

# NO EFFECT OF CORDYCEPS SINENSIS SUPPLEMENTATION ON TESTOSTERONE LEVEL AND MUSCLE STRENGTH IN HEALTHY YOUNG ADULTS FOR RESISTANCE TRAINING

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**AUTHORS:** Hsu C.C.<sup>1</sup>, Lin Y.A.<sup>2</sup>, Su B.<sup>3</sup>, Li J.H.<sup>4</sup>, Huang H.Y.<sup>5</sup>, Hsu M.C.<sup>5</sup>

<sup>1</sup>Department of Anatomy, School of Medicine, Taipei Medical University, Taipei, Taiwan, ROC

<sup>2</sup>Graduate Institute of Coaching Science, National Taiwan Sport University, Taoyuan, Taiwan, ROC

<sup>3</sup>Department of Pathology, Buddhist Tzu Chi General Hospital, Hualien, Taiwan, ROC

<sup>4</sup>School of Pharmacy, Kaohsiung Medical University, Kaohsiung, Taiwan, ROC

<sup>5</sup>Graduate Institute of Sports Science, National Taiwan Sport University, Taoyuan, Taiwan, ROC

Reprint request to:

**Mei-Chich Hsu,**  
Graduate Institute of Sports Science,  
National Taiwan Sport University,  
250, Wen-Hua 1st Road, Kueishan,  
Taoyuan County, Taiwan, ROC  
Phone: + 886-3-3283201 ext. 2619  
e-mail: meichich@gmail.com

**ABSTRACT:** The purpose of this study was to assess the effects of oral *Cordyceps sinensis* supplementation combined with resistance training in young male adults. A group of 16 subjects were randomly allocated to two groups (double blind) to receive either *Cordyceps sinensis* (CS; 2.4 g/day; n = 8) or a placebo (P; 2.4 g maltodextrin/day; n = 8) during eight weeks of resistance training. Exercises were performed for three sets of 3 to 5 repetitions at a mean training intensity of 80% of 1 repetition maximum (1RM). Before and after training, measurements were taken 1 RM to bench press, leg press, and seated rowing. The body composition, plasma testosterone levels, as well as serum concentrations of blood urea nitrogen, creatinine, aspartate transaminoferase, and alanine transaminoferase were also measured. The results showed that CS supplementation did not significantly affect ( $p > 0.05$ ) the changes in all measurable variables after eight weeks of resistance training. This study suggested that CS is relatively safe to be ingested; however, CS supplementation for eight weeks neither appear to possess a significant ergogenic value nor affect testosterone level of resistance-trained young male adults.

**KEY WORDS:** body composition, *Cordyceps*, muscle strength, resistance training, testosterone

## INTRODUCTION

Resistance training is an essential component of almost every athletic training regimen and has become a popular recreational mode of exercise for many physically active individuals. Recently, herb supplementation is a common method used to enhance responses to resistance exercise; however, few have the benefit of increasing muscle strength. *Cordyceps sinensis* (CS) is a parasitic fungus found on the larvae of Lepidoptera, and has been used for centuries in traditional Chinese medicine as a time-honoured tonic food and Chinese herbal medicine.

Previous studies have shown that CS exhibits a broad spectrum of biological and pharmacological actions on the hepatic, renal, endocrine, and cardiovascular system [14]. Moreover, CS stimulates erythropoiesis and haemopoiesis, and enhances immunomodulation and anti-tumour activities [1, 13, 14].

*Cordyceps* may also increase testosterone level, as seen *in vivo* in mice and rat [5-7, 12]. It is hypothesized that the testosterone increases due to polysaccharides and/or glycoproteins in *Cordyceps* that are similar to luteinizing hormone (LH) in structure and bind to LH receptors, and thus stimulate testosterone production [5].

Testosterone is a steroid hormone secreted from the Leydig cells of the testis. The known effects of testosterone in increasing muscle mass and promoting positive nitrogen balance to influence muscle growth have formed the basis for examining the androgenic responses to resistance exercise. However, whether CS actually increases human blood testosterone levels or produces anabolic androgenic effects is not known.

This paper takes an initial step to bridge the gap in our knowledge by designing an experiment that tests whether 8 weeks of oral CS supplementation could enhance the gain in muscle strength.

## MATERIALS AND METHODS

**Subjects.** Sixteen volunteer males between the ages of 19 and 25 were recruited from Taiwan for the present study. Subjects were randomly and blindly assigned to two experimental groups: the placebo (maltodextrin) group and the CS group. Participants met all criteria as determined by a medical questionnaire before being included in the study. The principal criteria for eligibility were as follows: (a) absence of clinical disease; (b) no history of gastrointestinal

or renal disease; (c) no smoking; (d) no alcoholism. Subjects also refrained from consuming CS or any other nutritional supplement prior to enrolment in the study. Moreover, subjects were instructed to maintain a consistent diet throughout the study period. This study was approved by the Ethical Committee of National Taiwan Sport University, Taiwan and conformed to the 1995 Declaration of Helsinki as revised in Edinburgh 2000. Subjects gave written consent to participate. All subjects were physically active but had not been involved in any previous structured resistance training programmes.

