Effects of Hypopressive Exercise on Posterior Back Chain Kinematics and Pulmonary Function in Professional Female Basketball Players

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Context: Hypopressive exercise (HE) has been used as an alternative lumbo-pelvic injury prevention program and claimed to be a means of respiratory and flexibility improvement. However, the possible effects of HE on athletic populations and physical performance remain unclear. Objective: Examine the effects of a HE program on posterior back chain kinematics, thoracic mobility, pulmonary function, and lower lumbar pain in female basketball players over an 8-week training period. Design: Prospective (1) baseline, (2) midpoint (4 wk), and (3) after 8 weeks. Setting: Sports field. Participants: A total of 17 professional female basketball players (mean age 20.7 ± SD: 3.50; body mass index, 21.71 ± SD: 1.69). Intervention: Participants performed 8 HE weekly sessions of 30 minutes. Main Outcome Measures: Back chain kinematics was assessed with the sit and reach and finger to floor test, and back pain was assessed through numerical rating scale. Respiratory parameters were assessed by spirometry and through thoracic mobility. Results: The analysis of variance revealed significant differences between the 3 measurement periods for thoracic mobility (P > .01); forced expiratory volume in the first second (P < .05) while no statistical differences were found for the rest of spirometry outcomes. Significant differences were also revealed between baseline and after the intervention for the sit and reach test (P > .01), peak expiratory flow (P = .01), and forced expiratory volume in the first 25 seconds (P = .04). Also, significant differences between weeks were found in levels of lumbar pain (P = .003) and the finger to floor test (P = .002). Conclusions: These preliminary findings suggest that a HE program can improve posterior back chain and chest wall kinematics as well as lower lumbar pain levels. However, no gains seem to be observed for the majority of pulmonary variables except for peak expiratory flow and forced expiratory volume in the first seconds.

Keywords: spirometry, physical therapy modalities, respiratory muscles, female athletes, kinetic chain

Basketball is one of the world’s most popular Olympic team sports. The International Basketball Federation estimates that at least 450 million people of all ages and sex, ranging amateurs to professionals, play basketball worldwide.1 It is a high-intensity intermittent sport involving repeated jumps, sprints, and frequent changes in direction that require a high degree of cardiovascular fitness and neuromuscular prowess.2,3 Suboptimal physical conditioning and musculoskeletal limitations appear to predispose athletes to injury and poor sports performance.4,5 Greater fatigue, game load, and sport experience are associated with higher injury risk.6 In the particular case of female basketball players, the main sport-related injuries occur in the lower limbs, specifically in the ankle and the knee.7–9 The sport characteristics (jump landing and impact) alongside with the unique female biomechanical characteristics (ie, greater knee valgus, joint flexibility, decreased knee flexion during landing) make the ratio of sports injuries in female players higher than their male counterparts.10 In addition, a higher prevalence of lower back pain has been reported in female players in comparison with their male counterparts as well as athletes in other sports.11–14 Injury prevention programs primarily targeting the neuromuscular control factors of the hip and trunk have shown to be effective in reducing lower limb injuries in female basketball players.15–19

Recently, hypopressive exercise (HE) has gained attention by sport teams as an injury prevention strategy for professional athletes.20 HE is a postural and breathing-based exercise program used as a preventative and rehabilitative tool for a variety of clinical conditions ranging from pelvic dysfunctions,21 nonspecific chronic low back pain,22 or idiopathic scoliosis.23 HE combines conventional postural alignment exercises, stretching poses, and additional respiratory exercises that are added with the goal of improving diaphragmatic-pelvic coordination and deep core muscle activation.24,25 The HE breathing standard is latero-costal breath combined with an abdominal vacuum maneuver.25,26 This breathing pattern uses predominantly the chest and ribcage muscles, favoring the lateral expansion of the ribcage,25 which could influence pulmonary and respiratory muscle function.26 A descriptive study on the effect of HE on respiration in healthy females showed that HE activates the accessory respiratory musculature and mobilizes lung volumes without interfering with the respiratory ratio.26 Also, in healthy females, the practice of 3 different HE poses showed greater activation of the deep trunk muscles (pelvic floor muscles and internal oblique) than the external oblique and rectus abdominis.24

