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Effect of Administering Tempeh Drink on Muscle Damage Recoveries after Resistance Exercise in Student Athletes

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Abstract: Resistance exercise associated with muscle tissue damage, needs recovery immediately. Protein is the major nutrient that plays roles in tissue damage recovery. Drink made from tempeh extract is rich in protein content that may be used for muscle damage recovery. The aim of this research was to evaluate the effect of administering tempeh extract on muscle damage recovery. A double blind control trial method was applied in this study. Eighteen semi-trained men (18-24 y) were randomly divided into three groups (n = 6 each) i.e: group 1 received tempeh-extract (contain~23 g protein), group 2 received whey drink (contain~23 g protein) and the third group which received placebo drink, after exercise. Subjects performed resistance exercise with load of 75% of maximum strength (1 RM) with squats which was divided into six set of fifteen repetition with a 2 minute rest interval between sets. Creatine kinase level (CK), muscle strength and muscle soreness as marker of muscle damage were recorded before exercise and at six, 24, 48, 72 and 96 h post exercise. Administering of tempeh-extract drink significantly decreased the CK level and increased maximal strength at 24 h compared to placebo group, however no significantly different in muscle soreness.

Key words: Recovery, tempeh drink, muscle damage, resistance exercise

INTRODUCTION

Resistance exercise is the common component of an exercise. During exercise, especially eccentric exercise, such as weight training, plyometrics and sprint, this usually cause muscle damage (Bean, 2009), including torned sarcolema in several muscle fibers, miofibrils and z sarcomere line (Tortora, 2009). Several indicators of muscle damage are raised creatine kinase (CK) level, muscle soreness and reduced muscle strength (White *et al*., 2008; Udani *et al*., 2009; Cooke *et al*., 2010; Howatson *et al*., 2012).

The muscle damage which happens after resistance exercise should be recovered soon since it can cause muscle soreness and inconvenience in the next several days. According to Nosaka (2007), this condition can harm further training. Besides, according to Bean (2009), muscle damage can delay glycogen storage so that it needs longer time, which is 7-10 days. This delay can cause decreased ability to do training in the next days.

In the recovery process of muscle damage, one of the important nutrients is protein. Several study used protein sources which come from whey, milk and BCAA with different results. The study conducted by Burnley (2010) showed that giving whey protein is not significantly influence muscle strength, CK level and muscle soreness in 24 and 48 h after the exercise. Other study conducted by White *et al*. (2008) showed that whey protein consumption do not affect recovery of muscle damage compared to placebo. On the other hand, Buckley *et al*. (2010) showed that whey protein consumption after resistance exercise increases recovery of muscle damage. Moreover, Cooke *et al*. (2010) mentioned that giving isolate whey protein after resistance exercise can improve muscle strength in day 3 and 7 after exercise compared to placebo, but no difference in CK level.

Giving protein in the study of White *et al*. (2008) can explain the poor strength improvement and recovery after the resistance exercise. Moreover, only single dosage was given to the respondent, while in Buckley *et al*. (2010) and Cooke *et al*. (2010), the supplement was given regularly after the exercise and during recovery period.

Jackman *et al*. (2010) gave branched chain amino acids (BCAA) supplement after resistance exercise and during recovery period. Therefore, it affected reduction in muscle soreness in 48 and 72 h after the exercise but no effect on CK level compared to placebo. This study result was different from study conducted by Howatson *et al*. (2012) where BCAA supplementation was given 7 days before the resistance exercise, just before and after the resistance exercise and during 4 days after the exercise which showed significant effect

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on education in CK level and muscle pain and increase in muscle strength compared to placebo in 24, 48, 72 and 96 h after the exercise. Meanwhile, study by Gilson *et al*. (2010) on football athlete showed that giving chocolate milk after exercise only affected CK level and not for other indicators of muscle damage, namely maximum strength and muscle soreness.

One of potential protein sources which are rarely used for athlete is tempeh, the popular traditional food in Indonesia. Tempeh is the derived product of soybean which undergoes fermentation process using *Rhizopus oligosporus*. As traditional food, nutrient and non-nutrient component, such as isoflavone, in tempeh is better than them in soybean. Moreover, tempeh is relatively easy to produce, affordable, widely available in the market and easy to process. Tempeh also contains high BCAA (valine, leusin, isoleusin) (Hermana *et al*.,1996). Amino acid of soybean is improved 3-10 times by becoming tempeh (Wang *et al*., 1996). Digestibility value of tempeh is higher than soybean and therefore, it increases nutritive quality protein of tempeh so that it becomes potential protein source to repair muscle damage after resistance exercise. Tempeh can be processed to various dishes, such as drink called tempeh drink. Tempeh drink can be one of the alternatives of sport drink with good protein quality due to BCAA content which is expected to be beneficial to the recovery of muscle damage after resistance exercise. This study aimed to analyze effect of giving tempeh drink on recovery of muscle damage after resistance exercise by measuring maximum strength, CK level and muscle pain as the indicators of muscle damage.

