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Journal of Manipulative and Physiological Therapeutics, Vol. 34, No. 3, (March-April 2011), pp. 195-200.
DOI: 10.1016/j.jmpt.2011.02.004
Robert Topp was affiliated with the University of Louisville at the time of publication.

The Effects of a Closed-Chain, Eccentric Training Program on Hamstring Injuries of a Professional Football Cheerleading Team

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Abstract

Objective: *Hamstring injuries are a common occurrence among professional football cheerleaders. The purpose of this study is to identify the effects of an eccentric, closed-chain hamstring exercise intervention on hamstring injury– associated pain during the course of the football season among professional football cheerleaders.*

Methods: *Forty-three female cheerleaders participated in an eccentric, closed-chain hamstring exercise intervention protocol provided by doctors of chiropractic that incorporated loops of elastic-band or Thera-Band Loops (Hygenic Corporation, Akron, OH) during practice and at home during the regular football season. Hamstring injury–related pain was assessed in June, during team selection; in September, at the start of the season; and in December, at the end of season. No intervention was applied between June and September, although the sample participated in 4 hours of practice 2 to 3 times per week. The intervention was applied to the entire sample regardless of hamstring injury– related pain during the regular football season between September and December. The interventions included 2 exercises and were completed bilaterally 2 times per week at each biweekly practice and were encouraged to be done at least 3 additional times per week at home on nonpractice days.*

Results: *Among the subsample who reported hamstring-related injury pain between June and September, the exercise intervention significantly decreased (P b .007) pain between September (6.07 ± 0.58) and December (3.67 ± 0.65).*

Conclusions: *The eccentric, closed-chain hamstring exercise intervention reduced hamstring injury–related pain among this group of professional football cheerleaders. (J Manipulative Physiol Ther 2011;34:195-200)*

Professional football cheerleaders are among the population of athletes who incur sport-related injuries that affect their abilities to perform and their overall quality of life [1]. Professional football cheerleaders include dancers, gymnasts, and/or high school and collegiate cheerleaders ranging from 18 to 40 years. One of the primary skills of professional cheerleaders exhibited throughout their routines involves dancing. These routines last 2 to 4 minutes and involve a variety of complex movements accompanied by music. The intensity and frequency of these movements have been shown to lead to pain and varying types of injuries. A previous study revealed that pain and injuries frequently occurred among professional dancers while performing and led to retirement from dance and, ultimately, a decline in their overall quality of life [1]. Similar injuries have resulted in retirement among professional cheerleaders.

Previous studies by the authors have tracked various injuries suffered by the Washington Redskins Cheerleaders during the course of 2 seasons [2,3]. During those 2 years, hamstring injuries and low back pain were the 2 most common ailments identified, occurring in 31% and 34%, respectively, of the sample examined during the course of a football season. These studies indicated that the most common mechanism of injury in which hamstring injury occurred was when the individual performed a drop split maneuver. This maneuver involves the cheerleaders interlocked with their arms in a “chorus line” position as they perform a series of alternating high kicks, then jump in the air, perform a front split in midair, and land on the turf in the split position. Given that the drop split is a position of hip flexion at 90°, full knee extension of the front leg and full hip, and knee extension of the back leg, the demands on the front hamstring and biceps femoris specifically are even greater than that of running.

Muscle strain injuries are thought to occur when muscles are actively lengthened to greater than normal lengths. The combination of activating a muscle while simultaneously lengthening produces the mechanical strain that causes muscle injury [4]. The anatomy of the hamstring muscle places it in a vulnerable position during sports, making it susceptible to mechanical strains. The hamstring muscle is a biarticulate muscle, meaning it crosses 2 joints and has 2 major actions (ie, stretching with knee flexion and hip extension). As the lower leg swings forward during the end position of the drop split, the hip flexes and the knee extends simultaneously. Thus, the hamstring muscle becomes actively lengthened to greater than normal lengths. The biceps femoris muscle is thought to be more vulnerable to injury than the semitendinosus and semimembranous muscles [5]. The biceps femoris experiences greater active lengthening and electrical activity during the late swing phase of running. Onishi et al [6] reported that electromyography activity varied among the 3 muscles at different muscle lengths. The biceps femoris was maximally activated between 15° and 30° of knee flexion starting from

full knee extension, and the semimembranous and semitendinosus were maximally activated between 90° and 105°. In 1 study, biceps femoris strain injuries accounted for 80% of the total 170 hamstring injuries analyzed [7,8]. To understand the effects of hamstring injuries and to find ways to treat and prevent it, researchers have examined various exercise interventions that focus on closed-chain and eccentric mechanisms.

