Effects of Abdominal Postures on Lower Extremity Energetics During Single-Leg Landings

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Context: Functional implications of clinically relevant abdominal postures have been sparsely examined. Objectives: To evaluate the reliability of sustaining abdominal postures during single-leg landings and the effects of abdominal postures on lower extremity kinetics and energetics. Design: One-way ANOVA tested effects of leg-spring stiffness and lower extremity energetics across groups (control, abdominal hollowing [AH], and pelvic tilting [PT]). Participants: 12 male (24.0 ± 3.4 years) and 12 female (21.9 ± 2.3 years) healthy, recreationally active subjects. Main Outcome Measures: Leg-spring stiffness and relative joint-energy absorption from control, AH, and PT groups. Results: AH and PT ICCs and standard error of measurements (AH = 0.53 ± 0.4 cm, PT = 0.9° ± 0.8°) were moderate to high. Relative knee-energy-absorption effect sizes comparing the control and treatment groups revealed moderate treatment effects (AH = 0.66%, PT = 0.41%). Conclusions: Abdominal postures can be reliably performed during a single-leg-landing task. Energy-absorption effect sizes suggest a link between the trunk and lower extremity. Key Words: landing mechanics, abdominal hollowing, pelvic tilting


Landing activities require the active and passive joint restraints of the lower extremity to absorb ground-reaction forces (GRFs) in a safe and efficient manner.1 Energy absorption at the ankle, knee, and hip depends on the orientation of all body segments relative to the GRF during landing.2 Thus, the orientation of the head, arms, and trunk (HAT) segment relative to the hip, knee, and ankle must be considered a potential influence on the GRF and, thus, lower extremity energetics. For example, if during a landing a person is in a posture with the HAT more upright relative to the hip, the moment-producing capabilities of the hip extensors are most likely small,

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thus increasing energy absorption at the knee and ankle. If the HAT is in a relatively more flexed position relative to the femur throughout landing, however, the hip extensors can then contribute to absorb the energy at landing, possibly lessening the energetic demands placed on the knee and ankle. In addition, as the mass of the HAT segment accounts for about 60% of the body’s total mass, it might seem advantageous to consider other ways we can control the position of the HAT so that the lower extremity energetic demands are minimized. If the energetic demands placed on the active and passive restraints of the ankle, knee, and hip are minimized, the chance of sustaining lower extremity injuries commonly seen in landing tasks might then be reduced.

Abdominal hollowing (AH) and the posterior pelvic tilt (PT) are clinically based abdominal postures that have been used extensively for enhancing spinal stiffness and controlling the trunk’s orientation in order to restore low back function. These abdominal postures focus on positioning of the lumbar and pelvic region through either local (AH) or global (PT) muscle-activation techniques rather than strength. The global abdominal muscles consist of the rectus abdominis, internal obliques, and external obliques, and the transversus abdominis and lower portions of the internal oblique (anterior superior iliac spine and distal) represent local abdominal function. Spinal stiffness is increased as the local abdominals activate as they attach to the lumbar spine via the thoracolumbar fascia. This corset-like action is often referred to as the abdominal hoop mechanism. Because of their attachments onto the thoracic cage and pelvis, the global abdominals have the ability to generate flexion and rotation moments about the torso, thus controlling the orientation of the trunk with respect to the base of support. Although the HAT’s orientation is primarily controlled via global muscle activation, local abdominal-muscle contributions have been implicated as being central to maintaining a stable lumbar spine, thus allowing the global abdominal muscles to function more efficiently.

If either AH or PT posture can facilitate a more stable HAT, the lower extremity might more effectively absorb the GRFs during landing. This might result in an optimal stiffness of the lower extremity muscles (leg-spring stiffness) to decelerate the downward momentum. Unfortunately, most abdominal research has focused on validating the teaching of these clinically based maneuvers in non-weight-bearing positions such as 4-point kneeling, prone, and supine. The assurance that the subject can effectively maintain the AH or PT postures throughout a functional task is currently unknown. Thus, the purposes of our study were to examine the reliability of maintaining the AH and PT maneuvers throughout a single-leg-landing task and to examine differences in lower extremity energetics and leg-spring stiffness among AH, PT, and control groups.
Methods

Design
A one-way ANOVA was used to test the dependent variables leg-spring stiffness and relative energy absorption at each the ankle, knee, and hip. The independent variable was group at 3 levels—control, AH, and PT. Intraclass correlation coefficients (ICC_{2,k}) and standard error of measurements (SEMs) were used to assess the day-to-day reliability of performance of the AH and PT maneuvers.

