

# Effects of Supramaximal Eccentric Training and Eurycoma Longifolia Jack Supplementation on Quadriceps Strength in Elite Athletes

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## **Abstract**

**Background:** Athletes have used herbs such as ginseng, caffeine, and ephedrine to improve exercise and sports performance. A popular herb among Southeast Asian people is *Eurycoma longifolia* Jack (ELJ) that is purportedly important for health, and even recovery and fitness after an intense training. However, its use for training in athletes was unclear. At such, this study targeted to explore the outcome of consuming ELJ supplementation when implementing supramaximal eccentric training on strength, hormones and muscle thickness in athletes.

**Methods:** Sixteen rugby 7s athletes (age:  $21.5 \pm 1.5$  y, height:  $1.74 \pm 0.06$  m, weight:  $80.0 \pm 10.0$  kg) evenly assigned to one of two groups that supplemented with either ELJ (400 mg per day) or similar taste and appearance placebo (PLA). They performed a supramaximal eccentric training method three times per week for 3 weeks in which the rising the load every week from 110, 120, and 130% of concentric one repetition maximum (1RM). Dependent variables of 1RM concentric and 1RM eccentric strength during leg press; salivary hormone (testosterone and cortisol); and diameter of the muscles (vastus medialis, vastus lateralis, and rectus femoris) were collected within a week prior to, and after the training period.

**Results:** Mixed ANOVA showed a significant interaction of testosterone ( $p=0.018$ ), 1RM concentric, 1RM eccentric, muscle thicknesses of vastus medialis, vastus lateralis, and rectus femoris have produced significant changes ( $p<0.05$ ) over time. However, none was significant ( $p>0.05$ ) for between-group comparison.

**Conclusion:** The study concluded that improvements in muscular strength appears significant after three weeks of supramaximal eccentric training, either with or without ELJ. Furthermore, increases in muscle thickness and changes in hormones occurred similarly across groups for the highly trained cohort in the present study.

**Keywords :** Eccentric, supramaximal, athletes, testosterone, *Eurycoma longifolia*.

## Introduction

Herbal have been used for health and physical functions. Correspondingly, *Eurycoma longifolia* Jack (EIJ), a type of plant found in Southeast Asian origin has commonly used as the natural medicine for many purposes. Athletes are among those who use EIJ supplementation as well as other herbs such as ginseng, caffeine, and ephedrine to enhance sports and exercise performance (Chen et al., 2012; George & Henkel, 2014). Herbs were also thought to accelerate recovery process, uphold the health and fitness in high training, escalate muscle mass and bring down body fat (Chen et al., 2012; Hamzah & Yusuf, 2003). Earlier EIJ supplementation has been shown to enhance androgenic effect such as increased serum testosterone that is essential to increase muscle mass, which can potentially increase force generation or strength level (Bhasin et al., 1996; Hamzah & Yusuf, 2003). The study in male adult found enhancements of body fat-free mass, body fat mass, maximal muscular strength (1 repetition maximum [RM]) and arm perimeter when consuming 100 mg/day of EIJ extract during an 8-week intensive strength training as compared to placebo group (Hamzah & Yusuf, 2003). Yusuf et al. (2015) stated that EIJ supplementation (EIJ extract of 100 mg/day) improved free fat mass among the middle-aged women (aged 45 to 59 years) who performed 12-week strength training or 24 sessions. Similarly, significant elevation in the total and free testosterone concentrations, as well as force of muscles were evident among physically active seniors (57 to 72 year) after consumed 400 mg EIJ extract every day for 5 weeks (Henkel et al., 2013). Nevertheless, some other studies have not obtained positive outcomes of EIJ supplementation specifically on running power after consuming a drink with 0.001 mg EIJ/mL (Ooi et al., 2003), or 150 mg of EIJ capsules for seven-day prior the carry out exercise (Muhamad et al., 2010).

Although the research on EIJ still scarce, all previous studies on human that have investigated the effects of EIJ extract were conducted on either healthy, sedentary, or elderly subjects. On that note, there were hardly any study that have explored the ergogenic reaction of EIJ on sport performance such as strength (Chen et al., 2019; Hamzah & Yusuf, 2003; Henkel et al., 2013; Ooi et al., 2015; Sarina et al., 2009) but among non-athletic population. Recently, Zakaria et al. (2020) look into the effects of submaximal intensity eccentric training method among elite male Rugby Sevens players when consuming EIJ supplementation for 6 weeks. The major finding of the study indicated that the submaximal eccentric training (3 sets x 5 reps, 18 sessions, 75-100% load intensity) did not yield any significant between-groups difference ( $p > 0.05$ ) for the various physical (e.g. muscle thickness and body composition)

and physiological (e.g. strength, speed, power and hormones) measures but nevertheless, most of the within-groups comparisons yielded noticeable difference ( $p < 0.05$ ). This may suggest that improvement of the tested variables occurred over time at seemingly of similar rate between EIJ supplementation and placebo, but the quantification and patterns of positive trend were more prominent on EIJ group thus may have additional ergogenic impact as EIJ was also purported to induce an adaptogenic property in human (George et al., 2013). Notwithstanding that eccentric training was also a major part of rugby conditioning program which emphasized improvement on strength and power in enhancing lower body power output and the results was seen proven even in 3-weeks training block (Cook et al., 2013) during competitive season.

