 10-week training program for improved lumbo-pelvic stability (LPS), and to investigate the impact of improved LPS on athletic performance.

Design: Randomized-controlled study.

Setting: Testing was done at the University of British Columbia, Vancouver. Training was at colleges and universities in the immediate vicinity to Vancouver, Canada.

Participants: Thirty female varsity volleyball and basketball players aged 18–23 yrs were randomly assigned to treatment (T), pseudo-treatment (PT), or control (C).

Main outcome measures: For LPS the participants lied supine and the position of the pelvis and lumbar spine was monitored using a stabilizer Pressure Biofeedback Unit™ (PBU) while load was progressively added by movements of the lower limbs. T-test, Sargent’s, and Bass’ tests assessed agility, leg power, and balance, respectively.

Results: Non-parametric Friedman, Wilcoxon and Mann–Whitney techniques detected LPS improvement in T (2.8 ± 1.5) and PT (2.3 ± 1.4). Repeated measures ANOVA detected improvement in the agility (8.8 ± 0.7 s) and leg power (32.3 ± 4.5 cm) of T, and in the static balance ability of all three groups. Regression using Spearman’s rho revealed no significant correlations between the post-test scores for LPS and athletic performance, or between pre- to post-test changes in LPS was improved following training in the T and PT groups. While improvements in agility and leg power were limited to only the T group, there was no association between improvements in LPS and improvements in athletic performance.

Conclusion: The PBU may be an important tool in identifying lumbo-pelvic instability, however, its use is not recommended in the evaluation of treatment efficacy.

© 2005 Elsevier Ltd. All rights reserved.

Keywords: Stabilizer pressure biofeedback unit; Lumbo-pelvic stability; Abdominal muscle training

1. Introduction

The concept of spinal and lumbo-pelvic stability has progressed significantly over time. Panjabi, Kuniyohsi, Duranceau, and Oxland (1989) described the spine as a series of spinal segments, and spinal stability as the ability of each segment to resist translation or rotation in any of three anatomical planes; sagittal, frontal and coronal. This perspective has considerably improved our understanding of the relationship between applied loads, vertebral displacement (Panjabi, 1992) and the stabilizing role of musculature in and around the spine (Comerford & Mottram, 2000).

For ease of clinical assessment, stability has more recently been defined in reference to the entire lumbo-pelvic region (Jull, Richardson, Toppenburg, Commerford,
Lumbo-pelvic stability (LPS) is defined as the ability to control motion of the lumbar spine and pelvis relative to an arbitrarily defined neutral position. For patients with clinical evidence of lumbo-pelvic instability, Richardson and Jull (1995) developed a training regimen focusing on muscles of the local stability system, specifically transversus abdominus (TrA) and the lumbar multifidi (LM). A number of different outcome variables have been employed to investigate the efficacy of this training program including self-reported pain scores, functional disability and ROM in the hip and spine (Cusi, Juska-Butel, Garlick, & Argyrous, 2000; O’Sullivan, Twomey, & Allison, 1997; Young, McLaren, & McDowell, 1998).

More and more, the programs of many athletes incorporate LPS training is also commonly incorporated into the programs of many athletes. Purportedly, a high degree of LPS may contribute to athletic performance by aiding in the ‘efficient transmission of force generated by the lower body through the trunk to the upper body’ (Baker, 1999). Expert opinion from observation suggests that inability to stabilize the lumbo-pelvic region during running leads to ‘poor technique and inefficient force application’ (Faccioni, 1994). In spite of the incredible detail of the proposed mechanisms associated with poor LPS, there are few if any methods of assessing this domain.

Uni-planar flexion–extension radiography is a simple and cost-effective means of visualizing the movement of spinal segments, however, as an outcome measure of treatment efficacy, its value is questionable. In patients with spondylolysis and spondylolisthesis, LPS training has resulted in improved pain intensity and descriptor scores, functional disability levels, and hip ROM without radiographic evidence of a treatment effect (O’Sullivan et al., 1997). Furthermore, difficulties in reproducing functional radiographs and the lack of a standardized technique have made even the diagnostic value of this technique uncertain (Nizard, Wybier, & Laredo, 2001).

