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Research Article

Efficacy of Concentric vs Eccentric Loading in The Prevention of Hamstring Injury in Elite Athletes

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Abstract

The routine use of resistance exercises involving concentric and eccentric contractions can increase muscle strength, speed and endurance. However, modern understanding has limited potential to entirely understand the application of such resistance training and the muscle changes that occur to differentiate these two types of training. The purpose of this study was to compare the effects of concentric contraction (CON) and eccentric contraction (ECC) during an acute bout of resistance training on the hamstring contractile properties. A group of 20 male university representing athletes were divided into two equal groups, CON training and ECC training. The peak isokinetic torque of the muscles was assessed using isokinetic machine: biceps femoris (BF) and semitendinosus (ST). The muscles were assessed twice, before and after 10 maximal repetitions of either concentric or eccentric isotonic contractions. The results indicate a greater change in peak isokinetic torque parameters with ECC training, with $p < 0.001$ (Td and Tc). A serious session of resistance training makes changes in the muscle hamstrings contractile properties in both CON and ECC training. Eccentric training causes greater changes than concentric exercise, shortening contraction period (Td, Tc), surge radial movement velocity and disturbing variations in muscle belly displacement (Dm), so may be more effective in training.

1. Introduction

The effectiveness of the muscular system is a primary determinant of sports performance, injury prevention, and physical fitness [1]. Skeletal muscles, which are attached to bones and move them relative to each other, can have two types of contraction during muscle activation: concentric or eccentric in the instance of Concentric, the muscle attachments are taken closer together, while in eccentric, they move away from each other [2]. During a concentric contraction, the muscle shortens and exerts force, which is transmitted through the tendon to the joint, enabling movement and causing a change in the joint angle. Eccentric contractions also occur during everyday movements, allowing for the indulgence of mechanical energy through the deceleration of body actions [3]. This type of contraction occurs, for example, during landing from a jump or descending stairs, in which the quadriceps muscles generate force by lengthening and decelerating the movement. Eccentric contractions also allow the conversion of kinetic energy into elastic energy stored in the tendons, partially recovering energy and resulting in less muscle work [4]. During traditional resistance training, which involves lifting or lowering external weight, people combine concentric muscle work during lifting and eccentric work during lowering the weight.

Eccentric muscle contraction is a fundamental process of human movement, but surprisingly, it is an area of exercise science that has been poorly studied. It is believed that ECC contractions may induce greater muscle strength and hypertrophy than concentric contractions, as they generate greater muscular force [5, 6]. However, some authors argue that there are no differences between ECC and concentric resistance training [7, 8]. Concentric resistance training can effectively reduce pain [9], which can limit an organism's mobility. Eccentric training, on the other hand, is categorized by the production of higher torque [10], while generating lower bioelectrical muscle activity [11]. Additionally, eccentric training may result in better muscle adaptation in eliteathletes in a shorter period of time [12]. There is also evidence to suggest that properly conducted eccentric training can prevent injuries [13]. Despite many positive aspects, eccentric training can cause pain, swelling, and reduced range of motion due to muscle fiber damage, which can result in muscle weakness . Therefore, the impact of eccentric and concentric exercises on muscle parameters is still a matter of debate, and the mechanisms regulating these adaptations have not been fully elucidated.

The hamstring muscles are key muscles responsible for athlete's movement in many sports disciplines and are also among the most frequently injured muscles [14]. Their chief function is knee flexion, but they also make eccentric work to engage force during knee extension movements, slow down motion during late swing phase of sprinting, and prepare the foot for ground contact. Therefore, ensuring the strength of the hamstring muscles, especially in eccentric contractions, is important to maintain the overall functional capacity of the muscle group and prevent overuse injuries [15].

However, the effect of eccentric and concentric muscle contractions on the hamstring remains unclear. Research in this area is significant because optimal muscle contraction ability is crucial for training quality and performance outcomes [1]. To assess the muscular system's ability, despite numerous studies conducted, the effects of concentric and eccentric training on changes in the muscle contractile properties are still unknown. Such an assessment can help coaches utilize the differences in muscle profile during training, which can lead to the development of the most appropriate training program to enhance muscle growth and prevent injuries. Therefore, the aim of this study was to compare the effects of concentric vs eccentric training on changes in muscle parameters measured by means of isokinetic machine. The hypothesis was formulated that different training, such as concentric or eccentric training, would make different adaptations in hamstring muscle contractile properties after an acute session of resistance drill. We expected eccentric training to produce greater changes than concentric training, according to literature.

