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The Effect of Single-Leg Squat and Agility Tests on Delayed Onset Muscle Soreness (DOMS)

Mohamed M Abd-Alzaher, Ayman F Mekawi ***

**Health Courses, Department, Faculty of Physical Education, Helwan University, Egypt*
*** Health Courses, Department, Faculty of Physical Education, Helwan University, Egypt*

Abstract
Abstract: Muscle soreness and damage often occur after selective exercise routines, the severity of damage and soreness vary as a function exercise protocol. Purpose: This study was designed to examine the effect of single-leg squat and agility tests on Delayed Onset Muscle Soreness (DOMS). Sixteen male subject group from different sports participated in this study, with the mean (age 18.06+ 1.53 years, body mass 68.69 + 8.63 kg, body height 172.69 + 7.03 cm and training age was 6.38 + 3.03 years). Resting blood samples were drawn from the heated hand vein catheter immediately before using exercise protocol test and after recovery periods of 24 and 48 h for the measurement of Creatine kinase (CK) activity in serum .The participants in this study began the experimental protocol test by using single-leg squat. 30 minutes later the same subjects were exposed to agility test in the same training unit until each one of them reached voluntary exhaustion. The results showed that significant CK elevation 24 h after Appling the exercise protocol test compared to CK level before it was conducted, However the results also revealed that the change percentage between (Pre &post 24h was 81.4%) for measurement after 24 h recovery, and Significant decrease of CK after a period of 48 h recovery as compared to the level of CK 24 hours after it was conducted. Furthermore, the change percentage between (Post24&post 48 h was 47.79%) It was concluded that a significantly faster recovery of CK during 48 h recovery may depend on two factors: (1) training state of study subjects (2) Reduced muscle soreness after 48 h of recovery period as a result of the decreased damage response to such particular exercise protocol tests.

Keywords: *Single-Leg Squat test, Agility Test, Delayed Onset Muscle Soreness (DOMS), Recovery.*

Introduction

Athletic performance and preparation are typically impaired when an athlete is sore or injured. Thus, any practice that limits the extent of damage or hastens recovery would be of interest and practical value to the coach, trainer, or therapist. For the practitioner, the most obvious would be familiarity with the exercise and the intensity at which it is performed. Muscle soreness and damage often occur after selective exercise routines. The soreness typically peaks 24-48 hours after the exercise and subsides within 96 hours. The severity of damage and soreness vary as a function exercise protocol. (1)

All studies employed some form of eccentric exercise that standardized the injury protocol. However, the modes of eccentric exercise differed among studies and included isokinetic dynamometry (2,3,4), cycle ergometry(5), drop jumping (6) high-force eccentric exercise (7,8,9,10,11,12), box stepping (13), and downhill running. (14, 15)

In general, more damage occurs with higher intensity and unfamiliar actions. Additional factors such as muscle stiffness, contraction velocity, fatigue, and angle of contraction have also been shown to play a role. However, these factors are more difficult to control in the field environment. Regardless, a basic understanding of the proposed mechanisms of injury and treatment for delayed onset muscle soreness (DOMS) (1) will help the coach or practitioner try to use in some times the single-leg squat or agility tests in program designs, for diagnostic of athletic performance.

The single-leg squat is one of the tests that is used by clinicians and has been suggested to assess general leg strength and muscle endurance (16). However, agility is a common term used in strength and conditioning and is often considered an essential element of many sports and activities (17). Therefore, the objective of this study was to determine the effect of use combinations of single-leg squat and agility tests in the same training unit on induced Delayed Onset Muscle Soreness (DOMS), and evaluate fast recovery of CK after using experimental protocol test during 24 and 48 hours recovery in a group of athletes.

Subjects: Sixteen male subject group from different sports participated in this study, with the mean (age 18.06+ 1.53 years, body mass 68.69 + 8.63 kg, body height 172.69 + 7.03 cm and training age was 6.38 + 3.03 years).Their descriptive characteristics are shown in table (1).

