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Full Length Article

Ground reaction forces during a drop vertical jump: Impact of external load training

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ABSTRACT

External load training (ELT) is a supplemental training method used to potentially improve high intensity task performance. However, biomechanical parameters such as ground reaction forces (GRF), ground contact time, and time to peak GRF during a drop vertical jump (DVJ) following an ELT intervention have yet to be examined. Therefore, this study investigated the impact of ELT on certain biomechanical parameters of a DVJ task. Well-trained females stratified into two groups (ELT = 9, Control = 10) completed a DVJ from a 45.72 cm box onto a force platform at baseline, post-ELT, and post-detraining (DET). ELT consisted of wearing weight vests (WV) with 8% body mass for 32 h/week during daily living and 3 training sessions/week for 3 weeks. After ELT, a 3 week DET phase was completed. The control group replicated procedures without ELT intervention. The vertical, medial/lateral, and anterior/posterior components of the GRF were assessed during the initial contact, minimum force following initial contact, push-off, and second landing periods. Dependent variables were analyzed using a 2 (group) × 3 (time) mixed model ANOVA ($p < .05$). Significantly greater peak vertical GRF during the initial contact period was identified for the ELT group. Significant increases in the minimum vertical GRF following the initial contact period from baseline to post-ELT following the were observed for the ELT group, while significant increases in peak vertical GRF during the second landing period at post-ELT and post-DET in comparison to baseline was observed for both groups. The combination of greater vertical GRF during the initial contact period and the period following initial contact suggests that ELT may increase GRFs during a DVJ in comparison to routine training without a weighted vest.

1. Introduction

The use of weighted vests (WV) during training to improve high intensity task performance has been investigated in both industrial (O'Neal, Hornsby, & Kelleran, 2014) and traditional athletic populations (Cronin & Hansen, 2006). Bosco and colleagues proposed external load training (ELT), which involves wearing a WV during daily living and training, would further promote performance enhancement in elite level athletes through neuromuscular adaptations such as improved recruitment rates of fast-twitch motor units and enhanced stretch–shortening cycle function that would cause a rightward shift in the force–velocity curve (Bosco et al., 1984). The authors' theory was supported in a series of studies conducted in the 1980's which repeatedly reported that three

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weeks of ELT significantly enhanced vertical jump height and lower body power output during continuous countermovement jumps in elite level athletes (Bosco, 1985; Bosco, Rusko, & Hirvonen, 1986; Bosco et al., 1984). Further strengthening the impact of ELT was noted when four weeks of routine training without a WV resulted in a return to original performance capacity (Bosco et al., 1984). Despite the initial findings in seminal ELT investigations (Bosco, 1985; Bosco et al., 1986; Bosco et al., 1984), only a few recent investigations have further explored the potential impact of this supplemental training method (Lowe et al., 2016; Scudamore et al., 2016; Simpson, Miller, O'Neal, Chander, & Knight, 2017).

Empirical evidence supporting ELT has been limited, but wearing WVs in attempt to improve high intensity task performance appears to be an increasing trend. Recently, studies examining ELT protocols exclusively during daily living activities have reported performance enhancements in jumping, sprinting, and high intensity tactical tasks (Lowe et al., 2016; Scudamore et al., 2016), supporting the seminal findings of ELT. However, lower body jumping power output and 40 m sprint performance remained unchanged following an 8-day ELT intervention (Barr, Gabbett, Newton, & Sheppard, 2015), suggesting that eliciting further changes in performance may be dependent on exposure duration. Despite literature supporting the notion that long term ELT protocols can elicit acute high intensity task performance improvements (Bosco, 1985; Bosco et al., 1986; Bosco et al., 1984; Lowe et al., 2016; Sands et al., 1996; Scudamore et al., 2016), studies have been limited in scope by assessing performance changes that occur during various countermovement jumping and sprinting tasks in well-trained male populations.

