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Effects of Lower Extremity Anaerobic Fatigue on Neuromuscular Function and Jumping Performance

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ABSTRACT

King T, Kaper G, Paradis S. Effects of Lower Extremity Anaerobic Fatigue on Neuromuscular Function And Jumping Performance **JEPonline** 2013;16(4):19-23. The aim of this study was to determine the effects of lower extremity anaerobic fatigue on neuromuscular function and jumping performance. Performance was measured with a 3-D accelerometer. Variables examined were eccentric/concentric contraction ratios (E/C), power production, force production, contact time, and maximal height. Subjects included 9 male soccer players. The subjects completed three Countermovement Jump (CMJ) and Plyometric Jump (PJ) tests; one of each test was conducted during the pre-test session and immediately following fatigue protocols. The first fatigue protocol was the Wingate test. The second fatigue protocol was the Bosco test that consisted of maximal effort squat jumps for a minute. Statistical analysis was conducted using a paired *t*-test. No significance was found at the P≤0.05 level between pre-test and post-test values for E/C (Wingate P=0.65; Bosco P=0.70), power (P=0.71; P=0.10), force (P=0.79; P=0.35), contact times (P=0.20; p=0.71), or maximal height (Wingate p=0.18). The only significance found was the decrease between the pre-test (35.28 cm ± 4.00) and the Bosco post-test (32.46 cm ± 3.32) values of maximal height (P=0.048). The findings indicate that the Wingate and Bosco fatigue protocols did not stress the neuromuscular system. It is probable that the protocols may have failed to induce fatigue, as the results did not support current research. Though little correlation was found between lower extremity fatigue and jumping performance, it is reasonable that further research should be conducted to explore how different levels of fatigue may contribute to neuromuscular function and jumping performance.

Key Words: Soccer, Eccentric, Concentric, Wingate

INTRODUCTION

It is no secret that athletics has gained a substantial amount of attention over the past several decades. This newfound interest has led many societies to incorporate sports as an integral part of both health-related fitness and entertainment. Analyzing the muscular function aspect of athletics continues to provide insight into optimal training programs, which aids in improving performance and decreasing injury of athletes. In competitive sports, these features of athletic fitness are highly desirable.

One of the most world-wide prevalent sports today is soccer. Due to the nature of the sport, the lower extremities contain the primary muscles targeted during competition and training. This is also the likely reason why a majority of the injuries occur in the lower extremities of soccer players. In fact, Merron et al. (4) indicated that soccer players in their youth have been found to have 74% of their injuries lower extremity related, while senior soccer athletes have been found to have 89% of injuries specific to the lower extremities. Of the senior soccer players' injuries, 24% were localized to the knees and 22% targeted the thighs. Such high rates of lower extremity injury in soccer players have provided incentive for researchers to further explore soccer injuries and the causes.

Even though some soccer may be thought of as an endurance sport, there are bursts of anaerobic activities produced intermittently throughout a session. These high-intensity levels may only be maintained for a short duration as fatigue develops quite rapidly. To better understand the fatigue during soccer, Greig and Siegler (2) simulated soccer game conditions via a treadmill protocol and utilized multiple isokinetic dynamometer trails to measure fatigue. They concluded that eccentric hamstring strength tends to decrease over the course of a soccer game, which leads to the discussion of concentric versus eccentric training in soccer athletes. Eccentric muscle contractions are thought to allow for greater force production over concentric muscle contractions, yet in sports like soccer the deficiency in eccentric contractions is more often than not the cause of thigh injuries (1).

The ratio of eccentric to concentric muscle contractions therefore appears to be a valid consideration when assessing performance of a soccer player. The purpose of this study will be considering not only this ratio between eccentric and concentric muscle contractions, but also power production, force production, ground contact time, and maximal height in order to determine the performance effects of lower extremity fatigue.

METHODS

Subjects and Procedures

The subjects included 9 male soccer players from Bethel University (age 20.1 ± 1). Each subject met the researchers in the Exercise Medicine and Prevention Center, where the subjects completed an informed consent and became accustomed to the Myotest (Switzerland) Countermovement Jump and Plyometric Jump tests via video display. The Myotest device is a 3-dimentional accelerometer that measures movement in all directions, which is a quality necessary for integrated movements such as countermovement jumps and plyometric jumps.