In light of the challenges of measuring spinal stability, Jull et al. (1993) hypothesized that excessive movement of the lumbar spine and pelvis would indicate deficits in LPS, and devised a tool to measure the stabilizing capacity of the abdominal musculature. The stabilizer Pressure Biofeedback Unit™ (PBU) assesses sagittal plane control of lumbar motion under an imposed sagittal load (Jull et al., 1993). With the patient lying supine, a pressure cuff attached to a gauge is inserted under the small of the back, inflated to 40 mmHg and maintained at this pressure during the application of external loads to the upper or lower limbs. Lumbo-pelvic instability is defined as a deviation of the lumbar spine and pelvis from an arbitrarily defined neutral position and is indicated by a change in cuff pressure. In spite of its frequent use to assess deficits in lumbo-pelvic stability, improvements in LPS measured by this instrument have not been validated against improvements in function.

The purpose of the present study was to establish whether there is an effect on LPS and athletic performance after a 10-week training program.

2. Methods

2.1. Participants

After approval of the study by the University of British Columbia Clinical Ethics Committee, participants were recruited from college- and university-level basketball and volleyball teams in the immediate vicinity of Vancouver, Canada. For inclusion in the study, participants were required to be female, a member of their school’s basketball or volleyball team, and willing to sign a consent form. Participants presenting with exaggerated sway-back, flat-back, or lordotic postures, identified with the aid of a plumb-bob (Kendall, McCreary, & Provance, 1993), were excluded, as were those who had received treatment for back pain within the last year, or had any existing injury. Upon recruitment, participants underwent stratified random assignment (based on sport and level of competition) to one of three groups; treatment (T), pseudo-treatment (PT), or control (C).

2.2. Training

In weekly, supervised training sessions, participants (T and PT) learned and practiced the week’s exercises and, over the remainder of the week, completed three additional unsupervised sessions. Specific exercises are listed in Table 1. Participants were reminded of the importance of correct technique so as to minimize compensatory movements when performing the exercises. At the beginning of the following week participants were asked to hand in exercise logs outlining the number of reps and sets completed, and any problems encountered. The exercises were reviewed, and additional exercises were added.

Training for the treatment group focused on voluntarily activating the local stability muscles; transversus abdominus (TrA), lumbar multifidi (LM), and the pelvic floor (PF), and was divided into three stages (Table 1). The first two stages were each four weeks in duration and consisted of exercises promoting awareness of TrA, LM and PF muscles. Instructions were given to voluntarily contract TrA by pulling the umbilicus inwards toward the spine, LM by causing the muscles on either side of the lumbar spine to swell, and PF by tightening the muscles preventing urine flow (Richardson & Jull, 1995). In the first weeks of training TrA, LM and PF were contracted individually with the total contraction time increasing from week to week. During supervised training sessions compensatory movements such as gluteal or rectus abdominus contraction and pelvic tilting were discouraged. Exercises were progressed by co-contracting these muscles and eventually by
imposing torques upon the pelvis with the addition of lower and upper limb movement. Exercises were considered successfully completed if co-contraction was maintained and compensatory movement or muscle contraction was minimized. In the final two weeks, an unstable surface was introduced upon which the participants performed similar exercises in more functional positions while maintaining co-contraction of TrA, LM and PF. The specific exercises, repetitions and sets for this training program are detailed in Table 1.

The training program of the pseudo-treatment group recruited the global mobility muscles (rectus abdominus and the external obliques) through a number of trunk flexion, rotation, and lateral bending exercises. As in the treatment group, participants in the pseudo-treatment group were supervised weekly, and were asked to submit training logs for the three unsupervised training sessions each week. Exercises were done in supine and prone positions and were progressed by increasing either the number of sets or repetitions. The volume of training between the treatment and pseudo-treatment groups was matched by ensuring equal training time between the two groups. The specific exercises, repetitions and sets for the pseudo-treatment group are provided in Table 1.

