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Acute Effects of Stretching Routines with and without Rest Intervals between Sets in the Bounce Drop Jump Performance

Paulo Henrique Marchetti[1,2,*], Enrico Gori Soares[1], Fernando Henrique Domingues Oliveira Silva[1], Priscyla Silva Monteiro Nardi[2], Érica Paes Serpa[1], Willy Andrade Gomes[1], Brad J. Schoenfeld[3]

[1]Department of Human Movement Sciences, Methodist University of Piracicaba, Piracicaba, São Paulo, Brazil
[2]Institute of Orthopedics and Traumatology, School of Medicine, University of São Paulo, Laboratory of Kinesiology, São Paulo, Brazil
[3]Department of Health Sciences, CUNY Lehman College, Bronx, New York, USA

Abstract The purpose of this study was to evaluate the acute effects of static-stretching (SS) session with (intermittent) and without (continuous) rest intervals between sets on the bounce drop jump performance, with the same volume and intensity. The experimental protocol consisted of (1) a brief warm-up using sub-maximal jumps; (2) a pre-SS evaluation (passive ankle ROM and three trials of maximal single-leg jumping task for each lower limb); (3) ankle plantar flexors SS protocol (intermittent or continuous) was used only for a single-lower limb; (4) immediate post-SS evaluation (passive ankle ROM and three trials of maximal single-leg jumping task for the stretched lower limb). Then, subjects rest for 30 minutes and the topics 3-4 were repeated with the other lower limb and stretching protocol. The intensity used for both stretching protocols was between 70-90% of the point of discomfort. There were significant decrease in jumping height performance for both stretching protocols: continuous (P=0.001) and intermittent (P=0.006). There were significant increase in contact time only for the continuous protocol (P=0.025). Our findings indicated that both stretching protocols (intermittent or continuous) were effective to increase the passive ankle ROM, and to decrease the single-leg jump height, however only the continuous SS protocol showed increases in the contact time.

Keywords Biomechanics, Exercise performance, Power

1. Introduction

Static stretching (SS) is often incorporated into warm up routines as a part of preparation for a main training session or sport practice of athletes and recreational fitness participants[1]. With respect to power activities, several studies have reported deleterious effects of SS on different drop jump variables, such as jump height [1-4], contact time [2, 3] and electromyographic (EMG) activity [5, 6]. These plyometric performance reductions can originate from neurophysiological (i.e. mechanoreceptors of the skin, muscle and joint proprioception), hormonal, cellular (structural changes such as titin/nebulin), or mechanical (i.e. stiffness, torque-length characteristics) factors [1, 2, 7-11], and some studies indicate deleterious effects might persist for several hours post-stretching [12-15]. The main detriments to performance may be related to neural factors such as altered motor control strategies and autogenic inhibition reducing the stiffness of the musculotendinous unit leading to alterations in the force-length relationship[9]. These effects can be related to the stretch-shortening cycle, which relies on tissue mechanic properties (i.e. musculotendinous unit stiffness) and stretching reflexes (i.e. muscle spindle) to develop power [16]. Most studies investigating the force loss have utilized intermittent (i.e. with rest intervals) stretch protocols, that may elicit different changes in central drive and muscle mechanical properties when compared to continuous stretches (without rest intervals). Intermittent stretch has been reported to be more efficient in reducing muscle stiffness when compared to continuous stretch, which may be associated with the cyclic strain reducing muscle viscosity, the thixotropic behaviour (hysteresis) of the musculo-articular system, and changes in tissue oxygenation kinetics [17, 18]. Trajano et al. [18] analyzed the relative contributions of central versus peripheral factors to the force loss induced by acute continuous (one 5-min stretch), and intermittent (five 1-min stretches) plantarflexor stretches. The stretches were constant torque ankle performed on an isokinetic dynamometer, and the results suggested improves on ankle ROM for both protocols, and the intermittent protocol

* Corresponding author:
dr.pmarchetti@gmail.com (Paulo Henrique Marchetti)
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reduced the peak of torque more than continuous protocol.

No studies to date have evaluated the differences between intermittent or constant static-stretching protocols on jump performance. Therefore, the purpose of this study was to evaluate the acute effects of static-stretching (SS) session with (intermittent) and without (continuous) rest intervals between sets on the bounce drop jump performance.

2. Methods

2.1. Subjects

The number of subjects was determined by using the same variable from our pilot study (jump height variable), and ten subjects were deternubed to be necessary based on alpha level of 0.05 and a power (1-β) of 0.80 [19]. Therefore, we recruited fourteen physical active participants were assigned to this study (age 20±2 years; mass 77.2±8.3 kg; height 178.7±12 cm). All subjects were engaged in regular resistance training routine including squat exercise and jumps for not less than one year. Individuals who participated in this study had no previous surgery on both upper and lower extremities, no history of injury with residual symptoms (pain, "giving-away" sensations). All the participants signed an informed consent form after receiving instruction on the experimental protocol of the research. This study was approved by the University research ethics committee.

