Şengül AKDENİZ[1]

Ümid KARLI[1]

Tuğba DAŞDEMİR[1]

Hakan YARAR[1]

Bayram YILMAZ[1]

IMPACT OF EXERCISE INDUCED MUSCLE DAMAGE ON SPRINT AND AGILITY PERFORMANCE

ABSTRACT

Purpose: The purpose of this study was to investigate the impact of exercise induced muscle damage on sprint and agility performance.

Methods: Eleven healthy male soccer players [($\overline{X}$±SD) age: 21.63 ± 1.91 years; stature: 176.63 ± 5.31cm; body mass: 70.36 ± 3.72kg] who did not perform any high intensity physical training during last 3 months volunteered to participate in this study. Agility and sprint running times were measured, following determination of athletes muscle soreness level using visual analog scale (VAS), before (baseline) and at 1st, 24th, 48th, 72nd and 96th hours after muscle damaging exercise protocol. Five sets of 20 repetitions drop jumps were performed as a muscle damage exercise protocol. Repeated measure ANOVA was used for statistical analysis.

Results: Repeated measures ANOVA showed significant changes in muscle soreness [$F_{(5-50)}$= 196.65, p<0.01], agility [$F_{(5-50)}$= 32.034, p<0.01] and sprint running times [$F_{(5-50)}$= 9.28, p<0.01] relevant with time intervals. Muscle soreness and agility test times were significantly (p<0.05) higher than baseline values at all time intervals (1st, 24th, 48th, 72nd and 96th hours). Sprint running time was significantly (p<0.05) increased at 1st, 24th, and 48th hours compared to baseline values.

Conclusion: Consequently, results of the study revealed that exercise induced muscle damage affect agility and sprint performance negatively. The respondents should be careful in including unfamiliar exercises and exercises including intense eccentric contractions during the process of training planning for sports branches, where agility and sprint are important features.

Key Words: Muscle Soreness, Eccentric Exercise, Illinois Agility Test, VAS

EGZERSİZE BAĞLI KAS HASARININ SÜRAT VE ÇEVİKLİK PERFORMANSINA ETKİSİ

ÖZET

Amaç: Bu çalışmanın amacı egzersize bağlı kas hasarının sürat ve çeviklik performansına etkisini incelemektir.

Yöntem: Çalışmaya son 3 ayda yüksek şiddette fiziksel zorlanmaya dayalı antrenman yapmamış 11 sağlıklı erkek futbolcu [($\overline{X} \pm SS$) yaş: 21.63 ± 1.91 yıl; boy uzunluğu: 176.63 ± 5.31cm; vücut ağırlığı: 70.36 ± 3.72kg] gönüllü olarak katılmıştır. Kas hasarı egzersiz protokolü öncesi (bazal) ve egzersiz sonrası 1, 24, 48, 72 ve 96'ncı saatlerde, sporcuların vizual analog skala (VAS) ile ağrı düzeyleri belirlendikten sonra çeviklik ve sürat koşusu zamanları ölçülmüştür. Kas hasarı egzersiz protokolü olarak 5 set 20 tekrarlı derinlik sıçraması uygulanmıştır. Verilerin çözümlenmesinde tekrarlı ölçümlerde tek yönlü varyans analiz testi kullanılmıştır.

Bulgular: Tekrarlı ölçümlerde tek yönlü varyans analizi kas ağrısı [$F_{(5-50)}$= 196.65, p<0.01], çeviklik [$F_{(5-50)}$= 32.034, p<0.01] ve sürat koşusu sürelerinde [$F_{(5-50)}$= 9.28, p<0.01] zamana bağlı olarak anlamlı fark olduğunu göstermiştir. Kas ağrısı ve çeviklik süresi bütün zaman aralıklarında (1, 24, 48, 72 ve 96'ncı saat) bazal değerlere göre anlamlı (p<0.05) bir şekilde yüksek bulunmuştur. Sürat koşusu süresi ise bazal değerlere göre 1, 24 ve 48'inci saatlerde anlamlı (p<0.05) bir biçimde artmıştır.