Subjects
Twelve male (age 24.0 ± 3.5 years, height 177.1 ± 7.0 cm, mass 85.8 ± 16.7 kg) and 12 female (age 21.9 ± 2.4 years, height 166.3 ± 4.4 cm, mass 62.2 ± 4.4 kg) healthy and recreationally active athletes participated in the study. Recreationally active was defined as participating in any physical activity at least 3 sessions per week for 30 minutes each time. All subjects signed a written informed consent approved by the university institutional review board.

Instrumentation
Kinematic data for the head, thorax, pelvis, thighs, shanks, and dominant foot were sampled at 140 Hz using the Motion Monitor (Innovative Sports Training, Chicago, Ill) electromagnetic tracking system. A Bertec force plate, type 4060 nonconducting (Bertec Corp, Columbus, Ohio), was used to acquire GRFs at impact, and the Motion Monitor’s analog/digital system sampled these forces at 1000 Hz. Abdominal circumference was measured manually with a flexible nylon tape measure at the level of the umbilicus. During data collection the tape measure was affixed to the torso at the level of the umbilicus through Velcor™ belt loops affixed directly to the skin via double-sided tape. The tape measure was then held in place using a cotter pin (Figure 1). For the duration of the study, the same examiner set up and manually tensioned the tape measure for every trial on every subject.

Procedures
Familiarization Session. After the informed-consent form was completed, height and mass measurements were made and manually recorded. Subjects were then instructed by the examiner in a single-leg-landing task from a height of 30 cm. The examiner first demonstrated the task, followed by instruction. Instructions to each subject were as follows: Keep the hands on the hips at all times, start with both feet at the edge of the box, reach
straight out with the dominant leg, and shift the weight off the hips from the stance leg to the landing leg. The subject’s dominant leg was determined by asking which foot would be preferred to kick a ball. Subjects were specifically instructed not to jump up or outward from the box or lower the body down. Each subject was allowed ample practice until he or she felt comfortable with the task. After the initial task instruction, subjects were sex stratified and randomly assigned to the control, AH, or PT group and instructed relative to the assigned group. Initial circumference measurements were taken by the examiner at the level of the umbilicus and manually recorded for subjects assigned to the AH and control groups.

Instruction of the AH maneuver was for 4-point kneeling as described by Richardson and colleagues. The principal investigator performed all instruction for the AH maneuver. All subjects assigned to the AH group were first positioned with a neutral lumbar spine. Then subjects were instructed to draw their lower abdomen toward the spine without holding their breath. The examiner used tactile feedback by placing an index finger just below the subject’s umbilicus as a point of reference to draw the abdomen up toward the spine. Contraindicated global abdominal activity was visually monitored for and discouraged. Examples of global-muscle substitution included the lumbar spine flexing as a result of rectus femoris activity and holding the breath, which increases activity of all trunk muscles through intra-abdominal pressure increases. These clinically based instructions in the 4-point kneeling position have been used previously and validated with surface EMG and real-time ultrasound. A measure of the ability of AH is the decrease in circumference at the level of the umbilicus. This measure is based on previously documented clinical observations. Once a subject could perform the AH properly via these clinical standards,
circumference measures at the level of the umbilicus were taken by the examiner for 3 successful contractions with the subject in a standing position and maintaining a neutral lumbar spine. As defined by Richardson et al.\textsuperscript{14} a neutral lumbar spine in standing is one that maintains a natural lordotic curvature. AH instruction generally does not encourage decreases in lumbar lordotic curve\textsuperscript{14} unless the subject has an excessive lordotic curve.

The subjects assigned to the PT group were instructed in a supine position with their hands placed on the iliac crests. Subjects were instructed to use their abdominal muscles to flatten their back while posteriorly tilting the pelvis, resulting in a decreased lordotic curve.\textsuperscript{15} The examiner had subjects perform this posture while he held his hand between the lordotic curvature and the table. They were instructed to apply pressure to the hand of the examiner during the pelvic maneuver, but not excessive pressure so as to “press through the hand.”