In this scenario, HE has been suggested as a means to improve neuromuscular control of the trunk, lumbar flexibility as well as lumbo-pelvic muscle conditioning.22,24 However, knowledge of the efficacy of HE for the conditioning and/or treatment of pelvic
floor or lumbo-abdominal conditions remains scarce and questionable.27 One randomized controlled study found in patients with chronic low back pain a decrease in the levels of pain and improvements in lumbar flexibility after 8 sessions.22 Another randomized controlled trial found that an 8-week program of EH improved postural control and deep trunk muscle activation in healthy females.28

The increasing use of HE in injury prevention programs of professional sports teams29 raises the question of its efficacy as a supplemental neuromuscular injury prevention strategy. One study described an improvement in lumbar and hamstring flexibility after a 6-week in-season HE training program.30 However, to the best of our knowledge, no other published reports have assessed the efficacy of HE on respiratory parameters or lumbo-pelvic conditioning in athletes. Due to the type of breathing and postural techniques that are performed during HE,26 we hypothesize that HE could be an adjunctive method of conditioning to enhance mobility of the posterior back chain and improve chest wall biomechanics leading to enhanced ventilatory parameters. Improved thoracic biomechanics and deep trunk muscle activation has been suggested to enhance posterior back chain muscle mobility.30–32 Thus, the aim of this study is to examine the effects of an HE program on ventilatory parameters, posterior back chain kinematics, and low back pain in professional female basketball players.

Methods

Design

This study was a clinical trial with preintervention, midintervention, and postintervention assessments.

Participants

A sample of 17 female professional basketball players participated in this study throughout the middle of their sport season (from February to April 2019). Participants were recruited from 2 female basketball teams who competed in the same Spanish national league. Both teams trained 4 times/week for 90 minutes. The training sessions focused on improvements in the technical and tactical fundamentals of the game including defensive strategies. All sessions included a 10-minute dynamic warm-up with basketball drills. Demographics and injury history are outlined in Table 1. Inclusion criteria included the following: (1) professional female basketball players and (2) did not have any contraindication to participating in a HE program including hypertension, pregnancy, or pulmonary obstructive dysfunctions. Prior to commencing the study, the participants were informed about data collection procedures and the HE program. All participants signed an informed consent form. The experimental protocol was approved by the research ethics committee of the University of Alicante (UA-2018-12-03) and was conducted in compliance of the Code of Ethics of the World Medical Association Declaration of Helsinki for experiments involving humans gathered at the 64th General Assembly, Fortaleza, Brazil, October 2013 and the relevant Spanish legislation.

Interventions

All participants were evaluated before, at midpoint (4 wk), and immediately after the 8-week intervention by the same researcher. All the participants completed the intervention program, which consisted of a once weekly-supervised session of 30 minutes performed before their basketball training practice. The intervention was instructed by a licensed physical therapist certified in HE. The instructor recorded exercise adherence for every session and provided instruction on proper exercise form following the guidelines described by descriptive manuals.33 Prior to commencing the HE, a review of correct postural alignment was performed and a warm-up consisting of breathing awareness and self-myofascial release of the diaphragm. All the HE involved the following technical principles: (1) spine elongation with neutral pelvis, (2) ankle dorsiflexion, (3) knee flexion, and (4) scapular girdle muscle activation.31 All participants were taught and given cues for correct posture and alignment such as “pelvis neutral,” “stand tall and lengthen spine,” and “widen and open chest” during the execution of the poses. After the warm-up, 8 basic HE were performed in standing, kneeling, all on-fours, sitting and supine positions and repeated 3 times with 3 controlled breathing cycles between repetitions and exercises (Figure 1). The breathing cycles of the HE involved slow controlled latero-costal breaths combined with an abdominal vacuum maneuver.26 The abdominal vacuum consisted of a breath-hold after exhalation followed by a rib cage expansion. The breath-holding time for the abdominal vacuum progressed from 3 to 6 seconds during the 2 first weekly sessions, to 8 to 12 seconds at mid-point until reaching a maximum of 15 to 18 seconds in the last 2 weeks of the intervention.25 The cue was “hold breath while expanding rib-cage.” An observable abdominal draw-in of the entire abdominal wall and expansion of the rib cage was defined as a correct exercise form of the abdominal vacuum.25 Details of each HE are available elsewhere.25,33 The intervention protocol ended with 3 to 4 minutes of normal breathing frequency.