However, it would still be imprudent to make a firm conclusion regarding the effects of combined EIJ supplementation and eccentric training as this modality can also be done when the eccentric part of lifting is accentuated and accomplished at levels that are above than 100% of one's concentric 1RM which renowned as supramaximal eccentric (Krentz et al., 2017). Moreover, supramaximal eccentric training could have produced faster velocity of contraction than submaximal eccentric training based on a force-velocity curve. Of note, heavier (i.e. faster) eccentric training produced more effective training means for strength and hypertrophy than the lighter (i.e. slower) eccentric training (Farthing & Chilibeck, 2003). Furthermore, the magnitude of muscle damage, isometric strength, and arm circumference was higher, while longer recovery period was observed during the heavier eccentric training as in study by Nosaka and Newton, (2002). Therefore, EIJ supplementation during a supramaximal eccentric training is duly tested.

There have been very limited investigations of the effectiveness of EIJ supplementation taken daily for a group of highly trained participants (with the exception of a few studies using recreational athletes such as Muhammad et al. (2010) and Chen et al. (2014)) and that no study has examined the effects of EIJ supplementation over the course of an actual training mesocycle (i.e. 3-week) using supramaximal eccentric training for strength development. At such, the main objective of this study was to identify the efficacy of EIJ supplementation when implemented during training using the said protocol on physical, physiological, and performance changes in elite male Rugby Sevens players. We hypothesized that the intake of EIJ supplementation during a 3-week supramaximal eccentric training would increase and enhance gains in strength including muscle thickness and related hormones, compared to placebo supplementation.

## Methods:

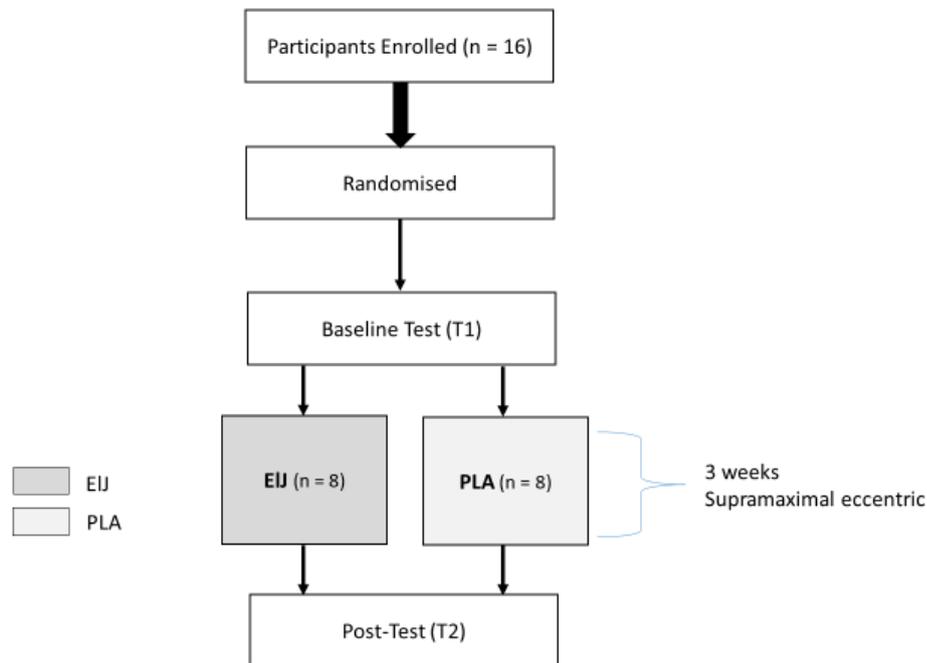
Sixteen male Rugby Sevens athletes (age:  $21.5 \pm 1.5$ y, height:  $1.74 \pm 0.06$ m, weight:  $80.0 \pm 10.0$ kg) were recruited in this study. Inclusion criteria were as followed:

- participated in 2015 and 2017 SEA Games in Rugby Sevens and represented or played for state or national level for more than 5 years,
- injury free, has never been hospitalised in the last 2 years, no surgery or serious injury to the lower limbs in the last 3 years, and lastly
- did not consume any other supplement during the study duration.

