Available online at www.sciencedirect.com

ScienceDirect

Journal of Sport and Health Science 4 (2015) 364–370

www.jshs.org.cn

Original article

Effect of different stretching strategies on the kinetics of vertical jumping in female volleyball athletes

Nicholas T. Kruse [a,*], Marcus W. Barr [b], Roger M. Gilders [b], Michael R. Kushnick [b], Sharon R. Rana [b]

[a] *Department of Kinesiology, University of Toledo, Toledo, OH 43606, USA*

[b] *School of Applied Health Science and Wellness, Ohio University, Athens, OH 45701, USA*

Received 4 March 2014; revised 28 April 2014; accepted 9 June 2014

Available online 6 September 2014

Abstract

Purpose: The present study aimed to examine the effect of static stretching (SS) and a sport-specific dynamic stretching (DS) session at two specific post-stretch time intervals in highly trained female athletes (age 19.90 ± 1.60 years; height 1.80 ± 0.06 m; mass 76.87 ± 9.95 kg) on kinetic parameters of peak force, time-to-takeoff, and rate of force development.

Methods: The data were collected over 3 days (randomized within subject design with control session). Following each stretch session (SS *vs.* DS *vs.* control) of equal duration (7 min total: 30 s per targeted muscle group) participants performed countermovement jumping on a force platform at 1 and 15 min after stretching.

Results: The DS session significantly improved upon kinetic variables of rate of force development, peak force, and time-to-takeoff relative to SS at 1 min after stretching. No significant effect was found at 15 min.

Conclusion: Together these findings suggest that when training and competing to jump quickly and maximally the female athlete should incorporate DS instead of SS as part of their pre-competition warm-up, but conduct performance within 15 min of their warm-up to elicit maximal gains.

Keywords: Dynamic stretching; Female athletes; Rate of force development; Static stretching; Time-to-takeoff

1. Introduction

The ability to generate muscular strength quickly is defined as the rate of force development (RFD), and is an integral factor in activities involving stretch-shortening cycles (SSC), such as jumping, sprinting, and throwing.[1] In this regard, coaches and athletes have sought to develop a pre-competition warm-up with stretching strategy that elicits the highest RFD relative to that given sport. Generally, athletes incorporate dynamic stretching (DS) and not static stretching (SS) as part of their general warm-up, because DS allows individuals to move through sport-specific movements in rehearsal that SS would otherwise not accomplish.[2] In this sense, DS has been shown to improve upon selected measures of power output,[2] jumping ability,[3] and reaction time,[4] whereas SS has been reported to create decrements in these same performance measures.[5–7] Despite compelling evidence in favor of DS and against SS, a recent review of literature[8] reports that approximately half of the stretching studies assessing the acute effect of SS and DS show no notable effect on SSC activities. Hence, to date, no clear consensus in the stretching literature has been accepted.

The ambiguity within stretching literature has been suggested to be the result of several notable factors, however, the timing of a specific stretch, the training status and/or the gender status of a sample population each has been shown to play a substantial role in performance outcomes.[8–11] With regard to timing, the time elapsed between completion of the stretch-to-performance measures has been shown to cause significant reductions in peak torque immediately after various stretching durations of 2, 4, 6, and 8 min, but return to baseline by 10 min

* Corresponding author.
E-mail address: nick.kruse@rockets.utoledo.edu (N.T. Kruse)
Peer review under responsibility of Shanghai University of Sport.

http://dx.doi.org/10.1016/j.jshs.2014.06.003

after stretching in young healthy males.[11] Furthermore, Mizuno et al.[12,13] reported that muscle-tendon unit (MTU) stiffness, a physiological index for rapid force generation, was significantly altered immediately after SS but returned to baseline by 10 and 15 min after stretching in healthy males. Although several articles provide a general consensus for when males should conduct stretching prior to activities, the magnitude of this effect is largely undefined in female athletes.