Table 1

Physical characteristics Mean + Std. and skewness for study subjects.

variables	Mean + std.	skewness
Age (years)	18.06+ 1.53	0.267
Height (cm)	172.69 + 7.03	1.455
Body mass (kg)	68.69 + 8.63	-0.474
Specific training age (years)	6.38 + 3.03	-0.197
Single Leg Squat Time of exhaustion (Sec)	87.88 + 15.65	0.802
Agility Time of exhaustion (Sec)	110.12 + 23.85	- 0.480

Experimental protocol

The objectives of the study, possible risks, and discomforts were explained to the subjects before obtaining written consent. The study protocol was approved by the local ethical committee, and was performed in accordance with the declaration of Helsinki. The test was conducted in Human Physical Performance Laboratory at Helwan University (Egypt), Faculty of physical Education, and each subject abstained from training or strenuous exercise for at least 36 hours prior to the beginning of the experimental protocol test. On their arrival at the laboratory, a resting blood sample was drawn from the heated hand vein catheter immediately before using a combination of single-leg squat and agility Tests and after recovery period 24, 48 hours to measure (CK) activity in serum, as an indicator for muscle damage . The participants of the study began the experimental protocol test by using of single-leg squat. 30 minutes later, the same subjects were exposed to agility test in the same training unit until each one reached such voluntary exhaustion.

Assessment of perceived muscular soreness

Participants reported perceived muscle soreness using a visual analog scale (VAS). The VAS is numbered from 1 to 10 (on the reverse side of a sliding scale unseen by the participant) with 0 indicating no muscle soreness and 10 indicating that the muscle are too sore to move. This method has been used successfully in previous studies (Marginson et al. 2005; Twist & Eston 2005, Jamie et at.2009) (18, 19, 20) to indicate muscle soreness.

Single-leg squat (SLS) Test

The Single-leg squat test was one of such tests used by the investigators that who been suggested assessing general leg strength and muscle endurance (16, 21). However, the (SLS) test had a good potential as a functional test because many daily and athletic activities involved components of this movement (22).

Agility test

The Illinois agility test is a timed task involving some straight sprinting and multiple direction changes around obstacles (23). In this study, the researchers modified the use of Illinois agility test through repeating working within Illinois agility test until each subject reached such voluntary exhaustion, the movement time was defined as the total time taken to complete both tests, starting from the moment that each subject initiated the test until reached voluntary exhaustion in each test.

Procedure of Illinois Agility Test	Procedure of Single-leg Squat Test
* The Test is set up with four cones forming the agility area (10 meters wide). Cone at point A, marking the start. *Cone at B&C to mark the turning spots. *Cone at point D to mark the finish. * Place the four cones in the center of the testing area, 3.3 meters apart. *Start lining face down with the hands at shoulder level. *On the "go" command, the subject begins the test. The test time is calculated when the subject hear start signal until he reaches voluntary exhaustion. * Get up and run the course in the set path (left to right or right to left). *On the turn spots B, and C, be sure to touch the cones with your hand. * The subject repeats this experiment until he reaches voluntary exhaustion.	*Stand in a comfortable position with feet shoulder width apart and back against a smooth wall. * Slide down the wall to assume the position shown in the diagram, with a 90° angle at the hip and knee joints. * When you are ready, lift one foot 5 cm off the ground and begin timing. *Hold this position for as long as possible. The watch is stopped when the position is no longer held and the subject reached voluntary exhaustion.

Statistical Analysis

Statistical Analysis- Descriptive statistics include both means and Std. Data before and after the experimental protocol for measurements of CK were analyzed by one-way ANOVA and using the least significant difference (LSD) test. The level of significance was set at $P< 0.05$.

Results

In the current study, the concentration mean of CK increases from 159.75 U/L up to 289.75 U/L directly after 24 hours recovery .The Change percentage between (Pre &post 24 h recovery was 81.4%). However, the concentration mean of CK still increases during 48 hours recovery up to 196.06 U/L. Whereas the Change percentage between (Pre &post 48 h recovery was 22.73%). On the other hand, the results in table (2) and (3) showed the decrease concentration mean of CK from 289.75 U/L directly after 24 h recovery to 196.06 U/L after 48 h recovery. Furthermore, the Change percentage between (Post 24 & post 48 h recovery was 47.79%) which is in favor of the measurement of CK post 48 h recovery.

Table 2

showed measurements of CK before and after using the Single Leg Squat and Agility tests through 24 and 48 hours of recovery periods for the subjects of the Study.

variable	measure	Mean	Post 24 h	Post 48 h
CK	pre	159.75	-130.0*	-36.31
	Post 24 h	289.75		93.69*
	Post 48 h	196.06		

The level of significance was set at $P < 0.05$; n =16

Table 3

showed Change percentage of CK before and after using the Single Leg Squat and Agility tests through 24 and 48 hours of recovery periods for study subjects, by using.