Sonuç: Bu çalışmada egzersize bağlı olarak oluşan kas hasarının çeviklik ve sürat performansını olumsuz bir biçimde etkilediği ortaya konmuştur. Sürat ve çevikliğin önemli olduğu spor dallarında antrenman planlanması sürecinde ekzentrik kasılmaların yoğun olduğu ve alışık olunmayan egzersizlerin kullanılması konusunda dikkatli olunmalıdır.

Anahtar Kelimeler: Kas Ağrısı, Egzentrik Egzersiz, İllinois Çeviklik Testi, VAS

[1] Abant Izzet Baysal University, School of Physical Education and Sport, Bolu, TURKİYE

INTRODUCTION

Exercise induced muscle damage which can be also expressed as micro-trauma, micro-injury or muscle damage, is defined as temporary cellular damage occurring in the skeletal muscle after exercise (Simith & Miles, 2000). The formation of exercise induced muscle damage is a common situation following high intensity exercises including eccentric contractions such as plyometrics or unaccustomed exercises (Hazar, 2004; Twist & Eston, 2007; Highton et al., 2009). In recent studies, increase of muscle proteins in blood (Howatson & Milak, 2009), long-lasting muscle soreness (Howell et al., 1993), inflammation (Cleak & Eston, 1992) and impairment of muscle function (Rawson et al., 2001) have been reported along with the formation of muscle damage.

In recent years, the effects of exercise induced muscle damage on athletic performance have become a subject of curiosity among researchers. In these studies, impact of muscle damage on various athletic performance components were examined following eccentric exercises or plyometrics including intense eccentric contractions. In the initial studies the impacts of exercise induced muscle damage on physical performance were assessed with isometric strength measurements. Negative effects of muscle damage on isometric strength were confirmed in various studies (Byrne & Eston, 2002; Sayers & Clarkson, 2001; Cleak & Eston, 1992). However, isometric strength measurements were widely used in most experimental studies to assess strength performance; it is thought that isometric contractions do not reflect the athletic performance including dynamic contractions. Because of researchers who aim to keep athletic performance forefront, preferred dynamic based tests to assess the effects of muscle damage on performance.

Studies done in this context indicated significant decrease in isokinetic strength following eccentric exercise protocols and this decline has reached to the highest level at 24th and 48th hours (Twist & Eston, 2007; Burt & Twist, 2011; Highton et al., 2009). In addition to this, studies examining endurance reported significant reduction in running distance after eccentric exercise, especially at 48th hour (Burt & Twist, 2011; Twist & Eston, 2009; Marcora & Bosio, 2007). Twist et al. (2008) investigated significant deterioration in the balance of dominant leg following muscle damage exercise protocol. Furthermore, significant degradation was reported in vertical jump performance (Marginson et al., 2005; Byrne & Eston, 2002) and in peak power output values recorded with cycle ergometer (Twist & Eston, 2005; Nottle & Nosaka, 2007; Byrne & Eston, 2002) following eccentric exercise protocols in various studies.

There is limited data on the effects of exercise induced muscle damage on sprint and agility performance. According to our observations, there were three recent studies which examined the influence of exercise induced muscle damage on sprint performance (Twist & Eston, 2005; Highton et al., 2009; Semark et al., 1999). Twist & Eston (2005) and Highton et al. (2009) who examined effects of exercise induced muscle damage on sprint performance established significantly high sprint running times at 30th minute, 24th and 48th hours after similar exercise protocols and recorded comeback to baseline values at 72nd hours. Nevertheless, in contrast to these studies Semark et al. (1999) did not find any impact of eccentric exercise protocol on sprint performance on trained athletes. Currently only one study examined the effects of muscle damage on agility. Highton et al. (2009) determined significantly higher agility performance times at 24^{th} and 48^{th} hours following exercise protocol and reported comeback to baseline values barely at 168^{th} hours.