#### *Cordyceps sinensis supplementation*

Each subject was instructed to ingest either 6 CS capsules (400 mg CS per capsule) daily or a maltodextrin placebo in the same capsule form. Both the subjects and the primary investigator were blinded as to which supplement was given. Each subject received his allotment of CS or placebo in eight weekly portions. The *Cordyceps* sample was manufactured by a submerged culture technique conducted by the Taiwan Sugar Research Institute. The fungus, *Cordyceps sinensis*, was isolated from naturally occurring *Cordyceps*, and the culture conditions were optimized and scaled up to a 6-kL fermentor using Taguchi's method [10]. The cultivated mycelia were spray-dried to obtain a powder. The contents of the soluble proteins, sugar, and adenosine derivatives were calculated from their degrees of concentration in a hot water extract of the powder. The fungus-bearing ergosterol content was determined from its degree of concentration in an ethyl acetate extract.

The compositions of the cultivated *Cordyceps* that we used were soluble protein (0.33%, w/w), sugars (5.81%, w/w), adenosine derivatives (5.92  $\mu\text{mol/g}$ ), cordycepin (1.23  $\mu\text{mol/g}$ ), ergosterol (8.81  $\mu\text{mol/g}$ ), and heavy metals (total amount, < 2 ppm).

#### *Experiment design*

All the subjects underwent test familiarization before participating in 8-week resistance training. Maximal muscle strength tests (one repetition maximum, 1RM) were performed at the beginning of the study (week 0) and after the training period (week 8). Fasting blood samples were drawn from an antecubital vein at 0800  $\pm$  0.5 hours before the resistance training and on the following day after the training period. Muscle strength test was completed on the same days as blood was collected.

#### *Heavy-resistance training*

All subjects performed resistance training 3 days per week on non-consecutive days for 8 weeks. These participants engaged in muscle strength training using Cybex<sup>®</sup> equipment. The circuit of resistance training programme targeted the large muscle groups. The subjects completed 5 sets of 5 repetitions of bench press (Cybex<sup>®</sup> 4024) and parallel squat (Cybex<sup>®</sup> 5341), and 3 sets of 5 repetitions of seated rowing (Cybex<sup>®</sup> 4010), leg curl (Cybex<sup>®</sup> 4110), leg extension (Cybex<sup>®</sup> 4105), and triceps extension (Cybex<sup>®</sup> 4035). Resistance was set at

80% of 1 repetition maximum (1RM). Following the determination of 1RM after 4 weeks of training, the training intensity was adjusted to 80% of the new 1RM. The performance of this resistance training session was supervised by strength coaches and student assistants/interns. At the end of each resistance training session, subjects gave completed training forms to the strength coaches to monitor progress.

#### *Muscle strength measurements*

The 1RM test was performed in bench press, leg press, and seated rowing. Before all tests the subjects performed a standardized warm-up consisting of three sets with gradually increasing load (50-75-85% of 1RM) and a decreasing number of repetitions (10-6-3). Thereafter, three to five repetitions were performed with 60-80% of the perceived maximum. Three to four subsequent attempts were then made to determine the 1RM, with a 5-min resting period between each lift. One-repetition maximum (1RM) was assessed for bench press and leg press with free weight machines, and for seated rowing with a weight machine (Cybex<sup>®</sup> 4010). During the 1RM testing, no injuries were observed.

#### *Body composition*

Body composition was measured using the bioelectrical impedance analysis method. Resistance and reactance measurements were made with a four-terminal bioelectrical impedance analyzer (Biodynamics Model 310 Body Composition Analyzer, Seattle, WA) using the procedures and anatomical sites described by Lukaski *et al.* [9].

#### *Blood sampling and biochemical measurements*

The blood sample was obtained from one of the forearm veins with a 20-gauge needle, syringe, and Vacutainer setup. In the morning, blood samples (20 ml) were collected between 7.30 and 8.30 a.m. to reduce the effects of any diurnal variations on the hormonal concentrations; they were stored in dark test tubes containing EDTA and then were refrigerated immediately. Blood was stored overnight in dark sealed boxes in a refrigerator at 4°C, and then centrifuged at 4°C at 3000 rpm for 10 minutes. All serum and plasma samples were then distributed to appropriate preservative tubes and stored at -20°C until analysis.

Serum was obtained for blood urea nitrogen (BUN), creatinine, aspartate transaminiferase (AST), and alanine transaminiferase (ALT), whereas EDTA plasma was obtained for testosterone analysis. The concentration of plasma testosterone was measured by the Chiron Diagnostics ACS: 180 automated chemiluminescence system (Chiron Diagnostics, Walpole, MA). On the other hand, the serum parameters were measured by a spectrophotometric technique (Johnson & Johnson DT-60II, Ortho-Clinical Diagnostics, Rochester, NY) by means of ultraviolet test kits (Ortho-Clinical Diagnostics). All the intra- and inter-assay percentage CVs for these parameters were less than 5%.