2.2. Procedures

Prior to the data collection, the subjects were asked which leg was preferred for kicking a ball, and the preferred kicking leg was considered the dominant leg [20]. The experimental protocol consisted of (1) a brief warm-up using sub-maximal jumps; (2) a pre-SS evaluation (passive ankle ROM and three trials of maximal single-leg jumping task for each lower limb); (3) ankle plantar flexors SS protocol (intermittent or continuous) was used only for a single-lower limb (4) immediate post-SS evaluation (passive ankle ROM and three trials of maximal single-leg jumping task for the stretched lower limb). Subjects then rested for 30 minutes and the topics 3-4 were repeated with the other lower limb and stretching protocol. All tasks were randomized among subjects and lower limbs, and all measures were performed at the same hour of the day, between 9 am and 12 pm.

2.3. Measures

Ankle Range of Motion (ROM): The subjects remained supine with the lower limbs aligned and the ankle joint in neutral position (90º to the ground). A researcher then passively moved the foot to the maximal ankle dorsiflexion ROM. The maximal passive ankle ROM was evaluated before and after the static- stretching protocol with a flexometer, with a sensitivity of 1º (Sanny®, Brazil).

Maximal single-leg jumping task (Single-leg Bounce drop jump, SBDJ): The bounce drop jump is a jump technique where the subject jumps maximally as soon as possible after landing, focusing on the ankle plantar flexors and involving minimum knee flexion and minimum ground contact time [21]. Subjects were instructed to perform the SBDJ falling from a step with 20 cm of height [22, 23], and terminate the landing phase in a standing position with arms crossed across the chest. After the landing phase on the mat contact (landing phase), subjects were instructed to jump maximally with minimal contact time [21]. Subjects were allocated at least 1-minute rest between jumps. To measure the effects of unilateral ankle plantar flexors SS protocol of each lower limb during SBDJ, we acquired the jump height and time contact data from a mat contact (Hidrofit, Brazil). The subjects performed 3 trials of SBDJ before and after of each unilateral ankle plantar flexors stretching protocol using two different protocols (intermittent or continuous) for each lower limb.

2.4. Intervention

***Unilateral ankle plantar flexor SS Protocol*:** During the SS protocol, all subjects remained supine lying down with the knee extended; the SS protocol consisted of a passive dorsiflexion stretch, of the dominant lower limb only. The researcher secured the ankle with one hand while applying force to the sole of the foot at the level of the metatarsal heads with the other hand using body weight to ensure sufficient force. All subjects were submitted to two different SS protocols, one for each lower limb, randomly. During the first protocol, all subjects performed one stretch of 6 minutes (continuous), and for the second protocol, six stretches of 1 minute, with 20 seconds of rest between sets (intermittent). The intensity was continually adjusted based on feedback from the subject to ensure the stretch subjectively achieved 70-90% of the point of discomfort (POD). Based on this same procedure used in prior investigations [1, 3, 24, 25], the subjects were informed that 0="no stretch discomfort at all" and 100%="the maximum imaginable stretch discomfort". The SS protocol was applied and controlled (POD) by the same strength and conditioning researcher.

2.5. Data Analysis

All data were analyzed by the Hidrofit software (Hidrofit, Brazil). The jump height (JH) was calculated by using the flight time formula: $JH = gt^2/8$, were g is gravity acceleration ($9{,}8 m/s^2$) and t is the time without contact with the mat contact. The contact time was defined as the time of the concentric and eccentric phases of the jump [26]. For all variables, the higher value was used to the performance analysis.

2.6. Statistical Analyses

The normality and homogeneity of variances within the data were confirmed with the Shapiro-Wilk and Levene tests, respectively. A repeated-measure ANOVA (2x2) was used, with factors being the SS protocol (intermittent or continuous) and conditions (pre-SS and post-SS protocols).

Post-hoc comparisons were performed with the *Bonferroni test.* Cohen's formula for effect size (ES) was used and the results were based on the following criteria: <0.35 trivial effect; 0.35-0.80 small effect; 0.80-1.50 moderate effect; and >1.5 large effect, for recreational trained according to Rhea [27]. An alpha of 5% was used for all statistical tests. Test-retest reliability (ICC) values were test for jump height variable: intermittent protocol (pre-SS=0.93 and post-SS=0.95) and continuous protocol (pre-SS=0.89 and post-SS=0.95).

3. Results

The results of flexibility measured by passive ankle ROM revealed significant increases between pre-SS and post-SS evaluations for both SS protocols: continuous (21±4° and 25.5±5°; *P*=0.014; ES=1.16; Δ%=16%) and intermittent (23±4° and 27±5°, *P*=0.011; ES= 0.88; Δ%=14.8%) (Figure 1).