The participant who was injured or pronounced unfit by the team doctor or skipped any training program more than once was excluded from the data analysis. Only the complete data was used. They were not allowed to engage in any physically demanding activities for 48 hours before the first testing time, and during the course of post-testing. Written consent was attained from all participants before the study. This study was conducted in obedience to the Declaration of Helsinki, and procedure and protocols were approved by the Institutional Review Board.

A randomized, double-blinded, parallel design experiment was applied in this study. Participants were randomized based on ABBA procedure with an isometric strength torque data at  $45^\circ$  for knee extensors. In this format, a player with the highest isometric strength was placed to ELJ group, players with the second and third highest torque score to PLA (placebo) group, fourth best player to ELJ, and so on. No between-group significant difference in physical characteristics ( $p > 0.05$ ). Participants were asked to refrain from consuming other supplements other than that provided to them during the period of this research. Furthermore, all participants stayed at the same athlete's dormitory in Universiti Putra Malaysia and consumed same type of meals upon preference and liking that were served in athlete's café. The meals eaten by all participants were similar and habitual prior to each testing session and throughout the day. Supplement compliance and testing attendance had to be 100% to be included in the analysis. All strength testing sessions occurred at the same time of the day (at 10 am). Familiarisation of testing equipment was done one week prior to the baseline data collection (T1) which was taken 7 days before the program started. Baseline tests including leg press 1RM concentric, 1RM eccentric, salivary hormone and muscle thickness. All the strength measurements were done in three separate days. Post-test (T2) were conducted 3 - 5

days after completion of 3-week training program. Figure A shows the study design for supramaximal eccentric training in three weeks intervention.



**Figure A: Flow chart of 3-weeks supramaximal eccentric training**

### Supplementation

The participants in the supplement group EIJ were ingested 4 capsules (1 capsule = 100mg) @ 400mg of hot water extraction EIJ in powdered form and capsuled by Biotropics Sdn Bhd i.e. Physta®, while the remaining participants were ingested similar amount of look-alike capsule or placebo (PLA), i.e. maltodextrin. This carbohydrate-type content was chosen as a PLA as carbohydrate supplementation has not been shown to improve or impair the recovery from eccentric exercise (Miles et al., 2007). The capsule was designed to have the same shape, colour, and taste. The participants were asked to take the supplement on day 1 up to the last day of the 3 weeks. A reminder was given on daily basis to consume the supplement every morning after breakfast.

### One-Repetition Maximum Protocol

The One repetition maximum (1RM concentric) and eccentric maximal strength (1RM eccentric) test procedures were identified from a series of a tries using a 45° incline leg press machine (from Cybex). The assessment was guided by qualified trainers. It was compulsory for the participants to warming up on a static bike (LeMond, USA) for 15-minutes and

subsequently with some passive and active stretching. The participants then performed maximal strength tests with the protocols that were altered from Phillips et al. (2004), McBride et al. (2009), and Wirth et al. (2015). Three-minutes rest were allocated after the warmup. Two straps with a pulling strength of 600kg were used on top of the equipment manual stoppers attached to the leg press machine to stop the plate loaded platform if participants could not maintain to control the heavy weights. During the 1RM and eccentric maximal tests, participants sat in the leg press machine with feet outstretched on the foot platform with straight legs. When the loaded platform was lowered to achieve a 90° of knee angle, a goniometer was used to visually establish the end point before pushing (concentric) movement. Participants performed several repetitions at weights equal to 30%, 50%, 70% for 2 to 4 reps, and 90% for one repetition of the estimated 1RM. The loads were gradually added using 10-20kg of weights. After each completed attempt, 5 minutes rest was given prior to the next effort. Participants were allowed up to 5 maximum attempts to accomplish a 1RM after the warm up sets of: 30% of estimated 1RM, done at 8-10 reps, 50% of estimated 1RM, done at 4-6 reps, 70% of estimated 1RM, done at 2-4 reps, 90% of estimated 1RM, done at 1 rep.

### **One RM Eccentric Protocol**

The procedure of 1RM eccentric assessment was modified from Wirth et al. (2015). For 1RM eccentric protocol, the lowering part or eccentric phase was subjected to 5 seconds for the knee angle to be at 90° angle for validity. Once reached at the 90° knee angle, the platform was pulled to the initial starting position by the spotters (assisted concentric). The full execution range was monitored and determined by trainers. If the participants allowed the lowering phase of the platform (i.e. less than 5 seconds), the repetition was considered void. Participants were given 5 minutes of rest between the individual tries. The maximum strength protocol was modified from the guideline of the National Strength and Conditioning Association (Baechle & Earle, 2008).

Briefly, participants were asked to perform a warmup set that consists of 50, 70, and 90% of individual one-repetition maximum for 10, 5, and 3 repetitions, respectively. Subsequent to this, they were asked to perform one repetition of the next three load intensities: 100% and 120% of concentric strength, and after that, if successful, to attempt 140%. When the athlete success each test, the load for the next test was further increased (20-40kg) or decreased (10-20kg) until failed, or a maximum of five further attempts, which were adequate to achieve maximum strength by all participants.