Indeed, there are very few studies investigating effects of exercise induced muscle damage on sprint and agility performance. Furthermore, the results of the studies examining the effects of muscle damaging exercises on sprint performance appear to be equivocal. Therefore the aim of this study was to investigate the impact of exercise induced muscle damage on sprint and agility performance.

METHODS

Participants

Eleven healthy male soccer players [($\bar{x}$ ±SD) age: 21.63 ± 1.91 years; stature: 176.63 ± 5.31cm; body mass: 70.36 ± 3.72kg; body mass index (BMI): 23.52 ± 3.59kg*m^2] who has 6 - 11 years training background and did not perform any high intensity physical training during last 3 months volunteered to participate in this study. Measurements were taken at the off season of the athletes when they were not training. At the beginning of the study before the applications detailed information was given to the athletes about the purpose, methods, contributions and possible risks.

Experimental Design

One week before the beginning of the experiment, the athletes were familiarized with the test battery to avoid the learning effect during the testing period of the study. Each athlete had repeated the tests (Illinois agility test and 30m sprint running) at least three times during separated days, before the baseline values were taken. At the first day of the study, anthropometric measurements were taken and then each athlete's baseline muscle soreness level was determined with visual analog scale (VAS). Later, Illinois agility test and 30m sprint running test were completed for pre-test. Afterwards, participants completed muscle damaging exercise protocol and VAS, Illinois agility tests and 30m sprint running tests were repeated at 1^{st}, 24^{th}, 48^{th}, 72^{nd} and 96^{th} hours following exercise. All measurements were taken in Abant Izzet Baysal University's synthetic floor sport hall at 22-24^{o}C temperature, between 15:00-18:00 hours. Athletes were asked to not to do any physical activity during last 24 hours before the test and were asked to come to tests with full rest. Also, they were asked to eat at least 3 hours before tests and were allowed to drink only water between test and last meal. Experimental design of the study was shown in table 1.

Table 1: Experimental Design of the Study

Pre-Test Baseline	Exercise Protocol	Post-Exercise				
		1^{st} hour	24^{th} hour	48^{th} hour	72^{nd} hour	96^{th} hour
VAS	5sets x 20 Repetitions Drop Jump	VAS	VAS	VAS	VAS	VAS
Illinois Agility Test		Illinois Agility Test	Illinois Agility Test	Illinois Agility Test	Illinois Agility Test	Illinois Agility Test
Sprint Test		Sprint Test	Sprint Test	Sprint Test	Sprint Test	Sprint Test

Anthropometric Measurements

Stature was measured to the nearest 0.1cm via a Stadiometer and body weight (BW) was measured to the nearest 0.1kg via a scale (Seca 700, Germany). Participants were asked to remove all clothing, shoes, jewelers and other accessories except a light shorts for the measurement. Body Mass Index (BMI) was calculated by body weight (kg) / height² (m²) formula.

Assessment of Perceived Muscle Soreness

Visual analog scale (VAS) graded from 0 to10 was used to determine perceived muscle soreness (Figure 1). With arms akimbo and squatting to an approximate knee angle of 90 degree, participants were asked to indicate the level of perceived soreness between numbers 0 (no muscle soreness) to 10 (too sore to move) based on the rating scale. This technique has been used successfully in previous studies (Twist & Eston 2007; Jakeman et al. 2010).