MATERIALS AND METHODS

Participants: The design of the study was double blinded randomized controlled trial. The subjects were 18 members of Badminton Student Club, Faculty of Sport Science, State University of Jakarta. The subjects had inclusion criteria, namely male, aged 18-24 years, had BMI of 18.5-25, conducted routine exercise, did not taking particular drugs, such as analgesic, aspirin and anti-inflammation, in minimum 7 days before the exercise, did not consume alcohol in 48 h before the exercise, did not have allergy to milk, did not have injury before the study and healthy without heart disease, diabetes or other chronic diseases. Every subject signed informed consent. This study was approved by Ethical Commission for Health Research, Faculty of Medicine, Diponegoro University and dr. Karyadi Government General Hospital No. 369/EC/FK/RSDK/ 2012.

Experimental drink: Total subject of 18 was randomly assigned to 3 groups of 6 people. The different treatment was given to 3 groups: the first group received tempeh drink; the second group received whey protein drink; and the third group received placebo drink. The drink was given with similar calorie (isocalorie) after resistance exercise. The tempeh drink per portion contained 437.99 kcal energy, 48 g carbohydrate, 17.1 g fat and 23 g protein, while whey drink contained 437.99 kcal energy, 23 g carbohydrate, 17.1 g fat and 23 g protein and placebo contained 437.99 kcal energy, 48 g carbohydrate, 27.33 g fat and 0 g protein. The drink was given to subject in the same bottle coated by aluminum foil with volume of 600 ml and chocolate flavor.

Experimental design: The subject was asked to do fasting for 12 h before the first measurement. They came at 7 am to Muscle Academy Gym (MAG), Somatokinetics Laboratorium, Faculty of Sport Science, State University of Jakarta. The data on muscle soreness, blood CK and maximum strength was collected. Muscle soreness was measured by using Visual Analog Scale (VAS) with scale of 0-10 (White *et al*., 2008). Before doing resistance exercise, the subject conducted warming up. After taking a rest for 5 min, the resistance exercise was conducted using squat. The subject was tested for maximum strength for 3 times. The squat was divided into 6 sets of 15 repetitions with interval for rest of 2 min/set. The subject conducted resistance exercise with weight of 75% of the maximum strength (1RM). After the resistance exercise, the subject conducted cooling down.

Soon after the resistance exercise was done, the subject consumed the drink (tempeh, whey and placebo) in 2 min. After 90 min interval from the exercise, the subjects received lunch. After eating lunch, they were allowed to leave the laboratorium and asked to come to the second measurement 6 h after the exercise. There was no food consumed between lunch and the measurement 6 h after the exercise.

The subjects repeated all measurements of muscle soreness, CK serum and maximum strength in 6, 24, 48, 72 and 96 h after resistance exercise. The drink was also consumed during recovery period, which were the second up to four days after the resistance exercise. For measurement in 24, 48, 72 and 96 h after the training, all measurements were conducted after 12 h fasting. All subjects were instructed to consumed normal diet and maintain minimum daily activity. The subject was expected to keep the eating habit or the physical activity and not consumed food other than the habit. The subjects were not allowed to consume soybean and its derived products (tofu, *oncom*, soy sauce) during the study. Moreover, the subjects did not consume vitamin supplements or anti-inflammation drug or drug related to muscle damage protection after the exercise. This restriction was done 48 h before and during measurement period (White *et al*., 2008). To control food intake, the subjects received food from the researcher. The subjects were also asked to make note on food

intake other than the food given. We determined plasma CK activity using a Creatine Kinase Reagent Set Roche/Hitachi, HITACHI 902, according to the manufacturer's instructions.

Data analysis: Data was analyzed using analysis of variance (ANOVA) to identify the differences between groups with 95% CI. Duncan Multiple Range Test (DMRT) with significance of 5% was used when there was difference.

RESULTS

Characteristics of subjects: The characteristics of subject before the study were presented in Table 1. Based on ANOVA, overall, there was no significant difference in terms of age, body weight, body height, BMI, (%) body fat and strength level (1RM).

Food consumption analysis: Based on food consumption analysis using recall method (not including supplement), there was no difference in energy, protein, fat and carbohydrate intakes between groups during the study (Table 2).