### **Salivary Hormone**

The saliva sampling (2 ml) was collected at 730am to analyse the hormonal responses over time. The samples were obtained according to a standard procedure (Salimetrics LLC, 2015). Briefly, participants were asked to wash mouth, rest, and relax in a seated and leaning forward position. Participants then deposited the unstimulated saliva into a receptacle. Participants were asked to keep away foods with high sugar or high acidity, or high caffeine content, 1-hour prior to sample collection as they could lower the saliva pH and increase bacterial growth (Salimetrics LLC, 2015). All samples collected were stocked and refrigerated at -80°C for future analysis. The salivary testosterone (pmol/L) and cortisol (nmol/L) concentrations were analysed using commercially obtainable ELISA kits (Salimetrics LLC, 2015). The assays were performed in duplicates, and the average value was used for further analysis. The previously determined intra-assay coefficient of variation was 8.4% and 10.0% for testosterone and cortisol, respectively.

### **Muscle Thickness**

Measurement of quadriceps thickness (anterior thigh of the dominant leg) were done by using B-mode Ultrasound Imaging Portable machine (GE, LOGIQ e, Connecticut, USA) with an electronic linear transducer of 10 MHz imaging or repetition frequency, using a gain of 58 dB, and a magnification which allows a depth of 30 mm. To locate the measurement sites, an anthropometric tape was set along the length of the thigh from the superior tip of the patella to the anterior superior iliac spine with the participants in standing position. A non-toxic pen was then used to mark each muscle. The vastus medialis was defined at 20% of the distance, and at 50% for both rectus femoris and vastus lateralis (Kawakami, Muraoka, Kubo, Suzuki, & Fukunaga, 2000). The actual location of the vastus medialis was 12.5% of thigh perimeter in the medial direction (towards midline) from the mid-point, and 10% in the lateral direction for the vastus lateralis. During the scanning process, participants lay relaxed in supine lying with a winded-up towel put in the popliteal fossa to alleviate the upper thigh. The transducer was positioned perpendicular to the longitudinal axis of quadriceps muscle with ultrasound gel placed between the probe and the skin, with minimal pressure, to get the real-time cross-sectional form (i.e. muscle thickness). A trained operator captured three measurements for each muscle and averaged for analysis. All images were downloaded and stored in a compact flash card to enable off-line measurements of the muscle dimensions. The measurement was done in the morning before any physical exertion during baseline testing and post-testing.

### **Eccentric Training Procedures**

The training procedure was adjusted from eccentric training guidelines as proposed by Mike et al. (2015). There were three sessions of strength training in a week which were conducted for three weeks. The leg press exercise was employed using a 45° incline leg press machine from Cybex. The use of leg press was sought to primarily target the knee extensor muscles (da Silva et al., 2008). During each training session, participants were asked to control the lowering part (eccentric phase) of the platform to reach 90° of the knee angle. For the entire concentric phase, the platform was pulled upwards by the spotters back to the initial position to complete the movement. The tempo of eccentric phase was controlled so that each movement was done with approximately 5s (Mike et al., 2015). Participants in training group were asked to perform 3 sets of 5 repetitions eccentric training in order to induce both strength and hypertrophic adaptations (Beachle et al., 2008; Krieger, 2009; Radaelli et al., 2015). In between sets, five minutes rest was given to the participants due to the great requirement on the neural system. The concentric phases of each repetition were done with external assistance (i.e. partner assisted) as per Table A.

**Table A: Training protocol for 3 weeks supramaximal eccentric training**

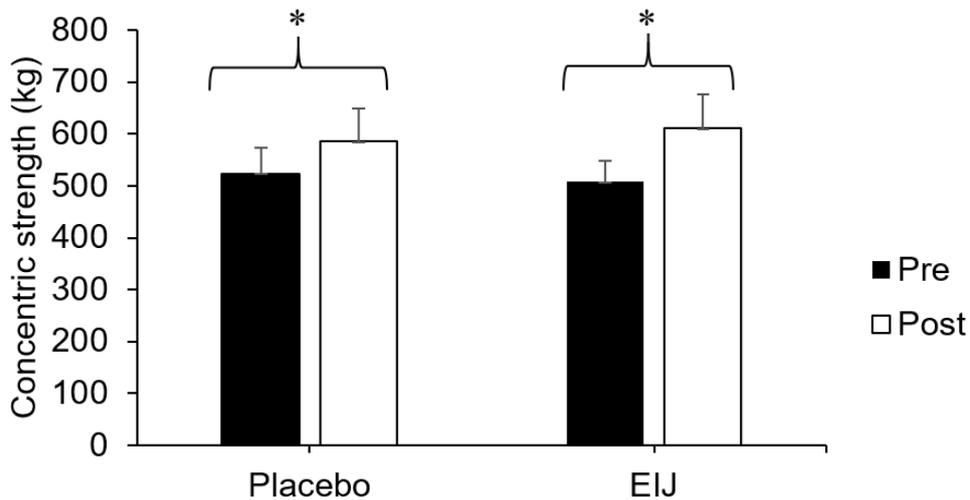
	Sets	Reps	Load	Tempo	Rest	Total number of sessions	Total number of sets	Total number of reps
Week 1	3	5	110%	5-0-A	4-5'	3	9	45
Week 2	3	5	120%	5-0-A	4-5'	3	9	45
Week 3	3	5	130%	5-0-A	4-5'	3	9	45