### Table 1

<table>
<thead>
<tr>
<th>Training week</th>
<th>Treatment exercises</th>
<th>Pseudo-treatment exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TrA, LM, PF contraction in quadruped, supine, prone, semi-prone, sitting, and standing positions 1×10- held for 10 sec. Side bridging- 2×30 sec</td>
<td>Crunches- 2×20, Side-lying crunches- 2×20</td>
</tr>
<tr>
<td>2</td>
<td>Exercises as above 1×10- held for 15 sec Side bridging- 2×45 sec</td>
<td>Crunches- 2×25, Side-lying crunches- 2×25</td>
</tr>
<tr>
<td>3</td>
<td>Exercises as above 1×10- held for 20 Side bridging- 2×60 sec</td>
<td>Crunches- 2×30, Straight leg raises- 2×10</td>
</tr>
<tr>
<td>4</td>
<td>Exercises as above 1×10- held for 30 sec Side bridging- 2×60 sec</td>
<td>Crunches- 2×30, Straight leg raises- 2×10, Pelvic Lifts- 2×15</td>
</tr>
<tr>
<td>5</td>
<td>Co-contraction of TrA, LM, PF in positions as above, 1×10-held for 15 sec</td>
<td>Curl-up- 2×30, Side-lying crunches- 2×30, Pelvic Lift- 2×20</td>
</tr>
<tr>
<td>6</td>
<td>Supine leg lifts- 2×10, Leg extensions- 2×5, Clamshell- 2×5</td>
<td>Curl-up- 2×30, Straight leg raises- 2×12, Pelvic Lifts- 2×20</td>
</tr>
<tr>
<td>7</td>
<td>Supine leg lifts- 2×10, Leg extensions- 2×10, Clamshell- 2×5</td>
<td>Crunches- 2×35, Bicycle kicks- 2×30, Leg extensions- 2×12</td>
</tr>
<tr>
<td>8</td>
<td>Supine leg lifts- 2×30, Leg extensions- 2×10, Bridging leg lifts- 2×10</td>
<td>Crunches- 2×35/1×30, Bicycle kicks- 3×40, Leg extensions- 3×12</td>
</tr>
<tr>
<td>9</td>
<td>Supine leg lifts- 3×40, Bridging on ball- 3×10, Arm flexion on ball- 3×10</td>
<td>Curl-up- 3×35, Bicycle kicks- 3×40, Bridge with curl-up- 3×30</td>
</tr>
<tr>
<td>10</td>
<td>Supine leg lifts- 3×40, Bridging on ball- 3×10, Arm flexion on ball- 3×10</td>
<td>Crunches- 3×40, Bicycle kicks- 3×40, Bridge with curl-up- 3×40</td>
</tr>
</tbody>
</table>

2.3. Measures

The effect of training on LPS was evaluated using a stabilizer Pressure Biofeedback Unit™ (Chatanooga, Australia) prior to, and upon completion of the 10-week training program. The PBU was comprised of an inflatable rectangular cushion (23×14 cm) connected to a pressure gauge (measuring 0–300 mmHg) and an inflation device. With the participant lying supine on a plinth, the cushion was inflated underneath the participant’s lumbar spine to 40 mmHg. Changes in pressure during subsequent testing reflected uncontrolled movement of the lumbar spine.

Prior to testing, all participants were instructed in the abdominal hollowing manoeuvre and told to perform this during subsequent LPS testing while attempting to minimize contraction of rectus abdominus. Scores were recorded as the highest level completed (0–5) with a pressure change no greater than 10 mmHg. The highest level attained in three trials was used for statistical analyses.

There were five progressions of the test exercise. Progressing from level one to five, the torque produced by movement of the legs and acting on the lumbo-pelvic region, was increased. If there was a change in pressure greater than 10 mmHg during testing the trial was stopped and the participant’s LPS was scored as the last level successfully completed. The degrees of difficulty of the test exercise were as follows:

**Level 1** In a crook lying position an abdominal hollowing manoeuvre preset the abdominal muscles and the participant slowly raised one leg to a position of 100° of hip flexion with 90° knee flexion. The other leg was then slowly raised to a similar position. This position was the start position for the following four levels.

**Level 2** From the start position, the participant slowly lowered one leg and, with the heel down on
the plinth, slid the leg out to straighten the knee, then slid it back up into the start position.

Level 3 From the start position, the participant slowly lowered one leg and, with the heel maintained approximately 12 cm off the plinth, fully extended the leg and then moved it back to the start position.

Level 4 From the start position, the participant lowered both legs together and, with the heels down on the plinth, slid the legs out to straighten the knees and then slid them back and raised them to the start position.

Level 5 From the start position, the participant simultaneously extended both legs keeping the heels approximately 12 cm off the plinth and then flexed the legs back to the start position.