Measure	Pre &post 24	Pre &post 48	Post24&post 48
Change presently	81.4%	22.73%	47.79%

% = percentage of change; n =16

Discussion

On the basis of these findings, it was expected that a significantly faster recovery of CK during 48 hours depends on two factors: First, the specific training state of the study subjects was (6.38 + 3.03 years) as shown in Table (1). Second, the effect of the exercise protocol tests on reduced muscle damage and significantly decreased in level of CK after 48 h recovery as compared with the measurement of CK after 24 h of recovery period, as shown in table (2). The current result was in agreement with what was reported by previous findings of Warren, et al (1993); Brooks, & Faulkner(1995); Child, & Donnelly (1998); Hunter, & Faulkner (1997) ; Lieber, & Fridén (1993); (24,25,26,27,28).Furthermore, the degree of injury or damage was often a function of the trained state of the muscle (24), and dependent on both the specific conditions of the exercise bout and the intrinsic factors related to the individual. (25,26,27,28). A study of Newton et al, (2008) reported that muscle damage was less for trained individuals compared with untrained individuals (29). It seems likely that "training" would prevent or reduce muscle damage even if the intensity of the eccentric exercise performed to elicit muscle damage is higher than that used during "training". However, this has not been systematically investigated (30). Friden et al reported that muscle soreness, strength reduction, and myofibrillar damage following eccentric bicycling were reduced in repeated eccentric bicycle training (30). Nosaka, (2009) reported that not only eccentric contraction but also isometric contractions at a long muscle length produce protective effect against muscle damage induced by eccentric contractions (31). It is well documented that repeated bouts of same eccentric exercise induces less muscle damage significantly than an initial bout (32,33,34,35,36), even when the number of eccentric actions in the subsequent bout is larger (37,38) there is some evidence indicating that fast-twitch fibers are more susceptible to eccentric contraction –induced damage (39,40,41,42). This may be due to an inherent weakness in these fibers (42). or selective recruitment of fast-twitch motor units for eccentric exercise (43,44,45,46,47). The repeated bout effect may be attributed more to mechanical adaptations (e.g. increases in passive or dynamic muscle stiffness, remodelling of intermediate filament system, increased intramuscular connective tissue) and/or cellular adaptations (e.g. longitudinal addition of sarcomeres, adaptation in inflammatory response, adaptation to maintain excitation-contraction coupling, strengthened plasma membrane, increased protein synthesis, increased stress proteins, removal of stress-susceptible fibers) (48). It seems that the repeated stimuli for a certain period of time (i.e. training) are necessary to induce muscle adaptations, but it is interesting that a single bout of exercise can also provide such strong and long-lasting effects (49).

Recent study by Boyle et al. (2004) reported that women with a history of yoga training (average of 53 months experience) demonstrated less peak muscle soreness at 24 and 48 hours after eccentric exercise compared to a control group similar in age, body mass index, and physical activity level. Although this was the first published study to explore chronic yoga training, it appears that this "preconditioning" of the muscle might help prevent soreness from a later stressful exercise bout (50). It is likely that large number of high intensity and fast velocity lengthening contractions at long muscle lengths in the agility test until each subject's voluntary exhaustion, in addition to the effect of static concentration in single leg squat test. Result of muscle damage and significantly elevation of CK after The exercise protocol tests, during 24 and 48 h of recovery periods. In general, the magnitude of muscle damage may be attenuated by eliminating a factor or factors exacerbating muscle damage, that is reducing may be through decreasing the number of contractions, intensity, velocity, and muscle length during eccentric exercise, especially through repeating the application of agility test and not having each subject reach voluntary exhaustion in the same test (31).

It was concluded that Exposing study subjects to single-leg squat and agility tests in the same training, with a recovery period of 30 minutes for each subject between the test until they reach voluntary exhaustion, resulted in significant elevation of CK after 24 and 48 hours recovery as compared with level of CK before exercise, and fast recovery for CK after 48 h recovery as compared with level of CK after using exercise protocol test by 24 h recovery. The results should be considered a starting point for further researchs in this area, especially when we aimed at evaluating the ability of athletes on performing other types of exercise protocol tests within some training periods and the effects of such procedures on The induced muscle damage or delayed onset muscle soreness (DOMS) as well as the recovery of creatine kinase (CK).

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