Outcome Measures

Participants were instructed to not perform vigorous exercise, avoid smoking, or consuming intoxicants before testing. The same researcher performed all the assessments during the same week for each team. Primary outcome measures were back chain kinematics and pulmonary function. Secondary outcomes were low back pain levels and thoracic mobility.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>20.71 (3.50)</td>
</tr>
<tr>
<td>Body height, cm</td>
<td>170.59 (7.53)</td>
</tr>
<tr>
<td>Body weight, kg</td>
<td>63.41 (7.32)</td>
</tr>
<tr>
<td>Body mass index, kg/m²</td>
<td>21.71 (1.69)</td>
</tr>
<tr>
<td>Years of sports practice, y</td>
<td>13.41 (3.57)</td>
</tr>
<tr>
<td>Frequency of basketball training, d/wk</td>
<td>4.06 (0.90)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Injury history</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low back pain</td>
<td>7</td>
</tr>
<tr>
<td>Exercise-induced asthma</td>
<td>2</td>
</tr>
<tr>
<td>Lower limb injuries</td>
<td>3</td>
</tr>
<tr>
<td>Left ankle sprain</td>
<td>1</td>
</tr>
<tr>
<td>Bilateral chondromalacia patella</td>
<td>1</td>
</tr>
<tr>
<td>Subluxation of sacroiliac joint</td>
<td>1</td>
</tr>
</tbody>
</table>
Primary Outcomes. Posterior back chain kinematics: To assess posterior back chain flexibility the finger to floor test was used. The participant is asked to stand in an upright position on a stool and then bend the trunk forward trying to reach both hands the toes while keeping knees extended. The outcome measure is the linear distance between the level of the stool and the middle finger measured in centimeters to the nearest 0.5 cm. This distance is thought to represent the lumbosacral and hip joint (hamstring) flexibility. The finger to floor test is a widely used field test to assess posterior muscular chain flexibility and has shown high reliability and sensitivity scores in active and sportive populations. Because the finger to floor is highly influenced by the balance demand on the upright position, the sit and reach test was added to assess back chain flexibility excluding balancing demands. During the sit and reach test, the participants sat on a mat with both feet against a standard sit and reach testing box (30.5 cm high). They kept their legs extended and soles of the feet against the box. Then they placed right hand over the left and slowly flexed the trunk forward as far as they could by sliding their hands along the measurement board with an extension of 23 cm. Each player performed 3 attempts of both tests. The highest value of the final angle was recorded. Tests were conducted following the American College of Sport Medicine guidelines.

Spirometry: Pulmonary function was assessed through a computerized spirometer (QM-SP100; Quirumed S.L.U., Valencia, Spain) according to the jointly technical standard guidelines from the American Thoracic Society and the European Respiratory Society for conducting spirometry. Prior to testing, the researcher instructed and demonstrated the test to ensure an understanding of instructions. The tests were performed in the standing position with a noseclip in place and lips sealed around the spirometry mouthpiece. Players were instructed to inspire maximally and then expire with maximal effort until no more air could be expelled while maintaining proper posture. Outcomes obtained from the spirometer were (1) forced vital capacity (FVC); (2) peak expiratory flow; (3) forced expiratory volume (FEV); (4) FEV in the first 0.25 seconds (FEV0.25); (5) in the first 0.75 seconds (FEV0.75); (6) between 25% and 75% of FEV (FEV25-75); (7) FEV in the first second (FEV1); and (8) ratio between FEV in the first second and forced vital capacity (FEV1/FVC). The curves were analyzed according to the provided criteria of acceptability and reproducibility praised by literature. Three breathing maneuvers were performed, and the best of the 3 values was noted as recommended by the American Thoracic Society and the European Respiratory Society guidelines.

Secondary Outcomes. Thoracic mobility: Thoracic mobility also known as chest wall expansion was used to measure chest wall range of motion and potential diaphragmatic function. Measurement is done in the standing position with a tape measure (marked in centimeters) at the level of T10 and following the procedure described by Magee. Participants were asked to perform a maximum inspiration followed by a full exhalation while maintaining upright position. The difference between the highest value obtained from the inspiration and the smaller value of the expiration is the thoracic coefficient. Each measurement was obtained three times, and the best result of the 3 was recorded.