### Statistical Analysis

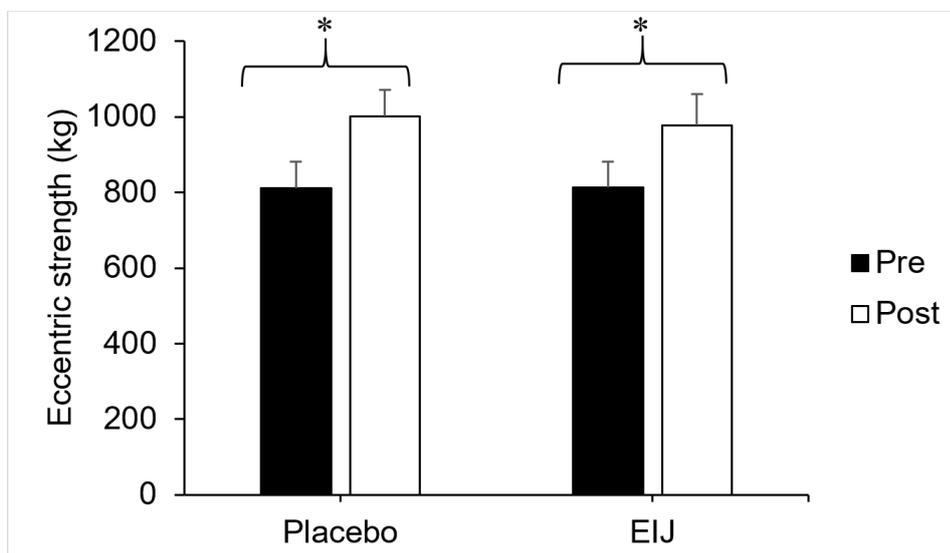
Two-factor mixed-design ANOVA was utilized to assess interaction, between-group or treatment (PLA vs EIJ), and within-subject or time-effect difference for dependent variables (pre and post); 1RM concentric and eccentric leg press, muscle thickness and hormones. Statistical of Paired t-tests were used to detect for group and time. Simple percent difference was generated using the following formula:  $([\text{post-test} - \text{pretest}] / \text{pretest} \times 100)$ . All collected data were presented as mean  $\pm$  standard deviation (*SD*). The accepted level of significance was set at  $p < 0.05$  for all tests. Statistical Package for the Social Sciences, version 22 (SPSS Inc., Chicago, IL) was used to analyse all data.

### Results

**1RM Concentric Leg Press:** In Figure B, results revealed no significant difference interaction between time and group,  $F(1, 14) = 4.068, p = 0.063(\eta^2 = 0.624)$  There was a significant main effect of time,  $F(1, 14) = 65.687, p = 0.001 (\eta^2 = 0.824)$  but there was no significant main effect of group,  $F(1, 14) = 0.035, p = 0.855 (\eta^2 = 0.002)$ .



**Figure B: Graph of concentric strength for pre and post measurement of the group with placebo (PLA) and EIJ**



**Figure C: Graph of eccentric strength for pre and post measurement of the group with placebo (PLA) and EIJ**

**1RM Eccentric Leg Press:** In Figure C, there was no significant difference interaction between time and group,  $F(1, 14) = 0.865, p = 0.365 (\eta^2 = 0.058)$ . There was a significant

main effect of time,  $F(1, 14) = 173.272, p = 0.001 (\eta^2 = 0.925)$ . but there was no significant main effect of group,  $F(1, 14) = 0.112, p = 0.743 (\eta^2 = 0.008)$ .

**Table B: 1RM concentric and eccentric leg press after 3 weeks of supramaximal training for EIJ and PLA group**

Variable	EIJ			PLA			Bet. group
	Pre (SD)	Post (SD)	Diff (%)	Pre (SD)	Post (SD)	Diff (%)	
<b>Strength (1RM)</b>							
Concentric leg press (kg)	505±41	610±66	20.8	523±49	585±64	11.9	8.9
Eccentric leg press (kg)	813±68	978±82	20.4	812±69	1001±70	23.3	-2.9

**Muscle Thickness**

**Vastus Medialis:** In Table C, results obtained no notable difference interaction between time and group,  $F(1, 14) = 0.196, P = 0.665 (\eta^2 = 0.014)$ . It showed a substantial main effect of time,  $F(1, 14) = 27.830, P = 0.001 (\eta^2 = 0.665)$  but there was no remarkable main effect of group,  $F(1, 14) = 0.577, P = 0.460 (\eta^2 = 0.040)$ .