Agility, leg power and static balance were evaluated as indicators of athletic performance. Agility was measured as the time to complete the T-test, a measure of four-directional agility and body control requiring rapid directional changes without loss of balance. The repeatability of the T-test has been established and validated against the hexagon test and 40-ya dash (Pauole, Madole, Garhammer, Lacourse, & Rozenek, 2000). Time was recorded to the nearest one-hundredth of a second for three test trials with the fastest trial used for statistical analyses. A non-countermovement vertical jump test was used to assess leg power (Sargent, 1921). Participants stood with feet shoulder-width apart, one hand on the hip, and the other hand at shoulder level, and, after flexing the knees to 70°, paused for a brief moment before jumping as high as possible. At the highest point of each jump, participants made a mark on the wall with one hand. Sargent’s vertical jump test has demonstrated excellent test-retest reliability and has been validated against other measures of lower extremity power (Johnson & Nelson, 1986). Three trials were performed with the average of the trials recorded as the vertical jump height. Balance was assessed using the Bass stick test. The time, to a maximum of 60 s, the participant was able to balance on the ball of one foot on a 1-inch wide stick without touching the floor was recorded three times on each foot. The times from all six trials were summed to give a final static balance score. Bass’ stick test has been assessed with a high degree of test-retest reliability (Johnson & Nelson, 1986).

2.4. Statistical analysis

Data collected during the assessment of LPS were of an ordinal nature and therefore required analysis using non-parametric statistical tests. Analysis of these data was carried out with a combination of Friedman, Wilcoxon and Mann–Whitney U tests. Associations between LPS and athletic performance were assessed using Spearman’s rho.

For the measures of athletic performance, a 3×2 ANOVA with repeated measures on the second factor assessed differences between and within groups as well as any interaction which may have occurred. For these same data, Pearson’s product-moment correlation coefficients assessed correlations and relationships between variables.

An alpha level of 0.05 was set as a cut-off point for statistical significance in both parametric and non-parametric analyses.

3. Results

Thirty-three athletes were recruited for the present study, thirty completed the 10-week training program and were included in the statistical analyses. Two athletes were excluded due to poor attendance at weekly training sessions and one athlete was forced to discontinue due to a sport-related injury. Twenty-four athletes were recruited from volleyball and six from basketball teams. At baseline there were no significant differences between groups in height, weight, age, time spent in either cardiovascular, weight or team training, or on any of the outcome measures (Table 2).

Results of the comparison of LPS, agility, leg power and balance scores are summarized in Table 3. A non-parametric Friedman analysis of variance by ranks revealed a significant increase (Chi square (2) = 22.43, p < 0.01) in

| Table 2 Baseline measures of the treatment, pseudo-treatment and control groups |
|-----------------|-----------------|-----------------|
| **Treatment (n=10)** | **Pseudo-treatment (n=10)** | **Control (n=10)** |
| **Sport** | Volleyball (9), Basketball (1) | Volleyball (7), Basketball (3) | Volleyball (8), Basketball (2) |
| **Age (yrs)** | 20.3 ± 2.0 | 18.9 ± 1.1 | 19.4 ± 1.7 |
| **Height (cm)** | 176.7 ± 6.0 | 177.5 ± 5.4 | 176.8 ± 6.8 |
| **Weight (kg)** | 73.2 ± 5.8 | 73.8 ± 5.9 | 73.3 ± 4.5 |
| **Cardio (h/week)** | 2.2 ± 0.5 | 2.5 ± 0.1 | 2.5 ± 0.4 |
| **Weights (h/week)** | 1.5 ± 0.1 | 2.0 ± 0.6 | 1.8 ± 0.2 |
| **Team practice (h/week)** | 10 ± 1.7 | 10.5 ± 1.4 | 12.0 ± 0.7 |
| **LPS (pre-training)** | 1.3 ± 1.25 | 0.6 ± 0.7 | 1.8 ± 1.4 |
| **Agility (s)** | 8.8 ± 0.7 | 8.8 ± 0.3 | 9.0 ± 0.3 |
| **Leg power (cm)** | 29.1 ± 6.0 | 30.1 ± 7.2 | 29.0 ± 4.0 |
| **Static balance (s)** | 88.4 ± 69.5 | 78.6 ± 63.6 | 54.8 ± 35.2 |

Values are reported as means ± standard deviation.
stability following the 10-week training period. Subsequent Wilcoxon tests localized this improvement over time to the treatment (z = −2.75, p < 0.01) and pseudo-treatment (z = −2.86, p < 0.01) groups. There was no statistical difference between the control group’s pre- and post-test LPS scores (z = −1.29, p > 0.05).

The ANOVA analysis of agility scores revealed a significant test-time by group interaction (F(2, 27) = 3.81, p < 0.05). A post-hoc Tukey test demonstrated significant improvement in the treatment group’s post-test agility times (t(27) = 3.75, p < 0.0005). No differences were found between either the pseudo-treatment (t(27) = 0.33, p > 0.05) or control groups’ (t(27) = 0.33, p > 0.05) pre- and post-test scores.