Creatine kinase activity: Figure 1 showed that there was increase in CK level after the resistance exercise in all groups. The highest increase was found 24 h after the resistance exercise in all groups. In 24 h after resistance exercise, the CK in tempeh drink group was significantly lower than it in placebo group. However, it was not different from whey group. In other periods (6, 48, 72 and 96 h after the exercise), the CK level in tempeh drink group was not different from it in whey and placebo group but tend to have the least increase compared to whey and placebo group.

Muscle strength: Reduction in muscle strength was found 6 h after the exercise, but not different between groups. In 24 h after the exercise, there was significant change in muscle strength in tempeh drink group compared to placebo but not whey group ($p<0.05$). In 48, 72 and 96 h after the training, there was no difference between groups in terms of muscle strength. However, there was tendency that tempeh drink group showed the biggest improvement in muscle strength. The change in muscle strength after resistance exercise was presented in Fig. 2.

Muscle soreness: The muscle soreness score increased significantly from the baseline for all groups and observation time. However, there was no difference in muscle soreness score between groups but there was tendency that the tempeh drink group had lowest muscle soreness score in all observation time (Fig. 3).

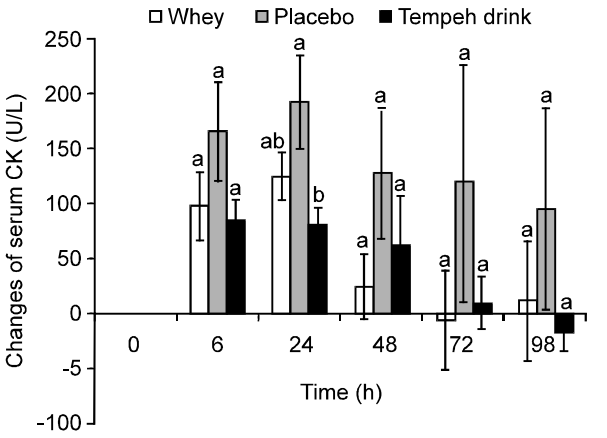

Fig. 1: Change in creatine kinase level after resistance exercise. Similar letter showed insignificance in each observation time in DMRT with 95% confidence interval

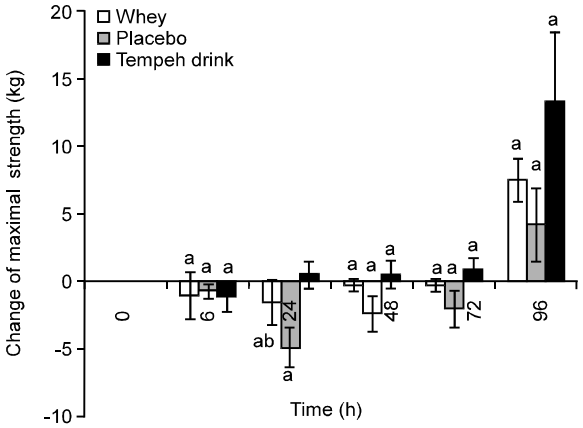

Fig. 2: Change in maximum strength after resistance exercise. Similar letter showed insignificance in each observation time in DMRT with 95% confidence interval

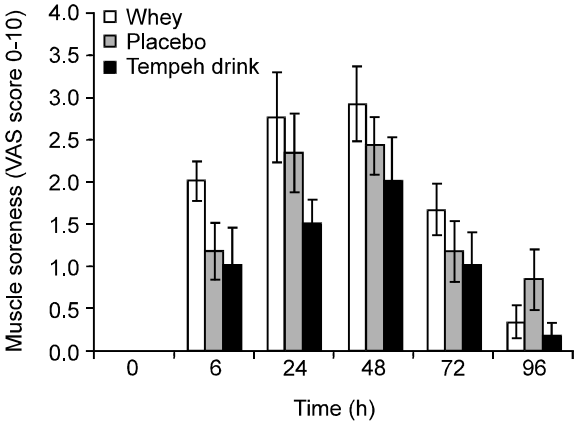

Fig. 3: Muscle soreness after resistance exercise

Table 1: Baseline characteristics of subject

	Whey	Tempeh drink	Placebo
Age (year)	19.93±0.66	20.80±2.09	19.33±1.36
Body height (cm)	171.66±5.85	168.83±4.53	169.50±3.44
Body weight (kg)	68.88±8.36	61.88±6.18	62.98±12.13
BMI	23.31±1.90	21.84±2.62	21.76±3.56
% body fat	20.20±1.99	16.50±3.62	17.75±5.10
Maximum strength	82.5±14.74	88.33±14.02	83.75±15.06