Numerical rating scale: In addition, another secondary outcome measure was low back pain assessed by numerical rating scale. This is the numeric analogical visual and graded version of the visual analog scale used to assess pain levels. Players were asked to rate their lower back pain severity and intensity from “no pain at all” (0) to worst pain ever possible” (10) by using the numeric rating scale. Each player was asked to circle a pain level that best described the level of back pain during the previous week. The numerical rating scale is a valid and reliable pain rating scale deemed appropriate for clinical practice whereby a change of 20% between time measurements is considered as clinically significant.

Statistical Analysis
A blinded specialist in statistics (not responsible for the intervention or data collection) analyzed the data and presented as means and SDs or 95% confidence intervals. Normality and homogeneity...
of all variables were tested with the Shapiro–Wilk test. All variables analyzed followed a normal distribution except for the finger to floor test and the numerical rating scale. One-way analysis of variance with Bonferroni post hoc was used to compare normal variables. For the nonparametric variables, analysis was carried out using the Kruskal–Wallis test. A level of statistical significance was chosen as \( P < .05 \). The effect size was calculated using the eta-squared (\( \eta^2_p \)) and maintaining the classification criteria previously established by Cohen\(^4\) for a sample of untrained subjects, which effect size will be considered (1) .01 approximately small, (2) .06 approximately medium, and (3) >.14 approximately large. All tests were carried out using Statistical Package for the Social Sciences (version 22; SPSS Inc, Chicago, IL).

### Results

All participants completed study-related tests successfully, and no unexpected events or injuries occurred. No dropouts occurred. Three main assessments were made at week 0 (pretest), week 4 (midterm measurement), and at the end of the protocol (posttest). Table 2 presents the means and SD for all of the outcome measures and 3 measurements performed during the study. Table 3 presents the data and changes from the analysis of variance test for all the outcome measures as well as effect size.

#### Primary Outcomes

The nonparametric analysis revealed significant differences between weeks for finger to floor test (\( P = .002 \)) with 51% increased gains of back chain kinematics from baseline to postintervention. Similarly, the sit and reach test elicited significant differences and large effect size from baseline to postintervention and midterm to week 8 (\( P = .00, \eta^2_p = .67 \)). Large treatment effects were obtained with an average gain of 7.3 cm of back chain kinematics at the end of the study.

The analysis of variance revealed no significant differences between assessments for the following spirometry variables: FVC, FEV, FEV\(_{0.75}\), FEV\(_{25–75}\), and FEV\(_1\)/FVC. However, significant differences and a large treatment effects were found when comparing weeks 0 to 4 and weeks 4 to 8 for FEV\(_1\) (\( P = .03, \eta^2_p = .62 \)) as well as between baseline and postintervention for PEF (\( P = .01, \eta^2_p = .59 \)) for FEV\(_1\) (\( P = .00, \eta^2_p = .62 \)) and FEV\(_{0.25}\) (\( P = .04, \eta^2_p = .31 \)).

#### Secondary Outcomes

The nonparametric analysis revealed significant differences between weeks (\( P = .003 \)) in the numerical rating scale for lower back pain. The comparison analysis for thoracic mobility revealed significant differences between week 0 and week 4 (\( P = .00** \)) as well as for week 4 to week 8 (\( P = .00** \)) with a large effect size (\( \eta^2_p = .87 \)).

#### Discussion

The aim of this study was to examine the effects of an 8-week HE protocol on posterior back chain and chest wall kinematics as well as low back pain and pulmonary function in professional female basketball players. Following the training period, significant improvements for the sit and reach test, finger to floor test, and thoracic mobility were reported. Also, clinically significant improvements in levels of lumbar back pain and in selected spirometry measures were found.

These preliminary results confirmed our initial hypothesis that such a program can improve posterior back chain kinematics over a period of 8 weeks. Increased length observed during the sit and reach and finger to floor test in our study suggest an increased ankle and hip angles as well as muscle flexibility. Decreased flexibility such as hip flexor tightness, decreased lumbar flexion, and extension and forward bending have been shown to be risk factors for lower back pain in athletes.\(^{11}\) A similar protocol of basic HE was applied to patients with chronic nonspecific low back pain over 8 sessions of 30 minutes.\(^{22}\) This randomized study found that the HE group improved significantly in terms of low limb flexibility, lumbar spine mobility, and levels of pain reduction.\(^{22}\) However,