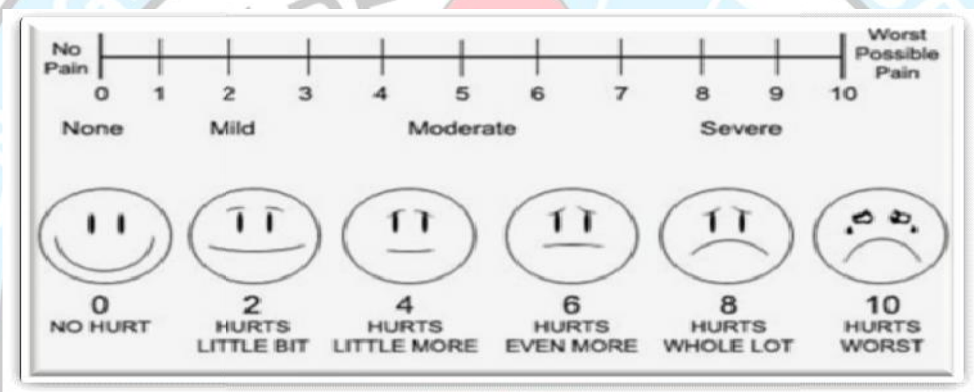

Figure 1: Visual Analog Scale (VAS)

Illinois Agility Test

The length of the course is 10m and the width is 5m. Four cones were placed in the center of test course with an equal distance (3.3m) apart. Test was composed of 40m straight run with 180º turns at each 10m and 20m slalom running between cones (Jarvis et al., 2009; Wilkinson et al., 2009; Hazır et al., 2010). The procedure of the agility test was shown in figure 2. Two electronic (±0.01sc sensitively) photo cells (Newtest 1000, Oulu, Finland) were set to start and finish of test course. Athletes were asked to complete the course in the shortest time and test time was recorded automatically. The test was repeated 2 times at 5 minute intervals and the best degree was used in statistical analysis. The applications were made on a synthetic floor.

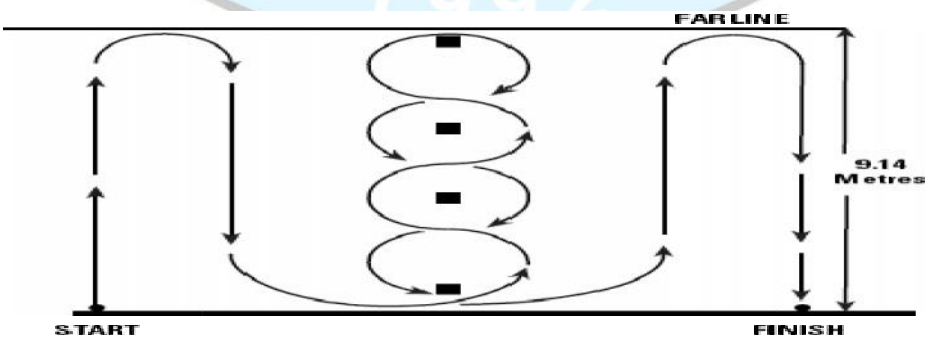

Figure 2: Illinois Agility Test Procedure

30m Sprint Running Test

Participants performed 2 times 30m sprint running at 5 minute intervals and the time elapsed between start and finish were recorded by photo cell timer to the nearest 0.01sec. After two trials the best running time was used in statistical analysis (Temoçin et al. 2004; Özkan et al. 2004).

Muscle Damaging Exercise Protocol

Exercise protocol is consisted of 5 sets of 20 repetitions totally 100 drop jumps from a height of 60cm. Rests between sets were 2 minute and jumps were performed at 10sc intervals. Athletes were asked to drop from a 60cm box with hands on hips and upon landing jumped up maximally from 90º knee flexion. This protocol has been used successfully to cause muscle damage in previous studies (Goodall & Howatson, 2008; Kirby et al., 2012).

Statistical Analysis

First, mean and standard deviations were calculated for all variables. Repeated measures ANOVA were used for the determination of the difference between consecutive measurements taken before and after muscle damaging exercise protocol. Contrast was defined as post hoc test to investigate the changes occurred during time intervals between baseline measurement and post-exercise measurements. The significance level was accepted as p≤0.05 and all analyzes were performed on SPSS version 16.0.