Brughelli and Cronin [9] recently published a series of exercises used to treat and prevent hamstring injuries in sports using exercises that had closed-chain and eccentric components. Although the study addressed the importance of the eccentric component in shifting the optimum length of tension development to longer lengths, Brughelli and Cronin did not account for torque on the hamstring because the exercises were done with a barbell weight for both. Another approach to eccentrically contracting the hamstrings at elongated lengths is to create looped elastic resistance using rubber tubing [10-12]. This is hypothesized to provide higher levels of resistance at the end range of motion of the hamstring while minimizing torque to the joints involved. The combination of high resistance and low torque aims to increase eccentric strength while minimizing injury due to high levels of torque that are commonly associated with isotonic resistance exercises. Stretchable bands and tubing have previously showed positive results for treating and rehabilitating lower extremity muscle strain injuries [10-12].

The purpose of this study is to measure the effects of an eccentric, closed-chain hamstring exercise intervention on hamstring injury–associated pain during the course of the football season among professional football cheerleaders.

Methods

Design

This study was a retrospective records review of 43 cheerleaders who were involved in an injury prevention protocol implemented during the football season between June and December. Participants were not actively recruited into this study; rather, their medical records were reviewed to provide data for analysis. This study was approved by the University of Louisville Institutional Review Board (no. 10.0434). Thus, the sample size was predetermined by the number of records that was available among the predetermined cheerleading squad.

Participants

Inclusion criteria of participants were that they were Washington Redskins cheerleaders during the football season from June to December. The sample consisted of 43 females ranging from 18 to 34 years, with a mean age of 25.60 years. All participants had been cheering for the Washington Redskins from 1 to 7 years, with an average of 2.58 years. Their professional cheerleading experiences ranges from 1 to 8 years, with an average of 3.23 years.

Data Collection

An injury survey that identified location, chronicity, and severity of injury along with relationship of injury to cheerleading experience and epidemiological variables was collected from the participants at 3 different time points. Data were collected in June, when the team was selected; in September, after preseason training but just before introducing the eccentric, closed-chain hamstring exercise intervention; and in December, after the football season and the eccentric, closed-chain hamstring exercise intervention. Severity of hamstring injury pain was collected from each participant by completing a survey that included a 10-point Likert-type pain scale that ranged from 0, indicating no pain, to 10, indicating most severe pain. All data were collected at a professional chiropractic clinic associated with the Washington Redskins cheerleading team.

Intervention

The exercise intervention included in-practice and home exercise programs incorporating a looped elastic band, specifically Thera-Band Loops (Hygenic Corporation, Akron, OH), that were given to all 43 cheerleaders regardless if they reported hamstring injury pain. These intervention exercises were a progression of 2 closed-chain, eccentric exercises (Figs 1 and 2). Participants performed these exercises 2 times a week at supervised practices 3 times per week as part of a home exercise program. startinginSeptember andendinginDecember. The During supervised practice twice per week, after 20 minutes participants were also encouraged to perform the exercises of routine stretching and warm-up exercises, the participants were divided into 2 groups: those with and without a hamstring injury. The group with hamstring injuries performed the split stance exercise (Fig 1) using the set and repetition progression found in Table 1. The non–hamstring injury group did the same split stance exercise followed by the single leg protocol for each exercise in the sequence. The hamstring injury group did not perform the single leg exercises to minimize further aggravating their injured hamstring. During each repetition or exercise, participants completed the eccentric portion of the maneuver for a

period of 5 seconds. The concentric portion of the exercise was performed for 2 seconds.

Statistics

Data analysis was completed using PASW Statistics 18.0 statistical software (Statistics Solutions, Palm Harbor, FL). The α level for all statistical tests was set a priori to .05. Descriptive statistics were obtained for several variables including age of the participants, total years of professional cheerleading, frequency of hamstring injuries, and treatments received. Repeated-measures analysis of variance (ANOVA) was used to determine differences in pain for the 3 time points. Tukey's post hoc comparisons were used to determine when significant differences occurred within the sample over time.