### Table 2  Summary of Results for All the Outcome Measures of the Study

<table>
<thead>
<tr>
<th>Outcome measures</th>
<th>Mean (SD)</th>
<th>95% CI</th>
<th>Mean (SD)</th>
<th>95% CI</th>
<th>Mean (SD)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRT</td>
<td>67.23 (6.10)</td>
<td>64.09</td>
<td>70.37</td>
<td>70.82 (5.98)</td>
<td>67.74</td>
<td>73.89</td>
</tr>
<tr>
<td>FFT</td>
<td>5.20 (5.51)</td>
<td>1.56</td>
<td>8.84</td>
<td>3.76 (4.56)</td>
<td>0.89</td>
<td>6.64</td>
</tr>
<tr>
<td>NRS</td>
<td>1.82 (2.81)</td>
<td>0.12</td>
<td>3.77</td>
<td>1.11 (2.31)</td>
<td>0.07</td>
<td>2.81</td>
</tr>
<tr>
<td>TM</td>
<td>3.65 (0.86)</td>
<td>3.20</td>
<td>4.09</td>
<td>2.93 (0.78)</td>
<td>2.52</td>
<td>3.33</td>
</tr>
<tr>
<td>FVC</td>
<td>2.78 (0.73)</td>
<td>2.40</td>
<td>3.16</td>
<td>2.93 (0.78)</td>
<td>2.52</td>
<td>3.33</td>
</tr>
<tr>
<td>PEF</td>
<td>3.74 (1.57)</td>
<td>2.93</td>
<td>4.55</td>
<td>4.64 (1.96)</td>
<td>3.62</td>
<td>5.65</td>
</tr>
<tr>
<td>FEV</td>
<td>73.53 (15.37)</td>
<td>65.62</td>
<td>81.43</td>
<td>79 (16.98)</td>
<td>70.26</td>
<td>87.73</td>
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<tr>
<td>FEV(_1)</td>
<td>3.48 (1.32)</td>
<td>2.80</td>
<td>4.17</td>
<td>4.04 (1.45)</td>
<td>3.29</td>
<td>4.97</td>
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<tr>
<td>FEV(_{0.75})</td>
<td>1.69 (0.70)</td>
<td>1.32</td>
<td>2.05</td>
<td>1.72 (0.55)</td>
<td>1.44</td>
<td>2.01</td>
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<tr>
<td>FEV(_{25–75})</td>
<td>2.61 (0.95)</td>
<td>2.12</td>
<td>3.10</td>
<td>2.93 (0.97)</td>
<td>2.43</td>
<td>3.43</td>
</tr>
<tr>
<td>FEV(_1)/FVC</td>
<td>27.28 (5.78)</td>
<td>24.30</td>
<td>30.25</td>
<td>27.78 (6.01)</td>
<td>24.69</td>
<td>30.88</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; FEV, forced expiratory volume; FEV\(_{0.25}\), FEV in the first 0.25 seconds; FEV\(_{0.75}\), FEV in the first 0.75 seconds; FEV\(_1\), FEV in the first second; FEV\(_p\)/FVC, ratio between FEV in the first second and forced vital capacity; FEV\(_{25–75}\), FEV between 25% and 75%; FFT, fingertofloor test; FVC, forced vital capacity; NRS, numerical rating scale; PEF, peak expiratory flow; SRT, sit and reach test; TM, thoracic mobility.
The diaphragm is known to not only play a respiratory function, but also an important role in spinal stabilization. Myofascially, the diaphragm is interrelated to the surrounding lumbo-pelvic structures and their myofascial tension and stiffness.46

The diaphragm is activated by hypopressive exercise (HE) training, which shares some similarities with HE (static exors and hamstring tendon, which could have a positive repercussion on their myofascial tension and stiffness.46

Our study is the first to assess pulmonary function after a HE protocol through spirometry in professional female athletes. Our findings did not show significant improvements in almost all of the spirometric outcomes except for peak expiratory flow. FEV1, and FEV0.25. These results are possible due to the high-level ventilatory training factors could have influenced training outcomes. The low poses with emphasis on slow breathing, assessed ventilatory parameters on healthy young participants.32 This study found an increase in chest wall mobility and respiratory pressures.32 Similar to our study, we found an increase in thoracic mobility. The improvements in thoracic mobility could have also positively impacted forced expiratory flow. Ventilatory performance depends upon the resting length and muscle compliance of the diaphragm. Reduced compliance of the diaphragm will lead to incomplete functional residual capacity.40 In this sense, a greater diaphragmatic motion and reduced stiffness due to the nature of HE, which includes breath training, could have favored lung expandability resulting in greater mechanical force production during maximal respiratory efforts.40 In fact, lower levels of peak expiratory flow and thoracic mobility have been found in nonhealthy populations compared with healthy controls.33 An 8-week training protocol based on diaphragmatic strengthening exercises among participants with nonspecific chronic low back pain found increased chest expansion, peak inspiratory flow, and stability of the trunk.32 Expiratory flow performance has also been correlated to deep abdominal muscle activity. The internal oblique muscle activity while holding maximum expiration showed a significant positive correlation with peak expiratory flow in a study involving older females.53 HE has shown to activate significantly the internal oblique and transverse abdominis compared with resting positions.24