The subjects in the AH and PT groups again practiced the single-leg landings while performing their respective postures until comfortable with the task. Subjects were instructed to maintain the assigned abdominal posture throughout the single-leg landing. Subjects in the control group only practiced the landing until comfortable with the task.

Days 2 and 3. On reporting for the second (within the next 48 hours) and third sessions (24 hours after the second session), subjects in the control group had 3 circumference measures taken in a relaxed upright stance. The AH and PT groups also had 3 circumference measures taken while performing their respective postures in the standing position. All subjects again practiced the single-leg landing according to their group assignment. Once the examiner was satisfied with a subject’s execution of the single-leg landing, the subject was prepared for data collection.

Kinematic setup entailed the examiner attaching 6-degrees-of-freedom position sensors (Ascension Technologies, Burlington, Vt) with double-sided tape to the following sites: over the anterior midshaft of the third metatarsal of the dominant foot, on both midshanks, and on the lateral aspect of both midthighs. Three more position sensors were placed over the sacrum, spinous process of C7, and occiput of the skull. Velcro belt loops were placed with Velcro tape at 6 sites on the torso at the level of the umbilicus: on both sides of the umbilicus, iliac crests and/or the most lateral aspects of the torso, and both sides of the vertebrae. A tape measure was put through the Velcro loops and fastened anteriorly with a cotter pin (Figure 1). The pin allowed the subject’s abdominal region to push on the tape measure to increase the circumference. The difference between pin measures before and after a landing trial indicated how well subjects in the AH group maintained the decreased circumference as compared with the control-group circumference measures.

Subjects performed 5 successful trials of the single-leg landings on day 2 and day 3. Trials were excluded on the basis of a hop, jump, or lowering
down from the box (as assessed by the examiner) or loss of balance at landing resulting in the contralateral foot being placed on the ground or hands coming off the hips.

**Data Processing and Analysis**

Using Motion Monitor software, kinematic and kinetic data for the ankle, knee, and hip were low-passed at 12 Hz using a fourth-order, zero-lag digital Butterworth filter. Euler angle equations were used to interpret kinematic data. The rotations for the hip, knee, and ankle followed a flexion (z), rotation (y), abduction/adduction (x) convention. Hip-extension, knee-extension, and ankle plantar-flexion joint moments were all assigned to be positive. All data were then exported for further analyses. Joint powers were calculated as the product of the joint moment and angular velocity. The area under the curve, and therefore mechanical work, is the integral of the power curve. Mechanical work was calculated at each of hip, knee, and ankle joints. The integral of the power curve when it was negative represented the amount of work done on the joints (energy absorption). These power and work calculations present conventional means to analyze lower extremity energetics and have been used by others.

Leg-spring stiffness (LSS) was calculated from the peak vertical GRF divided by the total vertical displacement of the center of mass of the 8 body segments digitized during the landing task. The sum of the estimated masses of the 8 digitized segments accounted for an entire body-center-of-mass model that accounted for 88.8% of the actual total mass. Pelvic-tilt joint displacement (PTJD) was assessed from the angle of the pelvis in the global mediolateral axis aligned in the sagittal plane. The PTJD was calculated from initial contact to the body center of mass’s maximum vertical displacement. PTJD was used to assess the day-to-day reliability of the PT group and was subsequently compared with the control group’s PTJD reliability measure. The circumference-difference measures from prelanding to postlanding were used to evaluate the reliability of the AH maneuver to compare with the circumference differences in the control group.

**Results**

**Reliability**

Intraclass correlation coefficients (ICC_{2,k}) and SEMs for all kinetics, as well as circumference measures, were calculated to determine day-to-day reliability and are presented in Table 1. The AH circumference measures were moderately reliable from day to day. The PTJDs provided consistent measures across days. The time delineations for the calculations of the PTJDs were as follows: control, 343 ± 41.2 milliseconds; AH, 337 ± 54 milliseconds; and PT, 336 ± 43 milliseconds (P = .944). Large between-mean-square values
### Table 1  Reliability, Precision, and Descriptive Statistics Across Groups*