The extensive occurrence of this form of injury demands the examination of optimal methods of both prevention and rehabilitation. Previous studies have cited numerous potential risk factors associated with hamstring strains, such as muscle weakness and lack of flexibility Burkett, 1970), insufficient hamstring strength in comparison with the quadriceps femoris, exhaustion and insufficient warm-up and poor lumbar position and core stability. Although the danger factors for hamstring injury are many, epidemiological indication recommends that the actual occurrence of hamstring muscle strains frequently takes place during eccentric contraction of the hamstring muscles.

More precisely, it has been previously recommended that it is the portion of eccentric hamstring contraction happening through the descending limb of the muscle's length–tension relationship that results in hamstring injuries [16]. This is postulated to be due to non-uniform lengthening of sarcomeres due to sarcomere length instability, resulting in microscopic damage to the muscles of the hamstring. If a sport requires multiple eccentric contractions, these microscopic areas of damage may result in a "weak link" of the musculature, from which a major soft tissue tear may arise [16].

This leads to another potential risk factor cited in previous research, the position of knee extension at which peak hamstring torque is produced [16]. In regards to the length–tension relationship, it is recommended that the larger the knee extension angle at which peak torque is produced the lower risk of hamstring injury [16]. Therefore, training to increase the knee extension angle at which peak hamstring torque is produced would result in reduced eccentric hamstring loading occurring during this descending limb of the length–tension relation. One method of hamstring training known to increase eccentric strength is the Nordic hamstring exercise [17]. This method of workout was shown to elevate eccentric hamstring strength more efficiently than traditional hamstring curls. However, the effects of this method of training on hamstring position of peak torque and dynamic performance is unknown.

2. Methods

2.1. Study design

This study contributes to the knowledge of the effects of resistance training using concentric and eccentric contractions, the effects of which are known but still poorly understood. A repeated measures design was used to determine the progressive response of the muscle during concentric or eccentric training. Isokinetic machine was used as a tool to measure the mechanical response of the muscle. The participants had no previous femoral injuries and were randomly assigned to two equal groups of 10, either concentric or eccentric training. On the day of the study, the athletes were asked to refrain from physical activity and stimulant-containing products.

2.2. Participants

The study group comprised of 20 young male athletes (age = 21.3 ± 0.9, body mass = 65.4 ± 5.4 kg, body height = 168.4 ± 9.6) who exercised 3 times a week. The training lasted approximately an hour and a half, and encompassed various physical activities aimed at improving overall fitness and health. The training program included concentric loading of hamstring for 10 athletes' and eccentric loading of hamstring for 10 athletes'. Additionally, strength exercises such as weightlifting and machine-based strength training were incorporated to build muscle strength. The training also aimed to develop motor skills, coordination, and flexibility. The athletes also engaged in stretching, Pilates, and gymnastics exercises to improve muscle flexibility and mobility. All participants were right-footed and provided informed consent to participate in the test. The pre- and post-training intervention results for the isokinetic testing including peak torque and position of peak torque for the hamstrings.

2.3. Procedure

Subjects were positioned on the chair of the Isokinetic dynamometer and performed 10 repetitions of concentric knee flexion and extension, both with speed of 90° per second and range of motions of 100° for warming up purposes (Borg up to 5, VAS up to 1, or test interrupted); followed by a break period of 120 second. The warm-up on the Isokinetic machine was chosen to improve specificity and familiarization with the following test. The athlete then performed five concentric and eccentric repetitions of knee flexion and extension at 60° per second for familiarization with the exercise velocity, followed by another rest period of 120 s. Then, they performed three concentric repetitions of knee flexion and extension (velocity: 60° per second and range of motion: 100°) with maximum effort.

3. Statistical analyses

Results

Eccentric training produced better and significant changes in the neural and muscular profile of the hamstring muscles compared to concentric training. The Td, Tc was significantly shorter, the Dm was lower after the eccentric training, and Vrd increased in both trainings. The results suggest that eccentric training may be more effective in improving the neural muscular adaptations of the hamstring muscle group compared to concentric training.