These results and our findings show a relationship between the trunk muscles and ventilatory performance.54 Collectively, the HE protocol used in the present investigation could have positively impacted neuromuscular performance of the trunk and breathing muscles but may not be sufficient for improving ventilatory performance outcomes besides forced expiratory values (ie, peak expiratory flow, FEV1) in professional female athletes.

Limitations and Strengths

The noncontrolled design of the trial is a limitation of our study. Future studies should include a larger sample and a randomized controlled design comparing HE interventions with other traditional exercise and/or lumbo-pelvic preventative training programs in both female and male athletes. It is also possible that other training factors could have influenced training outcomes. The low

Table 3 Differences Between Weeks and Effect Sizes for the Outcome Measures Analyzed in This Study

<table>
<thead>
<tr>
<th>Outcome measures</th>
<th>Weeks 0–4</th>
<th>Weeks 0–8</th>
<th>Weeks 4–8</th>
<th>F</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRT</td>
<td>0.06</td>
<td>0.00**</td>
<td>0.00**</td>
<td>16.86</td>
<td>.69</td>
</tr>
<tr>
<td>TM</td>
<td>0.00**</td>
<td>0.00**</td>
<td>0.00**</td>
<td>50.13</td>
<td>.87</td>
</tr>
<tr>
<td>FVC</td>
<td>0.09</td>
<td>0.01*</td>
<td>0.17</td>
<td>2.18</td>
<td>.22</td>
</tr>
<tr>
<td>PEF</td>
<td>0.14</td>
<td>0.18</td>
<td>2.47</td>
<td>.24</td>
<td></td>
</tr>
<tr>
<td>FEV</td>
<td>0.03*</td>
<td>0.03*</td>
<td>12.61</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>FEV0.25</td>
<td>0.29</td>
<td>0.04*</td>
<td>3.40</td>
<td>.31</td>
<td></td>
</tr>
<tr>
<td>FEV0.75</td>
<td>0.78</td>
<td>0.28</td>
<td>1.76</td>
<td>.19</td>
<td></td>
</tr>
<tr>
<td>FEV25–75</td>
<td>0.10</td>
<td>0.21</td>
<td>3.30</td>
<td>.30</td>
<td></td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>1</td>
<td>1</td>
<td>0.11</td>
<td>.01</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: F, Fisher; FEV, forced expiratory volume; FEV0.25, forced expiratory volume in the first 0.25 seconds; FEV0.75, forced expiratory volume in the first 0.75 seconds; FEV1, forced expiratory volume in the first second; FEV1/FVC, ratio between forced expiratory volume in the first second and forced vital capacity; FEV25–75, forced expiratory volume between 25% and 75%; FVC, forced vital capacity; PEF, peak expiratory flow; SRT, sit and reach test; TM, thoracic mobility.

*P<.05. **P>.01.
training frequency of the intervention (1 weekly session) should be considered. To the best of our knowledge, this is the first study to apply a HE program in an athletic population in order to assess back chain kinematics and pulmonary function. Our preliminary findings could initiate further research efforts regarding this topic and help sport coaches and health care providers understand the application of HE in comprehensive injury prevention programs.

Conclusions

Based on our findings, the addition of a HE program could promote increased posterior back chain and chest wall kinematics as well as a reduction in lower back pain levels in professional female basketball players. However, a once weekly HE program performed for 8 weeks does not seem to improve most ventilatory parameters in this athletic population. In summary, HE techniques could be used as an adjunctive therapeutic tool in the management of athletes with low back pain demonstrating impaired chest wall and back chain kinematics.

Acknowledgments

The authors would like to thank the participants of this study.

References


(Ahead of Print)