Results

Of 43 the participants, 15 (35%) reported having hamstring injuries at some point during the course of the study (June-December). Hamstring injuries were reported in 25% of participants in June (n = 11), 35% in September (n = 15), and 35% in December (n = 15). Of the injured participants, 13 reported seeking multimodal (chiropractic, physical therapy) treatment of hamstring injuries, and 2 participants did not receive any type of external treatment during this study. There were no dropouts during the course of this study.

A positive correlation was found between age and pain in September (r = .36, P = .02) and December (r = .41, P = .006) but not in June (r = .16, P = .31). Independent samples t tests indicated that there was no significant difference in age or duration of cheerleading between individuals who experienced an injury compared with those who did not experience an injury during the course of the study. However, individuals who were injured in September and December were significantly older but did not show any significant difference in the duration of cheerleading (Table 2).

Repeated-measures ANOVA results indicated a significant decline in pain among the 15 injured participants from September (mean, 6.07; SD, 0.58; P = .007) to December (mean, 3.67; SD, 0.65) during the implementation of the exercise protocol intervention (Fig 3). The hamstring pain reported by these individuals appears to decline by 50% between September and December during the time the intervention was being introduced. There was no significant difference in pain from June (mean, 3.67; SD, 0.65; P = .059) to September, during the time when the intervention was not introduced, although there was a trend toward increasing hamstring pain among this group during this time.

Discussion

The high rate of hamstring injuries within the sample of professional cheerleaders is consistent with previous findings [2,3]. The findings of this study also appear to support the use of an eccentric, closed-chain hamstring exercise intervention on reducing hamstring injury–related pain among professional cheerleaders. Friden and Lieber [4] identified that the combination of an active muscle being lengthened will produce mechanical strain that can cause muscular injury. Brughelli and Cronin [9] attempted to treat and prevent hamstring injuries using eccentric, closed-chain exercise but failed to account for the torque generated with isotonic exercises particularly in the extremes of muscle range of motion. The exercise intervention evaluated in this study, incorporating Thera-Band Loops, appeared to be effective in reducing hamstring pain. This finding, in contrast to those of Brughelli and Cronin, may be attributed to the exercise intervention using elastic resistance generating high resistance but low torque in the extremes of the hamstring range of motion. These findings are consistent with previous investigators who reported elastic resistance to be effective in treatment of hamstring injuries [10-12]. Based on the review of literature, we implemented functional eccentric exercises that included maximal muscle elongation and closed-chain unilateral multiple joint movements, which were simple to remember and perform. This exercise intervention appeared to reduce hamstring pain associated with the drop split maneuver that involves hamstring activation and hamstring lengthening. The results support that this closed-chain, eccentric program was able to reduce hamstring injury pain among professional cheerleaders during the course of a professional season (September-December).

Limitations

These results must be interpreted cautiously. This study only evaluated 1 group of athletes. The effects may have been different at other locations or with different cheerleading groups. In addition, declines in hamstring pain between September and December may be attributable to several other extraneous variables not related to the protocol. Furthermore, the small sample size of the study (N = 43) and the subsample of the group reporting a hamstring injury may have threatened the statistical power of the analysis. This threat may be particularly short term when examining the trend toward increasing hamstring pain between June and September. The study did not include a true control group. Without a control group, there is no way to determine if the trend toward increasing hamstring pain observed between June and September would continue once the more physically rigorous season began between

September and December if the intervention was not introduced. The effects of additional multimodal treatments were not considered during analysis of this study, and future studies should focus on the effects of such treatments on pain and rehabilitation. Future work will determine if the exercise protocol has a protective effect on reducing or preventing hamstring injuries in this population.

Conclusion

The results of this study indicate that an exercise intervention consisting of 2 closed-chain, eccentric hamstring exercises practiced twice per week may have an effect on reducing hamstring-related pain. These results, although promising, indicate the need for further study including a controlled clinical trial to determine if these exercises can mitigate hamstring injuries among professional cheerleaders.