**Vastus Lateralis:** There was no substantial difference interaction between time and group,  $F(1, 14) = 1.812, p = 0.200 (\eta^2 = 0.115)$ . There was a notable main effect of time,  $F(1, 14) = 16.946, p = 0.001 (\eta^2 = 0.548)$  but there was no remarkable main effect of group,  $F(1, 14) = 0.035, p = 0.854 (\eta^2 = 0.002)$ .

**Rectus Femoris:** There was no major difference interaction between time and group,  $F(1, 14) = 0.718, p = 0.411 (\eta^2 = 0.049)$ . There was a remarkable main effect of time,  $F(1, 14) = 9.006, p = 0.010 (\eta^2 = 0.391)$  but there was no significant main effect of group,  $F(1, 14) = 0.011, p = 0.918 (\eta^2 = 0.001)$ .

**Table C: Changes in muscle thickness before and after supramaximal eccentric training**

Variable	EIJ			PLA		
	Pre (SD)	Post (SD)	Diff. (%)	Pre (SD)	Post (SD)	Diff. (%)
<b>Muscle thickness</b>						
Vastus medialis (cm)	3.76±0.54	3.95±0.54	5.2	3.59±0.40	3.76±0.37	4.6
Vastus lateralis (cm)	3.25±0.38	3.43±0.48	5.4	3.26±0.29	3.35±0.31	2.7

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Rectus femoris (cm)	2.91±0.27	3.05±0.30	4.7	2.93±0.14	3.01±0.15	2.5
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### Salivary Hormone

**Testosterone:** In Table D showed that a notable difference interaction between time and group,  $F(1, 14) = 7.122, p = 0.018$  ( $\eta^2 = 0.337$ ). There was no huge main effect of time,  $F(1, 14) = 0.223, p = 0.644$  ( $\eta^2 = 0.016$ ) and no major main effect of group,  $F(1, 14) = 0.089, p = 0.770$  ( $\eta^2 = 0.006$ ).

**Cortisol:** There was no substantial difference interaction between time and group,  $F(1, 14) = 1.590, p = 0.228$  ( $\eta^2 = 0.102$ ). There was no remarkable main effect of time,  $F(1, 14) = 0.392, p = 0.091$  ( $\eta^2 = 0.191$ ) and no large main effect of group,  $F(1, 14) = 0.505, p = 0.489$  ( $\eta^2 = 0.035$ ).

**Testosterone-Cortisol Ratio:** There was no wide difference interaction between time and group,  $F(1, 14) = 4.525, p = 0.052$  ( $\eta^2 = 0.244$ ). There was no crucial main effect of time,  $F(1, 14) = 3.197, p = 0.095$  ( $\eta^2 = 0.186$ ) and no noticeable main effect of group,  $F(1, 14) = 0.081, p = 0.780$  ( $\eta^2 = 0.035$ ).

**Table D: Changes in salivary hormone before and after supramaximal eccentric training**

Variable	EIJ			PLA			Bet. group
	Pre (SD)	Post (SD)	Diff. (%)	Pre (SD)	Post (SD)	Diff. (%)	
<b>Salivary hormone</b>							
Testosterone (pmol/L)	291±113	351±0.61	20.9	374±99	287±59	-23.2	44.1
Cortisol (nmol/L)	3.6±2.6	3.9±0.21	8.4	3.5±1.6	5.2±1.4	48.6	-40.2
T-C Ratio	99.9±45	106.5±39.3	6.6	136.6±80	60.1±23.4	-56.0	62.6

### Discussion

Current study intended to investigate the outcome of three weeks of EIJ supplements when implementing supramaximal intensity eccentric training on physical, physiological, and performance changes in elite Rugby Sevens athletes. The analysis of changes in maximum strength for both 1RM concentric and 1RM eccentric showed significant changes over time

(pre and post), but no interaction effect or between-group noticeable difference was detected ( $p > 0.05$ ). A similar result was obtained for testosterone, but this also produced no between-group difference ( $p > 0.05$ ). Ultimately, in the study there appears no variable measures were positively affected by EIJ supplementation.