RESULTS

Muscle Soreness

The results of repeated measures ANOVA on the muscle soreness levels showed significant main effect for time [$F_{(5-50)}$= 196.65, p<0.01]. Compared to baseline mean values ($\overline{X}$ =0.27 ±0.47) the soreness levels determined after muscle damaging exercise protocol were significantly higher (p<0.05) (Table 2). Muscle soreness level was started to increase after exercise and peaked at 48th hour. Soreness level started to decrease at 96th hour which is the last measurement of the experimental design of the study, but still it did not return to baseline values completely. These changes were shown graphically in figure 3.

Table 2: Muscle soreness, sprint running and agility test times ϕ at pre and post muscle damaging exercise protocol

Variables	Baseline	1st hour	24th hour	48th hour	72nd hour	96th hour
Muscle Soreness Level	0.27 ±0.47	3.82 ±0.75*	6.27 ±0.79*	8.64 ±0.50*	6.82 ±0.98*	2.91 ±0.83*
Sprint Running Time(s)	5.46 ±0.53	6.01 ±0.45*	6.34 ±0.44*	6.00±0.46*	5.66±0.74	5.42±0.56
Illinois Agility Test Time (s)	16.78±1.56	18.50±1.83*	19.68±1.63*	19.13±1.18*	17.74±1.42*	17.34±1.70*

ϕ variables were presented as mean and standard deviation; * significantly different than baseline.

Sprint Performance

According to repeated measures ANOVA, there is significant main effect for time [$F_{(5-50)}$= 9.28, p<0.01] regarding to sprint running times. In accordance with baseline values mean ($\overline{X}$ =5.46 ±0.52) sprint running time was elevated significantly at 1st, ($\overline{X}$ =6.01 ±0.45), 24th ($\overline{X}$ =6.34 ±0.44) and 48th ($\overline{X}$ =6.00±0.46) hours after the exercise protocol (Table 2). As shown in Figure 4, sprint running times began to increase after muscle damaging exercise and the dramatic increase was observed at 24th hour. Slightly decrease was seen at 48th hour and complete return to baseline was seen at 72nd hour.

Agility Performance

Results of repeated measures ANOVA on the agility test performance times showed statistically significant main effect for time [$F_{(5\text{-}50)}$= 32.034, $p<0.01$]. Compared to baseline values ($\overline{X}$ =16.78±1.56) post-exercise agility test times were significant ($p<0.05$) high (Table 2). Agility test times started to increase following muscle damaging exercise and peaked at 24th hour. Decrease of the agility time started along with 48th hour but even at the end of the 96th hour still it did not return to baseline values. This situation was shown graphically in figure 5.