Practical Applications:

- Eccentric, closed-chain hamstring exercises may prevent hamstring injuries among professional cheerleaders.
- Home exercise may further potentiate the effect of the intervention.
- Age and hamstring pain appear positively related.

Funding Sources and Potential Conflicts of Interest

This study received funding from the Hygenic Corporation, which is the company that produces Thera-Band, the product used in this study. The study funding was managed by the Sport and Spine Rehab Clinical Research Foundation. Dr. Barton Bishop and Dr. Jay Greenstein are speakers who receive funding from Performance Health, a subsidiary company of Hygenic Corporation. The authors report no other conflicts of interest.

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Appendix

Figure 1: *Split stance eccentric hamstring exercise with band loop*

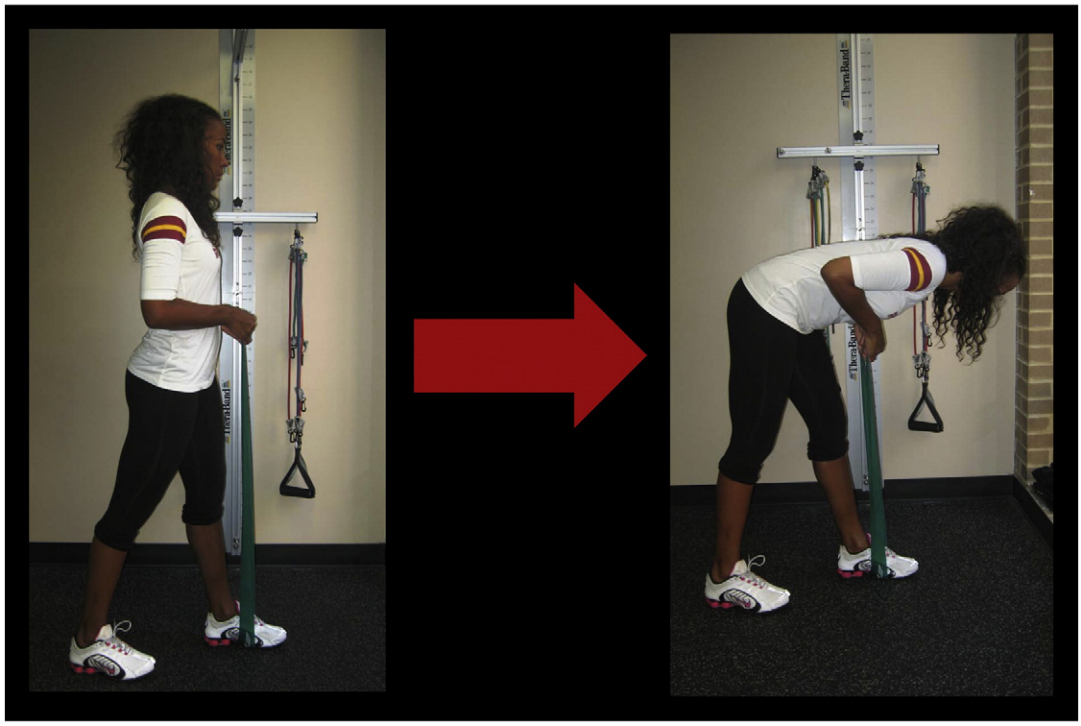