For leg power, repeated measures ANOVA revealed a significant effect of time of testing but no significant effect due to group membership. ANOVA also revealed a marginally significant test-time by group interaction (F(2, 27) = 1.76, p < 0.1). Post-hoc comparisons of the within groups effect demonstrated a significant difference between the treatment group’s pre- and post-test vertical jump heights (t(27) = 2.53, p < 0.05). No difference, however, was found between the pre- and post-test vertical jump heights of either the pseudo-treatment (t(27) = 0.09, p > 0.05) or the control groups (t(27) = 0.40, p > 0.05).

Repeated measures ANOVA revealed a significant effect of time of testing (F(1, 27) = 10.62, p < 0.01), but did not indicate a significant group effect between the pre- and post-test static balance times. There was no indication of a significant test-time by group interaction F(2, 27) = 0.09, p > 0.05). Post-hoc comparisons demonstrated significant improvements in static balance from pre- to post-tests in all groups.

Regression using Spearman’s rho (r_s) revealed no significant associations between LPS and athletic performance following 10 weeks of training, or between pre- to post-test changes in LPS scores and pre- to post-test changes in athletic performance following training (Table 4).

4. Discussion

Stability of the spine is provided by the integrated functioning of the active, passive and control subsystems (Panjabi, 1992). While the function of each of these subsystems can be attenuated through injury or disuse, it is hypothesized that function can be re-established by training the active subsystem. In order to do so, Richardson and Jull (1995) recommend the transversus abdominis (TrA), lumbar multifidi (LM) and pelvic floor (PF) muscles be contracted isometrically at low levels of voluntary contraction and in exercise positions, such as prone lying or quadruped kneeling, which decrease compensatory muscle activation. In patients with radiographically identified spondylyolysis or spondylolisthesis, O’Sullivan et al. (1997) investigated the effect of 10 weeks of this training program on pain, disability scores and spinal range of motion. An intervention group of 21 subjects completed a 10-week program beginning with contraction of the TrA and LM muscles, and progressing with increased contraction time and the application of a low load on the muscles by means of adding leverage through the limbs. A control group also underwent 10-weeks of physical activity which was directed by each patient’s medical practitioner and consisted of general weekly exercises including swimming, walking and gym exercise. After training, the intervention group demonstrated a greater reduction in pain intensity, pain descriptor scores, Oswestry functional disability levels and improved hip flexion and extension ROM when compared to the control group. These differences were maintained at the 3, 6 and 30-month follow-up times.

Decreased pain scores and increased ROM in patients with stability dysfunction are valid outcome measures of treatment efficacy and in the context of the study by O’Sullivan et al. (1997), are interpreted as improvements in LPS (Liebenson, 1998). While these measures may assess overall treatment efficacy, they do not provide a direct measurement of the effect on LPS itself. The stabilizer Pressure Biofeedback Unit™ (PBU) was developed to directly assess the ability of the abdominal muscles to actively stabilize the lumbar spine (Jull et al., 1993). This instrument represents a bold first attempt to assess LPS and,
although a gold standard does not exist with which to quantify its validity, it is frequently used to direct clinical decision-making in regards to LPS impairment.

The PBU measures the pressure exerted by the lumbar spine upon a pressure cuff inserted in the space between the lumbar spine and a plinth or exercise mat. A decrease in pressure greater than 10 mmHg represents an inability to maintain isometric contraction of the abdominal muscles. Successful completion of a level in the test exercise requires a constant lumbar spine position to be maintained. The assigned LPS score ultimately measures the amount of impairment present: participants with a low degree of impairment will attain a high level in the test exercise while those with a high degree of impairment will attain a low level in the test exercise.

In the present study, after 10-weeks of abdominal muscle training participants attained higher LPS scores by maintaining a constant pressure on the PBU under conditions of greater torque imposed upon the pelvis and lumbar spine. As discussed previously, this improvement in LPS score could alternately be viewed as a decline in LPS impairment. As such, the results of this study would provide, within an asymptomatic, athletic population, support for the notion that LPS impairment can be decreased following training.

