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Landing Mechanics of Military Personnel and Effects of a Lumbopelvic Hip Complex 6 Week Intervention Program

Derek Wahl

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ABSTRACT

The purpose of this study was to determine if a six-week lumbopelvic-hip complex (LPHC) intervention program would affect the landing mechanics of active ARMY ROTC cadets. Ten male Army ROTC cadets [182.3 ± 4.5 cm; 86.7 ± 9.2 kg; 19.5 ± 0.8 yrs] were recruited for this study. Participants performed a drop landing protocol pre and post LPHC intervention program. The LPHC intervention program consisted of six minutes of five body weight exercises prior to every organized ROTC conditioning that occurred three days a week for six weeks; consisting of 10 total exercises that were randomly alternated throughout the treatment days so that five exercises would be performed every day of the intervention. Results revealed significant differences in pre-test knee valgus and hip flexion scores (p<0.05). The ROTC cadets were able to improve their drop jump landing scores; with significant improvements statistically and/or clinically in all variables analyzed.

KEY WORDS: ACL injury; core stability; landing mechanics
INTRODUCTION

The mechanics of jump landings mechanics as well as anterior cruciate ligament [ACL] injuries have been studied extensively. ACL injuries frequently occur from non-contact landing instances [1]. Landing from a jump is a frequent movement performed in not only the sporting community but also in the military. Often military personnel are conducting ground movements, or deploying from a helicopter where they are required to jump down from a height and land in a position conducive to quick movement. With this type of landing strategy there is an inherent risk of knee injury. Landing in a position of knee valgus is the most common mechanism of knee injury [2]. Additionally if one is carrying extra load, susceptibility of injury is inherently higher. When military personnel are performing tactical maneuvers it is common practice for them to carry additional weight. The average infantry soldier could possibly carry as much as ninety to one hundred pounds, or as minimal as forty to fifty pounds when performing tactical movements. Thus with the additional weight, proper landing mechanics are substantial.

It is known for efficient movement, segments must perform in a proximal to distal manner through the kinetic chain [3]. When muscles perform synergistically from proximal to distal there is a great awareness of postural control that allows for coordinated movements and awareness of equilibrium [4]. It is coordinated movements of the lumbopelvic-hip complex [LPHC] that provide the ability to maintain or resume torso positioning, or postural awareness after static and dynamic muscular contractions [5].
Therefore it was the purpose of this study to determine if a LPHC intervention program would affect the landing mechanics of active ARMY ROTC cadets. It is hypothesized that there will be a significant difference in landing mechanics following a six week LPHP intervention program, with specific differences in hip and knee flexion as well as knee valgus, and vertical ground reaction forces.

METHODS

Ten male Army ROTC cadets [182.3 ± 4.5 cm; 86.7 ± 9.2 kg; 19.5 ± 0.8 yrs] were recruited. Data was collected at the University of Arkansas Health, Physical Education, and Recreation building. The University of Arkansas Institutional Review Board approved all testing procedures, and prior to participation the approved procedures, risks, and benefits were explained to all participants. Informed consent was obtained from the participants, and the rights of the participants were protected according to the guidelines of the University's Institutional Review Board.

Participants reported for testing prior to engaging in resistance training or any vigorous activity that day. Kinematic data were collected using The MotionMonitor™ motion capture system [Innovative Sports Training, Chicago, IL]. Participants will have a series of 11 electromagnetic sensors [Flock of Birds Ascension Technologies Inc., Burlington, VT] attached at the following locations: [1] medial aspect of c7; [2] medial aspect of pelvis at S1; [3-4] bilateral distal/posterior aspect of upper leg; [5-6] bilateral distal/posterior aspect of lower leg; [8-9] bilateral proximal dorsum of foot. Sensors were affixed to the skin using double-sided tape and then wrapped using flexible
hypoallergenic athletic tape to ensure proper placement. Sensors were placed over areas with the least muscle mass in attempt to minimize sensor movement. Following sensor assignment placement, a 10th sensor was attached to a wooden stylus and used to digitize the palpated positions of the body landmarks. [6,7,8]. Participants were instructed to stand in anatomical neutral while selected body landmarks were accurately digitized. Two points described the longitudinal axis of the segment and the third point defined the plane of the segment. A second axis was defined perpendicular to the plane and the third axis was defined as perpendicular to the first and second axes. Neutral stance was the y-axis in the vertical direction, horizontal and to the right of y was defined as the positive z-axis, and direction of movement was defined as the positive x-axis.

Once all electromagnetic sensors were secured on the participant, participants were instructed to perform three drop jump landing trials from a height of 47 cm. Participants were instructed to drop from the specified height and then perform a vertical jump upon landing. Participants performed 5-drop jumps. After all jump data were collected the participants were enrolled into a 6-week LPHC intervention program.