The Countermovement Jump (CMJ) test measures the height of a jump, while giving data for power output, force output, and velocity of the jump. The sequence of the test was explained by the researchers to the subjects. The CMJ test was selected on the Myotest device, and then placed on the Myotest belt that fit to the waist of the subjects. The subjects stood shoulder width apart with their hands on their hips. When the correct position had been obtained, testers started data collection on the Myotest device and the protocol was initiated. When a beep was heard, the subjects made a free lunge movement (bending their knees) and jumped as high as possible while keeping their hands on their waist. All subjects were encouraged to land softly as possible. After landing the subjects returned to the standing position and, while standing still, waited for the next beep before repeating the jump. After five repetitions, a double-beep signaled the end of the test. The goal of the test was to jump as high and with as much force generation as possible, both of which were explained to the subjects.

The Plyometric Jump (PJ) test measures the contractile properties of the leg muscles (flexibility, rigidness or stiffness), the reactivity, and the intramuscular coordination qualities of the lower limbs. The sequence of the test was explained by the researchers to the subjects. After starting the Myotest device, the “depth jump” test was selected. The Myotest device was placed on the belt that fit on the waist of the subjects. The subjects stood in the starting position with their hands on their hips with their feet shoulder width apart while looking straight ahead. When the correct position was obtained, data collection was initiated on the Myotest device. After a short beep, the subjects performed a takeoff jump, and then bounced back up five times as high as possible and with a ground contact time as short as possible. The subjects were instructed to maintain their hands on their waist and to jump off the soles of their feet with minimal bending of the knees during each jump. After 5 bounces, a double-beep signaled the end of the test. The goal of the test was to obtain maximum height and minimum ground contact time with each jump, both of which were explained to each subject prior to the jump.

All subjects were measured for height (cm), weight (kg), and blood pressure (mmHg). They completed three CMJ and PJ tests; one of each test was conducted during the pre-test session and immediately following (<2 min) the fatigue protocols. Variables examined were eccentric/concentric contraction ratios (E/C), power production, force production, contact time, and maximal height. The first fatigue protocol was the Wingate test that consisted of maximal effort cycling on a weight-based resistance cycle erogometer for 30 sec. The second fatigue protocol was the Bosco test, which consisted of maximal effort squat jumps for 1 min.

RESULTS

Statistical analysis was conducted using a paired *t*-test. No significance was found at the $P \leq 0.05$ level between the pre-test values and the post-test values for E/C (Wingate P=0.65; Bosco P=0.70), power (P=0.71; P=0.10), force (P=0.79; P=0.35), contact times (P=0.20; P=0.71), or maximal height (Wingate P=0.18). A significant decrease was found between the pre-test (35.28 cm ± 4.00) and the Bosco post-test (32.46 cm ± 3.32) values of maximal height (P=0.048).

DISCUSSION

The purpose of this study was to examine the effects of lower extremity anaerobic fatigue on neuromuscular function and jumping performance. The main finding was that fatigue was not induced to an adequate level by either the Wingate or Bosco fatigue protocols to alter neuromuscular function or jumping performance in college level soccer players. Of all the dependent variables evaluated, maximal height during the CMJ test after the Bosco fatigue protocol was the only significant value ($P \leq 0.05$).

Lower extremity anaerobic fatigue has been found to decrease a variety of muscular functioning (3). The fatigue protocols used in this study aimed to simulate the levels of fatigue experienced during a soccer game. The large number of lower extremity injuries seen in soccer matches seems to indicate that there is a high level of fatigue in soccer players during games. Even though the Wingate and the Bosco protocols have been verified as an appropriate means to induce anaerobic fatigue (5), it is likely that these protocols did not meet the high levels of fatigue average soccer players experience. The reason for this may be due to the intermittent nature of soccer. Whereas this research looked at a single taxing of the lower extremities, the anaerobic fatigue displayed during a soccer game occurs in intermittent bursts over the course of up to 2 hrs. Consequently, a more appropriate model of inducing lower extremity anaerobic fatigue in soccer players to the level which is seen in actual soccer games would be to conduct the fatigue protocols repeatedly over a defined period of time and at specified time intervals, then to measure performance.

CONCLUSIONS

The Wingate and Bosco fatigue protocols failed to stress the neuromuscular system. It is probable that the protocols inefficiently induced fatigue since the results did not support current research (3). It is important to point out that different positions require different levels of anaerobic training for optimal efficiency. If this research were to be repeated, the validity of the results would likely be improved by including soccer players only of a specified position (e.g., forward). Though little correlation was found between lower extremity fatigue and jumping performance, further research should be conducted to explore how different levels of fatigue in athletes exposed to anaerobic fatigue contribute to their neuromuscular function and jumping performance.

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