<table>
<thead>
<tr>
<th>Group</th>
<th>Measure (unit)</th>
<th>ICC(_{2,k})</th>
<th>SEM(_{2,k})</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>LSS (N/m)</td>
<td>.99</td>
<td>836.4</td>
<td>22,837.3</td>
<td>8601.2</td>
<td>22,366.2</td>
<td>7641.8</td>
</tr>
<tr>
<td></td>
<td>KEA (N · m)</td>
<td>.69</td>
<td>8.5</td>
<td>15.3</td>
<td>15.4</td>
<td>8.0</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>PTJD (°)</td>
<td>.91</td>
<td>1.1</td>
<td>5.3</td>
<td>2.6</td>
<td>5.4</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>CDIFF (cm)</td>
<td>.76</td>
<td>0.6</td>
<td>0.8</td>
<td>0.5</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Abdominal hollowing</td>
<td>LSS (N/m)</td>
<td>.95</td>
<td>1185.7</td>
<td>20,979.8</td>
<td>5294.5</td>
<td>19,856.9</td>
<td>4965.7</td>
</tr>
<tr>
<td></td>
<td>KEA (N · m)</td>
<td>.82</td>
<td>3.6</td>
<td>9.2</td>
<td>8.2</td>
<td>11.9</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>CDIFF (cm)</td>
<td>.53</td>
<td>0.4</td>
<td>0.7</td>
<td>0.2</td>
<td>0.8</td>
<td>0.6</td>
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<tr>
<td>Pelvic tilting</td>
<td>LSS (N/m)</td>
<td>.99</td>
<td>723.7</td>
<td>21,797.1</td>
<td>9705.5</td>
<td>21,522.3</td>
<td>10524.0</td>
</tr>
<tr>
<td></td>
<td>KEA (N · m)</td>
<td>.72</td>
<td>8.0</td>
<td>16.8</td>
<td>15.2</td>
<td>14.4</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>PTJD (°)</td>
<td>.91</td>
<td>0.8</td>
<td>3.2</td>
<td>2.4</td>
<td>3.2</td>
<td>2.5</td>
</tr>
</tbody>
</table>

*LSS indicates leg-spring stiffness; KEA, knee-energy absorption; PTJD, pelvic-tilt joint displacement (prelanding to postlanding); CDIFF, circumference difference (prelanding to postlanding).
accounting for the between-subjects variability for both LSS and knee-energy absorption contributed to the high-reliability ICCs calculated.

Kinetics

Analyses of LSS normalized to body mass (kg) and relative energy absorption at the hip, knee, and ankle revealed no statistically significant differences among control, AH, and PT groups (Table 2). When comparing the AH and control groups, moderate effect sizes were observed for relative knee- and ankle-energy absorption (.66 and .59, respectively). Moderate effects were also observed when comparing PT with the control group for relative hip- and knee-energy absorption (.44 and .41, respectively).

Comments

Reliability Measures

Although AH clinical-instruction techniques have been established and well documented to restore low back function, we were unable to find evidence of the ability to perform this maneuver during a functional task. Although the AH group had lower reliability measures than the control group, the SEMs were 62% of those of the control group, supporting moderate reliability for the AH group. The day-to-day variability in circumference measures at landing in any group might be attributed to whether or not the subject ate a meal before testing on one of the days or the hydration status of the subject before testing. To combat these possible day-to-day influences, ICCS were computed to assess within-day reliability of the circumference-difference measures. The ICCS and SEMs for the 3 groups were as follows: control, 0.94 ± 0.2 cm; AH, 0.69 ± 0.2 cm; and PT, 0.73 ± 0.4 cm. These within-day reliability estimates indicate that subjects in the AH group exhibited moderate trial-by-trial consistency.