Figure 2: *Single leg eccentric hamstring exercise with band loop*

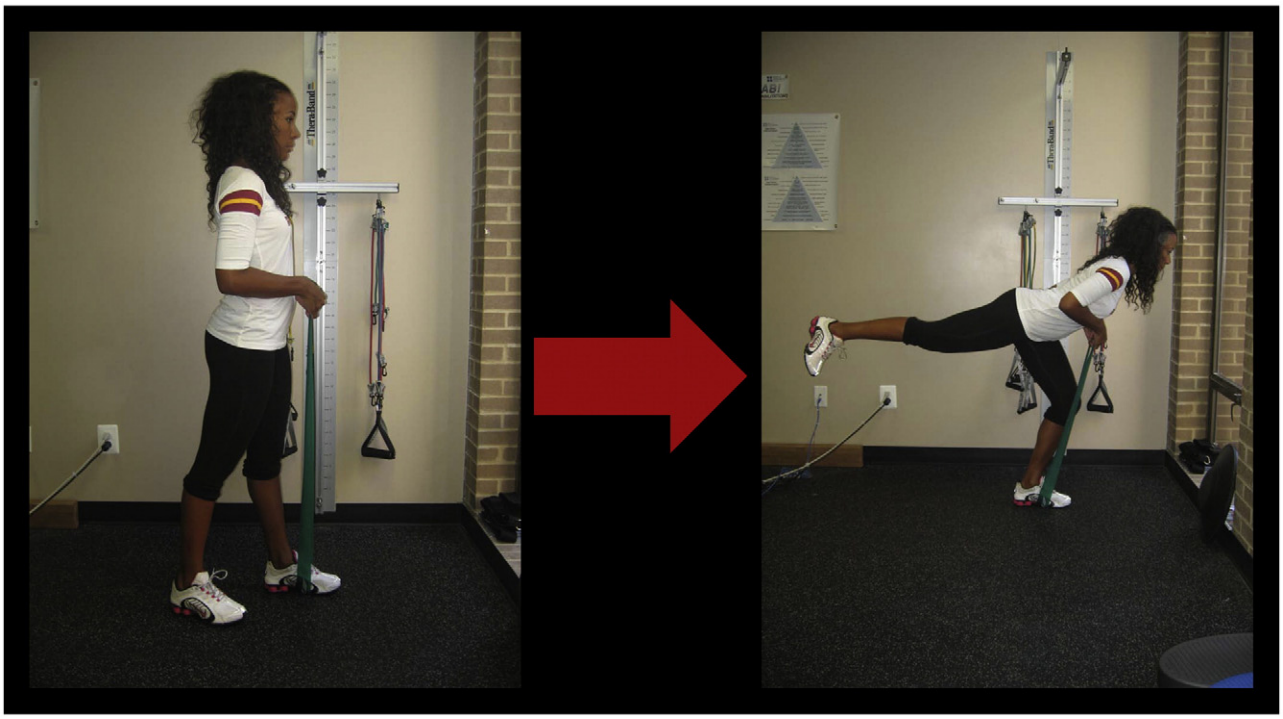

Figure 3: *Repeated-measures ANOVA results indicating significant decline in pain during exercise intervention*

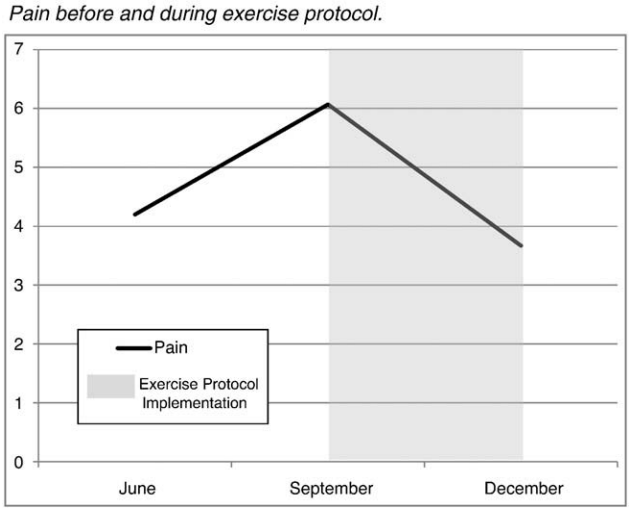

Table 1. *Hamstring exercise protocol: sequence of sets and repetitions*

Weeks	Total sets	Total repetitions
1-3	3	5
4-5	3	10
6-7	3	15
8-9	3	20
10-11	3	25
12-17	3	30

Each set and repetition is performed on each side by alternating sides on each set.

Table 2. *Correlations between age, duration of cheerleading, and pain in June, September, and December*

	1	2	3	4	5	6
1. Age	1					
2. Cheering for the Redskins	.488 *	1				
3. Professional cheering	.594 *	.822 *	1			
4. June pain	.159	−.103	−.195	1		
5. September pain	.357 **	−.037	−.004	.728 *	1	
6. December pain	.409 *	.033	−.020	.645 *	.771 *	1

* Correlation is significant at $P < .05$.
** Correlation is significant at $P < .01$.