Drop vertical jumps (DVJ) are commonly used to analyze bilateral rebounding mechanics and vertical ground reaction force (GRF) attenuation capability of the lower extremity (Bates, Ford, Myer, & Hewett, 2013a, Bates, Ford, Myer, & Hewett, 2013c; Ford, Myer, Schmitt, Uhl, & Hewett, 2011). Biomechanical changes that occur during DVJ tasks following standardized dynamic stabilization, plyometric and/or resistance training programs are well established (Chappell & Limpisvasti, 2008; Irmischer et al., 2004; Kondo & Someya, 2016; Myer, Ford, Brent, & Hewett, 2006; Myer, Ford, Palumbo, & Hewett, 2005), while acute increases in peak vertical GRF of up to 20% have been reported when completing a jump-landing task with an external load (Dempsey, Handcock, & Rehrer, 2014; Kulas, Zalewski, Hortobagyi, & DeVita, 2008; Sell et al., 2010). However, studies incorporating ELT interventions have failed to examine the potential impact on biomechanical parameters of a DVJ, especially in female populations. Therefore, the purpose of this study was to examine the influence of a 3-week ELT protocol on biomechanical parameters of a DVJ task in comparison to training without an ELT intervention in well-trained females. While research indicates that wearing additional loads during a DVJ task acutely increases peak vertical GRFs (Kulas et al., 2008; Sell et al., 2010), we hypothesized that three weeks of ELT would increase the magnitude and rate of GRF parameters during the DVJ task in comparison to routine training. An additional hypothesis was that three weeks of training without ELT would mitigate any increases in magnitude and rate of GRF parameters during the DVJ task.

2. Methods

2.1. Participants

Collegiate aged female participants free from any self-reported musculoskeletal injuries and actively participating in resistance, plyometric, and/or high intensity training ≥ 4 days per week for the previous 12 months were recruited for participation in the study. Sample size calculation using a mixed model analysis of variance in G-Power software (Düsseldorf, Germany) determined that 20 participants with a critical F of 4.41 would be needed to achieve a desired power of 0.80 using an effect size of 0.50 and alpha set at 0.05. Originally 21 participants were recruited, but two participants had to discontinue their participation due to injuries that were unrelated to the study. Therefore, 19 healthy female participants volunteered for participation and completed all phases of the investigation. The participants were required to complete and sign a Institution Review Board approved informed consent document that explained the requirements, procedures, and potential risks of participation prior to the initiation of data collection. All study procedures were approved by the primary author's Institutional Review Board. Additionally, participants filled out a self-reported physical activity recall questionnaire so investigators could monitor the training regimens of each individual participant. Participants' height and mass were recorded using a standard stadiometer (Webb City, MO, USA) and physician's scale (Tanita, Corporation, Japan), respectively.

2.2. Experimental procedures

Following the initial visit to the laboratory in which the previously mentioned documents were collected, participants completed a familiarization trial. During the familiarization trial, testing procedures were explained and each participant performed multiple trials of the drop vertical jump (DVJ) task (described below) in an attempt to mitigate any potential learning effects. Additionally, this familiarization trial served to stratify participants into ELT (n = 9) and control ((CON); n = 10) groups by ranking participants based on their performance on the single countermovement jump and 25-m sprint. These tests were chosen because they are commonly used to assess athletic performance capability (Vescovi & McGuigan, 2008). Following completion of the familiarization trial, participants returned to the lab less than a week later to complete their baseline (BL) trial. After completion of the BL assessment, participants completed an ELT protocol (described below) and returned to the laboratory three weeks later to complete a post-ELT trial. Following completion of the post-ELT assessment, participants completed a 3-week detraining (DET) phase in which the ELT group was restricted from wearing WVs but were instructed to continue normal training. The control group was restricted from wearing WVs but continued normal training regimens for the duration of the study. Following the completion of DET, participants returned to the laboratory and a final assessment was completed (post-DET).