Clinically, researchers have described AH as exhibiting a decrease in circumference at the level of the umbilicus. Furthermore, because the subjects in the AH group required a reduction in circumference (to indicate AH), whereas the subjects in the control group did not, the AH-group measures were more sensitive to indiscriminant factors described previously, leading to increased circumference changes that were not detected in control-group subjects. The reliability results provide preliminary evidence that AH can be performed consistently within day and between days in a single-leg landing. In order to validate this circumference measure as a functional assessment of AH, fine-wire EMG or real-time ultrasound needs to be employed simultaneously, but use of fine-wire EMG is difficult and limited because the dynamic activity might cause an intramuscular wire to move. In addition, real-time ultrasound is traditionally used in a restricted
Table 2  Kinetics and Energetics Across Abdominal Groups, (N · m/kg) × 100*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Control</th>
<th>Abdominal Hollowing</th>
<th>Pelvic Tilting</th>
<th>Effect Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>LSS</td>
<td>286.6</td>
<td>59.8</td>
<td>294.7</td>
<td>63.2</td>
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<tr>
<td>Relative HEA</td>
<td>33.4</td>
<td>25.2</td>
<td>36.9</td>
<td>19.1</td>
</tr>
<tr>
<td>Relative KEA</td>
<td>34.4</td>
<td>31.8</td>
<td>18.8</td>
<td>9.6</td>
</tr>
<tr>
<td>Relative AEA</td>
<td>32.2</td>
<td>21.6</td>
<td>44.3</td>
<td>19.4</td>
</tr>
</tbody>
</table>

*LSS indicates leg-spring stiffness; Obs., observed; AH, abdominal hollowing; PT, pelvic tilting; HEA, hip-energy absorption; KEA, knee-energy absorption; AEA, ankle-energy absorption.
environment. Once validated, this circumference measure might be used to clinically assess a patient’s ability to perform AH. The subjects in the PT group exhibited consistent PTJD from day to day, leading us to conclude that this abdominal posture could be maintained reliably during single-leg landings.

Differences in Abdominal Postures

Although there were no significant differences found at the lower extremity during this study, it seems relevant to examine plausible explanations for these results. The first explanation would be that there was no effect of the abdominal postures on the lower extremity during single-leg landings. The second explanation involves evaluating whether or not these abdominal postures were effectively instructed and performed. In regard to the second explanation, we first thought it was necessary to examine the subjects’ ability to perform these abdominal postures in a standing position. The circumference-difference measures performed in a standing position show that the subjects in the AH group effectively decreased their circumference in the lower abdomen (–1.46 cm), whereas the PT subjects actually increased their circumference (+0.43 cm) somewhat (P < .001; Table 3). The transversus abdominis and lower fibers of the internal oblique are the only abdominal muscles that complete the circumference around the lower abdomen through thoracolumbar attachments on the posterior trunk and abdominal fascia on the anterior trunk. The horizontal fiber orientation of these muscles allows for a corset-like action when activated and effectively decreases the circumference of the abdomen. Using clinical instructions and guidelines proposed by others, this maneuver elicits minimal spine movement and maintains a “natural” lumbar lordosis.

The position and orientation of the rectus abdominis and external oblique muscles give them a mechanical advantage to modify the position of the pelvis in the sagittal plane because of their anterior attachments on the pelvis and thoracic cage. This movement of the pelvis on the HAT in

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Circumference-Difference Measures in a Standing Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Mean (cm)</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
</tr>
<tr>
<td>Abdominal hollowing</td>
<td>–1.46*</td>
</tr>
<tr>
<td>Pelvic tilting</td>
<td>0.43</td>
</tr>
</tbody>
</table>

*A negative number indicates a decrease in circumference as a result of abdominal hollowing.
the sagittal plane is referred to as pelvic tilt. We assessed differences in the pelvic angle at initial contact with the force plate and the PTJD. As shown in Table 4, the pelvic angle at initial contact indicated that the subjects in the PT group were in more of a pelvic tilt relative to the subjects in the AH group ($P = .046$). Based on principles of anatomy and kinesiology, these results indicate that the subjects in the PT group used their global abdominals to attain their initial pelvic angle at contact with the force plate.

**Table 4  Pelvic Angles During Single-Leg Landings Across Groups**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Group</th>
<th>Mean (°)</th>
<th>SD</th>
<th>$F$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial pelvic angle (initial contact)</td>
<td>control</td>
<td>–2.12</td>
<td>1.69</td>
<td>3.59</td>
<td>.046*</td>
</tr>
<tr>
<td></td>
<td>abdominal hollowing</td>
<td>–2.74</td>
<td>3.09</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>pelvic tilting</td>
<td>0.64</td>
<td>3.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pelvic-tilt joint displacement</td>
<td>control</td>
<td>5.31</td>
<td>2.59</td>
<td>1.85</td>
<td>.182</td>
</tr>
<tr>
<td></td>
<td>abdominal hollowing</td>
<td>4.99</td>
<td>2.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pelvic tilting</td>
<td>3.22</td>
<td>2.38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Abdominal hollowing significantly different from pelvic tilting.