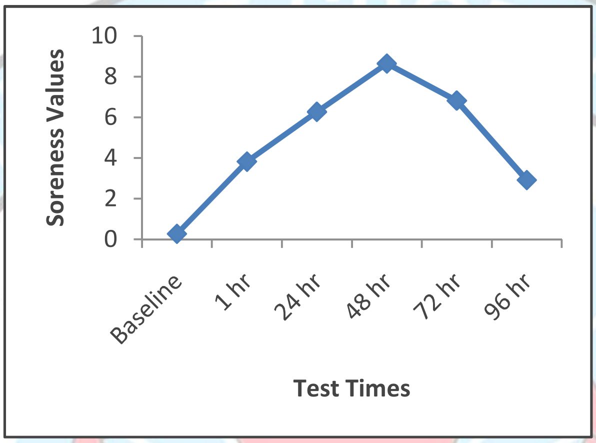

Figure 3: Perceived Muscle Soreness

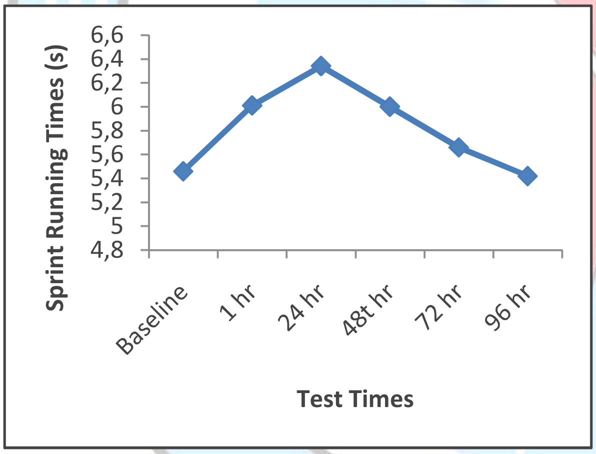

Figure 4: Sprint Running Test Times

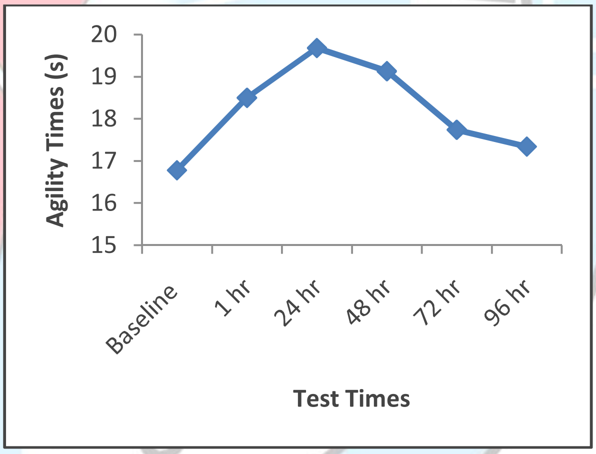

Figure 5: Illinois Agility Test Times

DISCUSSION

In this study, the effect of exercise induced muscle damage on sprint and agility performance was investigated to contribute the process of forming exercise prescription and planning the training and competition periods of athletes by taking into account the exercises which can generate muscle damage. In the present study, it was found that exercises causing muscle damage will cause reduction in sprint and agility performance in parallel of the increase of the muscle soreness. In this section, the effect of muscle damage on sprint and agility performance will be discussed and interpreted.

Exercise induced muscle damage can be determined by various methods directly or indirectly. Muscle damage could be determined directly by muscle biopsy or magnetic resonance imaging; and indirectly by reduction of muscle power, increase of edema and soreness, changes of serum levels of muscle enzymes and increase of some inflammation indicators (Harbili et al., 2008). In this study, exercise induced muscle damage was assessed indirectly by perceived muscle soreness level (Twist & Eston 2007; Jakeman et al. 2010). The results showed athletes' perceived muscle soreness levels were significantly high following (at 1st, 24th, 48th, 72nd and 96th hours) the muscle damaging exercise protocol compared to baseline values. Increase in the perceived muscle soreness, following exercises including depth jumps, was the indicator of the effectiveness of the muscle damaging exercise protocol. As it is presented in figure 3, following the exercise protocol muscle soreness level of participants showed gradual increase and peaked at 48th hour. Then, in the following time periods, it started to decrease, however, at the last measurement (96th hour) significant difference was still present and the soreness levels did not return completely to the baseline. Highton et al. (2009), Twist & Eston (2007), Marcora & Bosio (2007) and Semark et al. (1999) reported muscle soreness increase after similar (movement jump, plyometrics, drop jump) exercises protocols.

Findings of the present study also showed that 30m sprint running times following exercise protocol (in 1st, 24th and 48th hours) were higher than the baseline values. Following the exercise protocol %16 and %10 increases was determined in sprint running times respectively at 24th and 48th hours compared to baseline. Significant difference was disappeared at 72nd and 96th hour (Figure 4). Twist and Eston (2005) reported significant increase in 10m sprint times at 30th minute, 24th and 48th hours, following muscle damaging exercise protocol (10 sets of 10 vertical jumps). In another study, Highton et al. (2009) notified significant rise in 5th and 10th meter times of 10m sprint running respectively at 24th and 48th hours. The findings of the studies (Twist & Eston, 2005; Highton et al., 2009) mentioned above are consistent with the results of present study.