**INTERVENTION PROGRAM**

The LPHC intervention program consisted of six minutes of five body weight exercises prior to every organized ROTC conditioning that occurred three days a week for six weeks. The primary investigator supervised all intervention sessions. The intervention program consisted of a total of 10 exercises [Figures 1-10] that were randomly
alternated throughout the treatment days so that five exercises would be performed every day of the intervention. All participants were encouraged to be compliant with the LPHC program and monitored throughout the duration of the intervention by the primary investigator.

RESULTS

A paired sample t-test revealed significant differences in pre-test knee valgus and hip flexion scores (p<0.05). There were no significant differences between knee flexion (p=0.34) or ground reaction forces (p=0.66). Knee flexion did increase from pre to post intervention (5.47°) just as ground reaction forces displayed a decrease (46.7 N). Means and standard deviations for all kinematic variables are presented in Figures 11-14.

DISCUSSION

The incorporation of a six week LPHC intervention allowed for improved landing mechanics as seen in all variables analyzed. It should also be noted that none of the participants were instructed on proper landing techniques. We saw an increase in knee flexion between the pre and post testing. Though this was not a statistically significant result; these findings are clinically significant. It has been shown that an increase in knee flexion allows for greater force dissipation as well as injury prevention. [9]. The significant decreases in knee valgus as well as the increase in hip flexion are essentially the results of the increase in knee flexion. When examining the improved landing mechanics after the six-week LPHC intervention, it also allowed for a decrease in ground reaction forces; which is a factor in injury prevention [10].
It has been reported that landing with decreased hip flexion, knee flexion and increased knee valgus are associated with increased risk of ACL injury [11]. The current study examined landing mechanics pre and post implementation of a six-week LPHC intervention program. Recently Hewett [12] and Myers [13] have introduced training interventions that have positively affected injury prevention. Specifically, Hewett [12] recommended four points of emphasis in training appropriate jump landings. Those points included: (1) correct posture of chest over knees; (2) jumping straight as opposed to side to side or front to back; (3) soft landings transferring toe to heel with a bent knee; and (4) instant recoil to prepare for the next jump.

Determining methods of decreasing ground reaction forces and then educating military personnel on these techniques is necessary to allow optimal performance in the field. A previous study assessing the effects of instruction in jumping technique and experience on ground reaction forces found that subjects who received verbal instructions on how to land softly landed with significantly less force compared to those who had to rely only on previous experiences [14]. Landing from a jump in a position that absorbs the impact of the landing is not a skill commonly taught [14,15] which may explain why those receiving verbal instruction were able to land with less force. Participants in the current study did not receive verbal instructions and had no military training on how to land safely and dissipate the landing forces. However, the implementation of the LPHC intervention program was able to improve the landing mechanics and also allowed for decreased ground reaction forces.
CONCLUSION

In conclusion, all ROTC cadets were able to improve their drop jump landing scores; with significant improvements statistically and/or clinically in all variables analyzed. While the significant improvements were in hip flexion and knee valgus, a still equally important improvement was the decrease in knee flexion. All participants benefitted from the six-week LPHC intervention, which will translate well in the future when these cadets will be conducting ground movements while carrying additional weight. All military personnel would benefit from integrating a LPHC workout plan as part of their physical training.
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Figure Legends:

Figure 1. Side Plank: body remains in a straight line and the position is held for 30 seconds.

Figure 2. Front Plank: body remains in a straight line and the position is held for 30 seconds.

Figure 3. Flying Squirrel: shoulders are externally rotated and hips are internally rotated with torso and thighs held off the floor for 30 seconds.

Figure 4. Bird Dog: contralateral arm and hip are extended with body maintaining pelvic neutral is held for 30 seconds.

Figure 5. Hip Abduction: hip and knee are in slight flexion and hip abduction repetitions are performed for 30 seconds.

Figure 6. Clams: hips and knees are in flexion, hip is abducted with feet remaining in place. Repetitions should be performed for 30 seconds.

Figure 7. Advanced Front Plank: body is in the front plank position, then contralateral arm and legs are extended while body remains in a straight line and held for 30 seconds.

Figure 8. Pelvic Tilt: contralateral hip is pulled into extreme hip flexion while other hip is extended maintaining pelvic neutral and held for 30 seconds.

Figure 9. Advanced Bird Dog: hip is extended as high as possible and then lowered to the floor in a controlled manner. Repetitions are performed for 30 seconds.

Figure 10. Push Ups: body should be in a straight line maintaining pelvic neutral with repetitions performed for 30 seconds.

Figure 11. Hip flexion means and standard deviation pre and post LPHC intervention.

Figure 12. Knee flexion means and standard deviation pre and post LPHC intervention.

Figure 13. Knee valgus means and standard deviation pre and post LPHC intervention.

Figure 14. Ground reaction force means and standard deviation pre and post LPHC intervention.
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Figure 14. Ground reaction force means and stand deviation pre and post LPHC intervention.