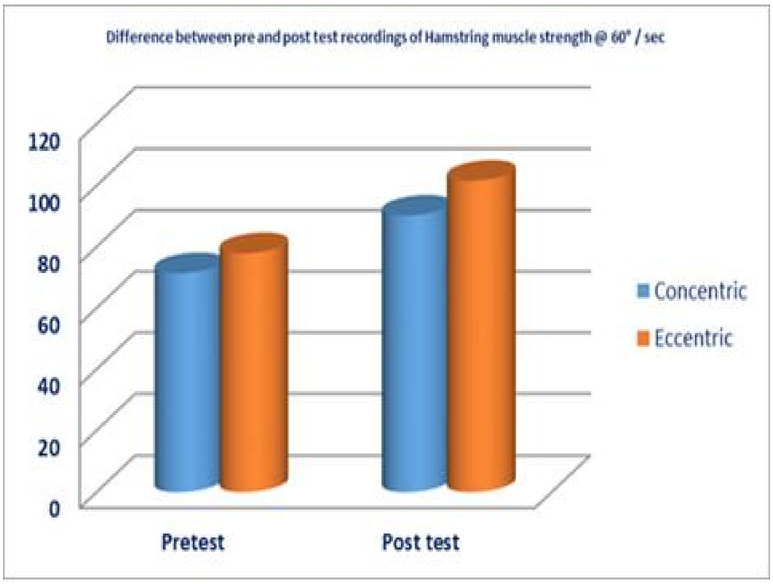

Figure 1: Shows pre and Post-test hamstring muscle strength for concentric and eccentric @ 60° per sec

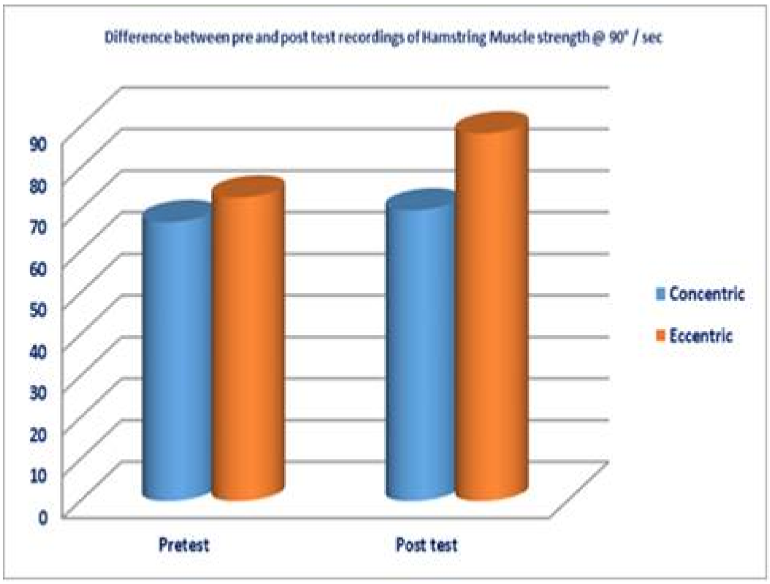

Figure 2: Shows pre and Post-test hamstring muscle strength for concentric and eccentric @ 90° per sec

The current study investigated the effects of an acute bout of resistance training on the contractile properties of the hamstring muscles, specifically focusing on the impact of contraction type (concentric vs eccentric) on muscle performance. The outcomes revealed several important results, providing valuable understandings into the muscular adaptations of the hamstring muscles subsequent different exercise interventions.

4. Discussion

The discussion of the study was explaining the efficacy of concentric vs eccentric loading in prevention of hamstring injury in elite athletes. Table 1 and Table 2 shows that the hamstring muscle strength is significantly improved in both concentric and eccentric groups at 60° / sec. whereas, at 90° / sec only eccentric group was found significant improvement because the eccentric exercises are better than concentric exercises in improving the muscle strength to prevent hamstring injuries in elite athletes. According to study conducted by Gilselon that hamstring muscle strength is improved in both concentric and eccentric group and zakas et al found that the hamstring and quadriceps ratios varies in different individual and different sports persons.

Table 1: Pre-test and Post-test recordings of Hamstring Muscle Strength (60° / sec)

Group	Pre-test	Post-test	Statistical Significance
Concentric	71.40±4.01	90.20±1.23	t=14.39, p<0.0001, S
Eccentric	77.90±1.73	101.60±2.07	t=52.85, p<0.0001, S
Statistical Significance	t=4.7115, p>0.0001, NS	t=14.99, p<0.0001, S	-

Table 2: Pre-test and Post-test recordings of Hamstring Muscle Strength (90° / sec)

Group	Pre-test	Post-test	Statistical Significance
Concentric	67.10±3.35	69.90±6.24	t=1.39 ,p=0.199,NS
Eccentric	73.00±4.11	88.40±4.03	t=25.67,p<0.0001, S
Statistical Significance	t=3.52, p=0.0024, NS	t=7.87 p<0.0001, S	-

5. Conclusion

Results of the present study showed that the eccentric exercises are better than concentric exercises at 90°/ sec in improving the strength of hamstring muscles to prevent the hamstring injuries of elite level athletes.

Article Information

Disclaimer (Artificial Intelligence): The author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.), and text-to-image generators have been used during writing or editing of manuscripts.

Competing Interests: Authors have declared that no competing interests exist.

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