In contrast to these studies, the results of the study of Semark et al. (1999), did not overlap with the findings of the present study, regarding to sprint performance recorded after similar exercise protocol. In that study, highly trained athletes performed 7 sets of 10 drop jumps as muscle damaging exercise protocol and then completed 30m sprint running test. The running times at 5th, 10th, 20th and 30th meters were recorded before and after the exercise protocol. Athletes sprint times, delayed onset muscle soreness and creatine kinase (CK) levels were recorded at 12th, 24th, 48th and 72nd hours. Although muscle soreness levels were increased at 24th and 48th hours following exercise, sprint times did not differ compared to baseline values. Similarly, they did not observe any elevation on serum CK levels. In this study, the explanation why sprint performance did not impair may be that the muscle pain was not caused by damage to the contractile fibers, but by injury-induced shortening or disruption of the non-contractile tissue in the skeletal muscle (Jones et al., 1987). Furthermore, various researchers conclude that if high intensity unaccustomed exercises had not performed before; then it can generate muscle damage (Hazar, 2004; Twist & Eston, 2007; Highton et al., 2009). Therefore, the explanation for why Semark et al. (1999) did not report any impairment of sprint performance could be the characteristics of the participants of the study who were highly trained athletes. Also, athletes may be accustomed to the exercise protocol, so the muscle damage did not occur.

Agility is defined as the capability of quick change of direction and at the same time maintenance of balance without losing speed (Lemmink et al., 2004). From this definition it is easy to understand that agility consist of quick movement direction changes and also sprint and balance features. Illinois agility test, including quick movement direction changes was used in the present study as data collection instrument. Baseline agility times were significantly different than post-exercise agility times (at 1st, 24th, 48th, 72nd and 96th hours). Compared to baseline values, agility times were increased approximately %17 and %14 respectively at 24th and 48th hours after exercise protocol. Following the exercise protocol agility times of participants showed an increase and peaked at 24th hour, which is the worst agility time. In the following time periods it started to decrease, however, even at 96th hour agility times had not comeback to baseline values (Figure 5).

Currently, there is only one study which examined the effects of exercise induced muscle damage on agility performance. In that study, Highton et al., (2009) asked athletes to perform 10 sets of 10 vertical jumps as muscle damaging exercise and then reported the effects of muscle damage on agility performance by using 505 Agility test as data collection instrument. It was reported that agility test time were increased approximately %5 and %8 at 24th and 48th hours respectively, compared to baseline values. In general these findings are similar to the results of the present study. While in that study agility times returned to baseline values at 72nd hour, in present study it did not return barely to baseline even at 96th hour. Possible explanation for this reason could be the different content of the muscle damaging exercise protocols they used. Because different than the study of Highton et al., (2009), drop jumps, which were harder than performing vertical jumps, were used in the exercise protocol of the present study. While, performing drop jumps are harder than performing vertical jumps.

In the present study, as the relation of two performance variables (sprint and agility) were examined together, it was observed that sprint running times had returned to baseline at 72nd hour but agility times had not return to baseline even at 96th hour. Possible explanation for this reason could be the characteristics of the tests. For instance, sprint test is performed in a straight linear direction, so that the performance may be maintainable even in the presence of muscle soreness. On the other hand perceiving muscle soreness may have dramatic disturbance impact during agility test performance including quick direction change movements and therefore, there is still an absence of comeback to baseline values even at 96th hour. Additionally, perceived muscle soreness did not return to baseline at 96th hour completely, same as agility performance. So, it could be concluded that agility performance is more sensitive to muscle soreness. Similar changes were shown within the time in the graphics of muscle soreness and agility test (Figure 3 and Figure 5).

CONCLUSION

In conclusion, muscle damage exercise protocol applied in the present study led to increase in muscle soreness level and reduction in speed and agility performance.

The respondents should be careful in including unfamiliar exercises and exercises including intense eccentric contractions during the process of training planning for sports branches, where agility and sprint are important features.

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