No significant differences between groups (p>0.05)

Table 2: Food consumption analysis

Nutrient	Whey	Tempeh drink	Placebo
Energy (kcal)	2589.7±135.56	2507.61±226.41	2661.71±133.72
Carbohydrate (g)	415.1±23.05	407.80±33.79	426.23±30.40
Fat (g)	61.79±6.61	58.92±6.28	66.51±4.02
Protein (g)	85.28±6.07	83.88±9.85	88.35±4.05

No significant differences between groups (p>0.05)

DISCUSSION

The result of this study is in line with study by Buckley *et al.* (2010) where whey protein consumption with 25 g protein after resistance exercise improved recovery of muscle strength in 6 and 24 h after the training but no effect on CK level and muscle soreness. White *et al.* (2008) which gave whey after or before resistance exercise with 23 g protein showed no effect on reduction in CK level and muscle soreness and increase in maximum strength in all observation time (6,24,48,72 and 96 h). The similar result is also found in study by Burnley *et al.* (2010) which showed that 0.4 g/kg body weight protein supplement after resistance exercise do not improve muscle pain, CK level and muscle pain. Cooke *et al.* (2010) mentioned that giving 1.5 g/kg body weight/day whey protein after resistance exercise during 14 days can improve muscle strength in day 3 and 7 compared to placebo, but not different in terms of CK level.

According to Nosaka (2007), protein intake has important role in recovery of muscle soreness due to resistance exercise since it will get benefit from increased availability of amino acid, such as arginine, glutamine and BCAA (isoleusin, leusin and valin), through supplementation. Resistance exercise that induces muscle damage causes more breakdown rather than synthesis of muscle protein so that the negative balance is higher. However, when given amino acid, the protein breakdown will reduce and the synthesis will be higher, resulting in positive protein balance. Even, positive balance after resistance exercise only can be achieved by higher availability of amino acid (Rennie and Tipton, 2000).

Amino acid supplementation will stimulate transportation of amino acid to the skeleton muscle, increase protein synthesis as well as reduce the breakdown so that it can repair muscle damage and or support recovery of muscle damage (Nosaka, 2007). Shimomura *et al.* (2006) stated that protein synthesis stimulation by leusin and protein breakdown education by BCAA can give positive effect on muscle damage reduction.

The significant difference in CK level and maximum strength in 24 h after the exercise is caused by condition that resistance exercise stimulate muscle protein synthesis (reaching 50-100% above the baseline) which happen maximumly in 3-24 h and keep increasing, although in low amount, up to 48 h after the training (Phillips *et al.*, 1997; Biolo *et al.*, 1995). Providing exogen amino acid, especially in 4 h after exercise, increases protein synthesis, reduces protein breakdown and produces positive protein balance (Biolo *et al.*, 1995; Tipton *et al.*, 1999). Other cause is the amount of BCAA content. In this study, tempeh drink contains 23 g protein per portion with total 4.16 g BCAA which consists of 1.11g isoleusin, 1.92 g leusin and 1.12 g valin. The study conducted by Howatson *et al.* (2012) which gave 20 g/day BCAA in 7 days before the training and 4 days during recovery period had significant effect on reduction of CK level and increase in muscle strength compared to placebo in 24, 48, 72 and 96 h after the training. However, the study by Jackman *et al.* (2010) which gave 29.2 g/day BCAA after the training in 3 days in a row affected reduction in muscle soreness in 48 and 72 h after resistance exercise but no effect on CK.

Result of no effect of type of drink on CK level other than 24 h after the resistance exercise is possibly due to the high variation on individual CK level. This condition is similar to White *et al.* (2008), Jackman *et al.* (2010) and Cooke *et al.* (2010). However, there is tendency that the tempeh drink group had the lowest CK level, the highest maximum strength and the least muscle pain. This may be due to antioxidant component in tempeh, which is isoflavone, which has important role in preventing free radicals which was produced during the exercise. Excessive training contributes to reactive oxygen spesies (ROS) formation. Inside the body, ROS which is free radicals will induce oxidative stress related to muscle damage after exercise. ROS activation will cause muscle cell membrane lysis (Tidball, 2005).

According to Howatson *et al.* (2010), this ROS is involved in secondary damage after primary mechanical damage. This cause muscle damage in tempeh drink group tends to be less. Thus, tempeh drink treatment gives the lowest muscle damage compared to whey and placebo. Therefore, tempeh drink is potential to be sport drink to improve recovery of muscle damage in athlete after resistance exercise.

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