Generally, the paucity of discovered effects across measurements were possibly justification by a lack of power to detect relatively precise improvement in strength, hormones, and muscle thickness possibly due to small sample size. This might also relate to the “fitness status” of participants, who were highly trained and healthy. It was previously noted that elite rugby players are generally well built and robust in physical characteristics. Consequently, their strength training demands (Coutts et al., 2007) are also higher for various types of strength workouts, which could have not influenced by EIJ supplementation. Eventhough, EIJ had been shown to be more beneficial among non-athlete population by increasing well-being including health (Talbot et al., 2013), we would expect EIJ’s adaptogenic property to be evidenced. Talbot et al. (2013) described that EIJ contains a group of little peptides referred to as “europeptides” that improved sex drive and energy status in studies of rodents and human (Tambi & Imran, 2010; Tambi et al., 2012). The authors clarified that EIJ might be useful to restorative the release rate of free testosterone, and therefore, useful as a “maintainer” of usual testosterone levels even during strenuous training to promote anabolism (Talbot et al., 2006). Talbot et al. (2013) then speculated that EIJ might be beneficial for those of subnormal testosterone levels, especially to athletes who perform intense training in addition to middle-aged people facing fatigue or depression. On the other hand, if were to look at the results for each group, the cohort in the present study did show some positive effects of EIJ supplementation, suggesting that the effects of EIJ supplementation may not be stronger to achieve significant level in sample of highly trained athletes,

The extent to which EIJ supplementation plays a role on the key parameters of sports remains a subject of further exploration. It is however important to record that a comparison between the magnitude of changes in percentage yielded “mixed” outcomes, with some variables were in favour of EIJ supplementation and others not. For example (as in Table B) during concentric leg press, EIJ group improved by 20.8% against PLA group that obtained only 11.9% ( $p > 0.05$ ) improvement, but oppositely, eccentric leg press was in favour of PLA by obtaining 23.3% that was higher than did by EIJ (20.4%;  $p > 0.05$ ). However, a pioneer

study conducted by Hamzah & Yusof (2003) in healthy male found significant improvement in muscle strength and size. In that study, the authors provided 100 mg/day EIJ water soluble extract or PLA, and then asked the participants to train three times per week for 5-week, which comprised of ten different exercises performed progressively from 60% load intensity for 2 sets of 10 repetitions. Their primary results indicated improvement in 1RM bench press, from ~73 to 78kg (6.8%) in the treatment group, while PLA produced a lesser improvement, from ~77 to ~79kg (2.8%). Nevertheless, the magnitude of strength improvement in our study was colossal if were to compare with the other previous studies (Chen et al., 2019; Hamzah & Yusuf, 2003; Ooi et al., 2015; Sarina et al., 2009) certainly due to the eccentric intensity imposed in the training program.

In the present study, participants were asked to perform supramaximal eccentric training (110 to 130% 1RM) using leg press exercise, three times a week for three weeks, and we observed a generally larger training effect ( $>11\%$ ;  $p = 0.001$ ) for pre and post-test as measured by leg press, regardless of the types of treatment (either PLA or EIJ), suggesting that improvement may mainly due to eccentric training itself. It was also noteworthy that the observed improvement in strength (and other various measures) over time in the participants occurred after only 3 weeks of supramaximal intensity eccentric training. In another EIJ and eccentric study, we have reported a similar finding was observed without any statistical differences between groups (Zakaria et al., 2020). In that study, we detected difference in percentage that showed EIJ group had higher increases in both concentric (18.9%,  $p < 0.05$ ) and eccentric (29.1%;  $p < 0.05$ ) strength as compared to PLA (10.5% and 24.4% with  $p < 0.05$ , respectively). For the same comparisons, we have obtained slightly different results in the present study as improvement of maximum strength during concentric 1RM (leg press) was favourable to EIJ group whereas it was oppositely, for 1RM eccentric strength.

It was established that eccentric training method derived in a better stimulation of hypertrophy and mechanical tension (Suchomel et al., 2019). This hypertrophic response is thought as a result of the growth of tissues that can occur as the process of breakdown is greater, promoting a higher growth factor (Hody et al., 2019; Kraemer & Mazzetti, 2005). Mechanical tension is responsible for improvement for muscle strength and muscle size (Hortobagyi, Devita, Money, & Barrier, 2001), and this higher ability of generating maximal forces may further enhance the improvement in muscle hypertrophy (Farthing & Chilibeck, 2003; Suchomel et al., 2019).

On the contrary, EIJ improved muscle thickness (vastus medialis, vastus lateralis, and rectus femoris) in a larger magnitude (5.2, 5.4, and 4.7%, respectively) than did PLA (4.6, 2.7, and 2.5%, respectively;  $p = 0.460, 0.854$  and  $0.918$  respectively). This results concurred with our previous study, where we found a larger increase in muscle thickness (vastus lateralis, rectus femoris, and vastus medialis) in EIJ group, without achieving a statistically significant ( $p < 0.05$ ) (Zakaria et al., 2020). There were several evidence that heavy resistance training including eccentric training had increased skeletal muscle hypertrophy which was in line to improved protein translation (Bodine et al., 2006; Coffe & Harley, 2007) and enhanced gene expression that involved in anabolism (Bickel et al., 2005; Kosek et al., 2006), cell activation and proliferation which added nuclei for increasing myofibers (Kadi et al., 2004; Olsen et al., 2006; Petrella et al., 2006). All of this may explain for the increased in muscle thickness that was evidenced in this study.