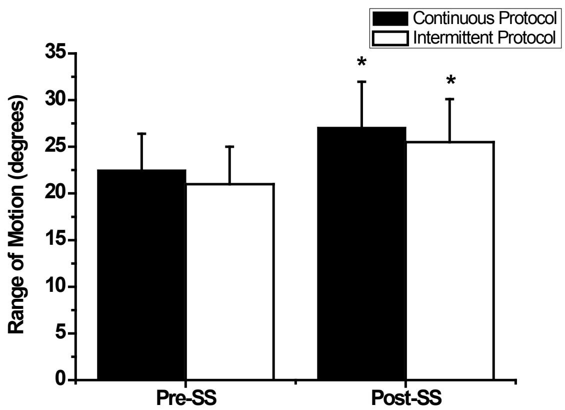

Figure 1. Mean ± standard deviation of the range of motion between pre-SS and post-SS evaluations for both SS protocols (intermittent or continuous). *Significant difference between pre-SS and post-SS protocol, $*P<0.05$

There were significant decreases in jumping height performance for both stretching protocols: continuous (15.7±3.4cm and 11.9±3cm; *P*=0.001; ES= 1.57; Δ%=24.2%) and intermittent (16.2±3cm and 12.7±3cm; *P*=0.006; ES= 1.0; Δ%=21.6%) (Figure 2a). There was significant increase in contact time only for the continuous protocol (267±39 ms and 290±46 ms; *P*=0.025 ES= 0.53; Δ%=7.9%) (Figure 2b).

4. Discussion

The purpose of this study was to evaluate the acute effects of a static-stretching (SS) session with intermittent and continuous protocols on the bounce drop jump performance, by using the same intensity, and volume. Initially, this study demonstrated that the acute effects of both SS protocols significantly increased passive ankle ROM (dorsiflexion). Thus, our combination of total volume (360 sec.) [1, 2] and level of intensity (70-90%POD) [1] was effective to increase the flexibility, independent of the SS-protocol, corroborating the study of Trajano et al., [18].

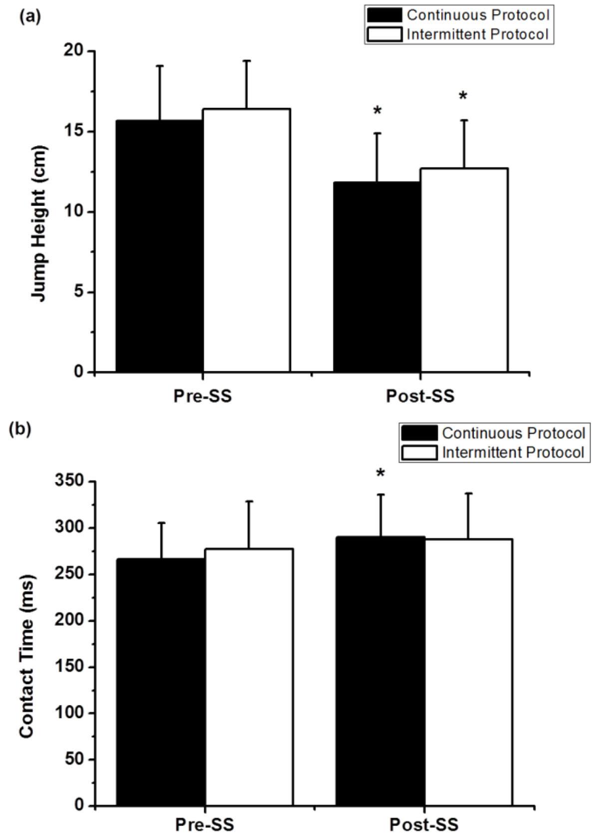

Figure 2. Mean ± standard deviation of the jump height (a) and contact time (b) during unipodal bounce drop jump task for different stretching protocols (intermittent or continuous). *Significant difference between pre-SS and post-SS protocol, $*P<0.05$

With respect to jump height, we observed a performance decrease in both stretching protocols (intermittent and continuous), but the continuous protocol presented a higher effect compared with intermittent protocol (moderate effect size). Some possible explanations for the decrement on jump height may be related to the structural and neurological mechanisms from the total load (volume x intensity) from both stretching protocols [28], or, possibly, due to a higher time-dependent effect from the viscoelastic tissue around the joint, affecting the elastic force transference during the stretch-shortening cycle [29] and consequently proprioceptive feedback [2, 9, 30]. Previous studies reported performance decrements on jump height followed by both static stretching protocols (intermittent or continuous) [11, 31].

The contact time (CT) during SBDJ is an important component of jump performance and it affects the stretch-shortening cycle. The present study observed an increase in the CT only for the continuous protocol, with a small effect size. Time-dependent characteristics can delay the force transmission between the eccentric and concentric phases of jump performance, so the potential elastic energy stored by the muscle-joint complex during loading phase is not completely restituted during unloading phase, leading to a stress-relaxation effect [32]. Therefore, our results do not corroborate with McNair et al. [33] and Nordez et al., [34] who demonstrated a more efficient effect in reducing muscle stiffness to intermittent stretch when compared to continuous stretch.

Some other possible explanations to our findings (out of scope of this work) were some alterations in the physiological characteristics such as a structural damage (i.e. titin, nebulin) [2, 35], or even cell metabolism effects such as ischemia and tissue hypoxia [36], which can lead to a decrease in force and power production.

5. Conclusions

Our findings indicate that both stretching protocols (intermittent or continuous) were effective to increase the passive ankle ROM, and to decrease the single-leg jump height, but only the continuous SS protocol showed increases in the contact time.

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