There is a limitation regarding the validation of the circumference measures used to assess the ability of the subjects to perform the AH maneuver. Currently there are valid techniques of instructing AH in supine and 4-point-kneeling positions.\(^4,5,12,23\) None of these research studies, however, has validated a method that ensures that the AH is being performed properly in a functional weight-bearing manner. This study attempted to provide preliminary support that circumference measures can be used. Perhaps a better way to assess these measures would be to use a within-subject design to assess the “normal” circumference increases during a functional task, followed by the same measures using the AH maneuver. As in the current research project, however, assigning a subject to 1 group controlled for the potential carry-over influence of one abdominal posture to the other.

The design of this study only provided subjects in the AH and PT groups 1 familiarization day to learn and subsequently perform the postures.
Although both abdominal-circumference and PT measures provided reasonable day-to-day and within-day reliability, we acknowledge that because the lower extremity results were not significant we also cannot be sure that these abdominal postures were effectively learned and performed during the single-leg-landing task. O’Sullivan et al reported that the implementation of AH and specific exercises over a period of 10 weeks effectively changed abdominal activation patterns during a supine crook-lying position. It is still not known how long it takes a person to achieve appropriate involuntary abdominal activation during functional tasks. Strictly from a teaching perspective, in order to achieve a simple posture (AH or PT), these results show that these postures can be voluntarily attained rather easily in a couple of sessions. Assessment of the initial pelvic angle at impact (Table 4) and the circumference-difference measures in the standing position (Table 3) suggest that the PT and AH groups used different postures. We did not measure muscle-activation changes in these muscles, however, so results cannot be extrapolated to strengthening issues. In addition, direct correlations between muscle activation and abdominal postures could not be obtained.

Both of the abdominal maneuvers used in this study could potentially result in some degree of posterior pelvic tilt. Although the AH instruction emphasizes maintaining a neutral lumbar lordosis, when the transversus abdominis activates and the circumference decreases, the intra-abdominal pressure increases, as well. This increase in intra-abdominal pressure could in turn act to “straighten” the lumbar spine effectively, resulting in some posterior PT. The AH is intended, however, to be a submaximal contraction of the transversus abdominis. Because the extension moment at the trunk resulting from an increase in intra-abdominal pressure has been demonstrated to be minimal, any PT associated with transversus abdominis activation is considered to be minimal. Table 4 supports this rationale in that the AH subjects were not in as much of a posterior pelvic tilt as the PT subjects.

The definition of a neutral position of the spine or pelvis is still unclear in the literature. We do know that there is a significant relationship between sagittal pelvic angle (PT) and the total segmental lumbar lordosis. The instructions given by the examiner for AH were to maintain a neutral lumbar spine. Using the approach by Richardson et al, this neutral lumbar spine maintains a lordotic curve. This is not to be mistaken for neutral pelvic angle as defined by Kendall et al, which stipulates that the pelvis is in neutral when the anterior superior iliac spine and pubic symphysis are in the same frontal plane. This position inevitably results in decreased lordotic curve (that is sometimes absent) that we do not think is a functional or neutral lumbar spine. Because we did not measure contributions of the muscles directly with EMG, we cannot say for sure which muscles were contributing to the pelvic motion of the abdominal postures.
Finally, the sample size used in this pilot study was small (12 men, 12 women: 8 controls, 8 AH, and 8 PT). Because of the large effect sizes observed in this study, more subjects achieving a power of .80 would likely lead to statistically significant results. Using knee-energy absorption as a variable, and given the effect size of .66 observed in this study, 18 men and 18 women would be needed to achieve a power of .80.

Summary

This research has provided preliminary evidence of the effects of abdominal postures on lower extremity kinetics and energetics. Effective differences at the lower extremity, as well as initial pelvic angle and abdominal circumference measures, suggest that the abdominal postures were achieved and can be reliably performed in a single-leg-landing task. Methods to validate the circumference measurements also need to be improved. In conclusion, this study indicates that abdominal postures might have an influence on lower extremity energetics biomechanics and supports the need to consider the influence of the HAT segment during lower extremity assessment.

References