As previously mentioned, we described that mechanical overload (e.g. eccentric actions) was contributed to the development of muscle thickness for the knee extensor muscles, probably more than the influence of the treatment (PLA and EIJ) in this present study. However, these hypertrophied muscles could have been due to stimulation of the mTOR (mammalian target of rapamycin) signalling pathway developing from the simultaneous action of protein ingestion and training (Farnfield et al., 2012). Thus, the increase in muscle thickness with EIJ supplementation may translate to improve strength. Although no statistical differences, the improvement in strength that was observed in EIJ group as natural adaptogenic was parallel to that achieved for the muscle thickness, as compared to PLA. On the other hand, this lack of difference ( $p > 0.05$ ) in muscle thickness between groups remains unclear but could be attributed to aforesaid factors such as the participants training characteristics (volumes and intensity) that were similar for both group. However, such results were not entirely surprising due to the characteristics of supplement that has yet been shown to be substantial in elite athletes for various parameters of performance. But, the present study only highlights prospective positive effects of EIJ supplementation (e.g. muscle thickness), the outcomes were not conclusive or irrefutable.

This study involved supramaximal eccentric-only training to examine the strength potential of eccentric movement without the delimiting influence of the concentric force capacity. The eccentric training guidelines emphasised lower net forces for the deceleration of foot carriage and downward movement in a slow-moving, regulated manner. The minimal involvement of Short Shortening Cycle (SSC) in this eccentric-only movement (Higbie et al., 1996) and the

slow-moving movement are linked to the lack of task specificity for certain sports (Wagle et al., 2017) which was not resembling the nature of the sport and the participants in this study. Therefore, the extended Time Under Tension (TUT) at higher force levels surpasses what can be attained through conventional resistance training (Suchomel et al., 2019). As a result, it offers robust impetus for musculoskeletal adaptation, which benefit the long-term development of muscle strength and size given the significance of mechanical impetus for muscle adaptation (Hody et al., 2019; Hortobagyi et al., 2001, Roig et al., 2008). More studies are necessary to gain a better understanding on the acute and chronic effects of such eccentric training and the interactions of TUT and different force levels considering the immense interest on elite athletes that involved a higher level of eccentric training as seen in this study including the potential involvement and benefits of popular tropical herbs such as ELJ.

### **Conclusion**

This study focused to study the efficacy of EIJ supplementation when training using supramaximal intensity eccentric protocol on strength performance changes in three weeks. The analysis of changes in maximum strength (1RM) for both concentric and eccentric showed significant changes over time (pre and post), but no interaction effect nor between-group significant difference was present. A similar result was obtained for testosterone, but this also produced no between-group difference. In the present study, there appears no variable measures was positively affected by EIJ supplementation. Despite using a different eccentric training methods, the observed results in this study seems comparable to our preceding investigation (Zakaria et al., 2020). The superiority was evidenced and conciliated by the capability of such contraction to produce substantial force (Farthing & Chilibeck, 2003; Roig et al., 2008) and it was confirmed in this present study. Another study by Zakaria et al. (2018) had established that similar magnitude of strength gained need only half of the time if were to perform supramaximal eccentric training, compared to 6-weeks submaximal eccentric training. Nevertheless, Krentz et al. (2017) has proven that both low intensity eccentric (submaximal) and high intensity eccentric (supramaximal) were both effective for improving muscle strength and hypertrophy but the former required less exertion thus more favourable.

It was previously noted that elite athletes (Rugby Sevens players) were generally well built and robust in physical characteristics. Consequently, their strength training demands are also higher for various types of strength workouts, which could have not influenced by EIJ

supplementation. Moreover, EIJ had been shown to be beneficial among non-athlete population by increasing well-being including health specially to stressed, elderly and LOH individuals (Henkel et al., 2013; Ismail et al., 2012; Talbott et al., 2013). George et al. (2013) described that EIJ contains a group of little peptides referred to as “europeptides” that is naturally adaptogenic energizer in the maintenance in which will optimizing testosterone level only when suboptimal (Tambi, 2005). It should be noted that the participants averaged age were 22 and none of them have recorded low testosterone level for their age group. Nevertheless, the adaptogenic property of EIJ possibly exerted its effect in some ways for measurement that showed slight increasing trend in EIJ group though none reached significance. Talbott et al. (2013) also speculated that EIJ might be beneficial for those athletes who perform intense training suffering with fatigue by reducing catabolism and promoting anabolism (Talbott et al., 2006). On the other hand, the cohort in the present study did show some positive effects of EIJ supplementation compared to PLA group, suggesting that the effects of EIJ supplementation may not be stronger or achieve significance level in sample of highly trained male elite athletes.

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