Interestingly, declines in the level of LPS impairment were not related to improvements in any of the measures of athletic performance. This raises important questions concerning the appropriateness of assessing treatment efficacy with a measure indicating a level of impairment, as opposed to a measure indicating functional ability. It is likely that the high function of the study population limited the ability to detect functional improvements following training. Further investigation may produce different results in a population of individuals with LPS impairment severe enough to cause functional deficits.

An abundance of literature exists to suggest that the treatment and pseudo-treatment groups’ exercises differentially activated the local stability and global mobility muscle systems (Arokoski, Valta, Airaksinen, & Kankaanpää, 2001; Beith, Synnott, & Newman, 2001; Richardson, Jull, Toppenburg, & Comerford, 1992; Richardson, Toppenberg, & Jull, 1990; Vezina & Hubley-Kozey, 2000). However, EMG analysis was not performed in this study and as a result the specificity with which these exercises were able to recruit the corresponding muscle systems rests on the correct execution of the exercises by the participants. The limited supervision of exercises during training may be seen as a limitation to this study and efforts were made to rectify this limitation by requiring participants to attend a once-per-week supervised training session, and to hand in training logs detailing each week’s unsupervised training sessions. Despite these efforts there was no difference in LPS improvement between the treatment and pseudo-treatment groups.

An equivalent improvement in LPS after training of either the local stability or the global mobility muscle systems does not support the results of a previous investigation (Young et al., 1998). Young et al. (1998) compared the effect of 4 weeks of sit-up type exercise with 4 weeks of lumbo-pelvic stabilization training as described by Richardson and Jull (1995). Following training, a greater improvement in the ability to stabilize the lumbo-pelvic region (assessed via the PBU) was demonstrated by the LPS-trained group leading the authors to conclude that traditional abdominal strength training was inadequate for the development of LPS (Young et al., 1998). Whether the findings of the present study are due to failure of the training programs to differentially recruit the two muscle systems or to the stabilizing role of the two muscle systems being equivalent cannot be adequately answered within the framework of this study.

In spite of the lack of difference between treatment and pseudo-treatment groups in the effect of training on LPS, there was a differential effect of training on agility and leg power scores. The improvement in agility and leg power of the treatment group is misleading and likely the result of a confounding variable given the lack of association between LPS and athletic performance. If, as suggested by some authors, movement were generated more efficiently and with greater power as the spine becomes more stable, a strong association between athletic performance and lumbo-pelvic stability would be expected (Baker, 2000; Faccioni, 1994). However, the findings of the present study do not support this suggestion.

A likely explanation may be due to the homogeneity of the study population resulting in less variation between athletic performance scores and thereby distorting the strength of the association between LPS and athletic performance. If this study were carried out within a symptomatic population of significantly impaired function, an association may be detected between LPS and functional improvement. For this reason, it is important to recognise that the findings of this study are limited to a specific, asymptomatic athletic population.

5. Conclusion

The present results provide evidence that LPS training enhances lumbo-pelvic stability. However, since the treatment and pseudo-treatment groups demonstrated a comparable enhancement of LPS, there is no evidence that the muscle group exercised differentially results in improved LPS. The non-existent correlations between changes in LPS scores and changes in athleticism, suggest that the relationship between LPS and athleticism may need to be reconceptualised. In the revised conceptual model, LPS tests would be seen as additional measures of athleticism, not as measures of a hypothetical construct upon which athleticism is contingent. These findings provide evidence that the stabilizer Pressure Biofeedback Unit™ (PBU) is a sensitive instrument to detect impairment in LPS and
subsequent improvement in this impairment following 10 weeks of abdominal muscle training. Whether the improvement in LPS detected by the PBU is related to a functional improvement, specifically within an athletic population, is questionable. The PBU may be useful in directing clinical decision making, however, it is not a useful tool in detecting functionally relevant outcomes of LPS training in a high-functioning athletic population.

Acknowledgements

This project was made possible by grants from the Nike Global Research Foundation and the B.C. Sports Medicine Research Foundation. In addition to these organizations, the authors gratefully acknowledge Dr Donna Macintyre and Dr Rob Lloyd-Smith for their assistance and advice in the completion of this study; Mr Doug Reimer, Ms Deb Huband, Mr Gerry Lambert and Mr Dave Dalconale for their enthusiasm with the study and their willingness to allow their teams’ participation; those who provided access to facilities in which to train and test subjects including Mr Ed Knowles, Ms Sonya Lumholdst-Smith and Ms Lela Stewart of the YMCA; and finally a special thanks to the athletes who dedicated their time and energy to participate in this study.

References