Investigating potential SSC performance outcomes after the application of stretching in female athletes would be particularly important because gender differences have been shown to exist with regard to how the MTU operates.[14] The MTU has been hypothesized to be a primary candidate that is mechanistically linked to the effect of stretching by altering the length-tension and force-velocity relationship of skeletal muscle SSCs.[15] For example, a single bout of SS has been shown to alter the length-tension relationship (a left-ward shift)[16] and this has led to a concomitant reduction in RFD.[15] In this regard, a stiffer MTU is capable of generating a higher RFD, because there is less “slack” for the tendon to “pick-up” during skeletal muscle SSCs, thereby reducing the time lag from onset of muscular force generation to externally applied ground reaction forces (GRFs).[15] Notwithstanding, females have been shown to exhibit a more compliant (less stiff) MTU than male counterparts and authors reason that the difference may alter the force-time curve during SSC activities.[17] Even more, strength trained and/or plyometric trained individuals (i.e., high jumpers, volleyball players, basketball players) are well documented to decrease their MTU compliance (i.e., increased stiffness) parallel to improvements in RFD.[17,18] Therefore, although resistance- and plyometric-trained individuals have a positive response during maximal force exerting tasks, female athletes may differentially alter how their MTU operates under different stretching conditions at different times, thus altering their kinetic profile during SSC activities. This paradox warrants further examination.

The force generating capacity that the MTU exhibits during SSC activities can be quantitatively assessed from GRF-time data using a force platform, and provides the most accurate way to assess strength qualities during vertical jumping.[19] By measuring selected kinetic variables related to how quickly one jumps, such as time-to-takeoff (TTT),[20] how maximally one produces force, such as peak force[21] and variables linking both components, such as the rate at which force can be generated (e.g., RFD),[22] it is possible to distinguish any notable effect that stretching of the lower extremity may have in female athletes.

Therefore, the current investigation aimed to evaluate: 1) the kinetic profile that female volleyball athletes exhibit during vertical jumping after SS and DS, and 2) to quantitatively describe changes in these kinetic parameters at two specific timing intervals (1 and 15 min) after stretching. On the basis of abovementioned evidence it was hypothesized that a sport-specific DS protocol compared with an equal duration of SS, would improve kinetic parameters 1 min after stretching but, by 15 min kinetic parameters would return to baseline (control).

2. Materials and methods

2.1. Participants

Ten female, collegiate varsity volleyball players (mean ± SD: age 19.90 ± 1.60 years; height 1.80 ± 0.06 m; mass 76.87 ± 9.95 kg) were recruited for this investigation. Participants were considered highly trained on the basis of a brief athletic training questionnaire, meaning that each participant was currently participating in regular off-season strength training and plyometric training, volleyball drills, and weekend competitions under the supervision of strength and conditioning coaches at the time of experimental testing. Frequency and duration of participation ranged from 2 to 5 days per week and 50–60 min per session. To prevent any potential diurnal variations in performance measures participants were asked to report to the laboratory at approximately the same time for every session (~1300–1500 h). Participants were verbally informed of the protocol and then read and signed the informed consent form. This investigation and all procedures utilized was approved by Ohio University’s Institutional Review Board.

2.2. Experimental design

This investigation used a randomized within subject design to evaluate the effectiveness of a traditional bout of SS, a DS routine (as prescribed by the coaches) and a control (no stretching) session of equal duration on kinetic variables describing the shape of the GRF-time curve during countermovement vertical jumping (CMJ) on a force plate. Kinetic parameters that were assessed from the raw vertical GRF trace (Fz) of the force platform were TTT, peak force (F_{pk}), and RFD_{avg}. Because some athletes do not begin competing immediately after their warm-up with stretching routine, we examined the effects of DS and SS post-stretch timeline testing beginning at 1 min and ending at 15 min (Fig. 1).

Each participant volunteered to participate in four sessions which consisted of one familiarization session and three randomized experimental testing days (Fig. 1). In the first session participants became familiarized to the procedures of each experimental session. This included correct CMJ technique as well as familiarization to the SS procedures. It was assumed that all participants understood the DS procedures, as this was their typical pre-match warm-up routine that was extrapolated from the coaching staff. After the familiarization session the following three randomized experimental testing sessions were conducted: 1) an SS session followed by three CMJs each at 1 and 15 min after SS, 2) a control session using only a general aerobic warm-up followed by three CMJs each at 1 and 15 min after warm-up, and 3) a DS session followed by three CMJs each at 1 and 15 min after DS.

Prior to each stretching session a brief aerobic warm-up was conducted on a cycle ergometer (Monark, Ergomedic 874E, Vansbro, Sweden) using 1 kg of resistance and cycling at a cadence of 60 RPMs for 5 min. Participants then performed one of three randomly assigned experimental stretching protocols, which lasted for a total duration of 7 min. After stretching, a stop-watch was started in order to monitor testing at 1 and 15 min after the stretch intervention. At each specific timing