Statistical analyses

Data were analysed using SPSS 12.0.1 (SPSS Inc., Chicago, IL, USA), and the results are expressed as means ± SEMs. Differences between the groups in baseline subject characteristics, blood biomarkers, and muscle strength were evaluated with unpaired *t*-tests.

**TABLE 1.** CONCENTRATIONS OF BLOOD UREA NITROGEN (BUN), SERUM CREATININE, SERUM ASPARTATE TRANSAMINOFERASE (AST), AND SERUM ALANINE TRANSAMINOFERASE (ALT) IN THE PLACEBO (P) AND CORDYCEPS SINENSIS (CS) GROUPS BEFORE AND AFTER 8 WEEKS OF RESISTANCE TRAINING (N=8)

Variables and group	Week 0	Week 8
BUN (mg/dL)		
P	12.0 ± 0.7	12.5 ± 1.1
CS	14.2 ± 1.1	13.7 ± 1.2
Creatinine (mg/dL)		
P	1.3 ± 0.1	1.2 ± 0.1
CS	1.3 ± 0.1	1.3 ± 0.1
ALT (U/L)		
P	25.7 ± 4.6	27.7 ± 5.3
CS	35.7 ± 7.0	23.8 ± 4.5
AST (U/L)		
P	15.0 ± 0.9	16.5 ± 1.8
CS	25.1 ± 3.6	16.7 ± 2.1

Legend: All values are mean ± SEM. There was no significant effect of time, group, or time × group interaction (two-factor ANOVA; *p*>0.05).

**TABLE 2.** SUBJECT ANTHROPOMETRIC CHARACTERISTICS AND PLASMA TESTOSTERONE CONCENTRATIONS IN THE PLACEBO (P) AND CORDYCEPS SINENSIS (CS) GROUPS BEFORE AND AFTER 8 WEEKS OF RESISTANCE TRAINING (N=8)

Variables and group	Week 0	Week 8
Body height (cm)		
P	170.0 ± 3.1	—
CS	175.6 ± 1.8	—
Body mass (kg)		
P	69.2 ± 4.4	70.2 ± 4.5
CS	75.3 ± 5.1	75.8 ± 5.0
Body mass index		
P	23.9 ± 0.1	24.2 ± 1.0
CS	24.3 ± 1.4	24.5 ± 1.4
Fat-free mass (kg)		
P	59.7 ± 3.5	59.9 ± 3.3
CS	62.7 ± 2.6	61.7 ± 2.6
Body fat (%)		
P	13.7 ± 1.6	14.4 ± 1.7
CS	15.6 ± 2.2	17.5 ± 2.1
Plasma testosterone concentration (nmol/L)		
P	21.4 ± 1.6	22.5 ± 1.6
CS	23.2 ± 1.8	24.0 ± 2.9

Legend: All values are mean ± SEM. There was no significant effect of time, group, or time × group interaction (two-factor ANOVA; *p*>0.05).

To compare the effects of the placebo and CS interventions on the measured parameters, we compared the before- and after-training values. A two-factor ANOVA (group × training) was used to test for differences between the placebo and CS groups. *P* values were those generated by the type III tests of fixed effects for main effects and interactions. Values of *p* < 0.05 were considered significant.

RESULTS

Analysis of post-study questionnaires revealed that subjects who tolerated the supplementation protocol well have no reports of medical problems or symptoms. Table 1 represents some kidney and liver function enzyme results observed for the P and CS groups. There was no significant difference between groups after 8 weeks of supplementation in BUN, creatinine, ALT, and AST (*p*>0.05). These findings suggest that CS supplementation does not promote clinically significant changes in general markers of health.

Table 2 represents the results of the subjects' anthropometric characteristics and plasma testosterone concentrations that were observed for the P and CS groups. No significant change was observed between the P and CS groups after 8 weeks of supplementation in total body mass, body mass index, fat-free mass, percentage body fat, or plasma testosterone (*p*>0.05).

Table 3 represents the changes in muscle strength observed for the P and CS groups. No significant difference was observed between groups in 1RM bench press, leg press, or seated rowing (*p*>0.05).

DISCUSSION

We investigated the effects of CS supplementation during resistance training when the supplement was taken daily in young male adults for 8 weeks. To our knowledge, this is the first study to investigate the effect of CS supplementation during muscle strength training.

CS supplementation, as a potentiator of testosterone action in animals [5,7] would be expected to increase testosterone production in humans. Hypothetically, gains in testosterone would affect muscle

**TABLE 3.** ONE REPETITION MAXIMUM (1RM) MUSCLE STRENGTH IN THE PLACEBO (P) AND CORDYCEPS SINENSIS (CS) GROUPS BEFORE AND AFTER 8 WEEKS OF RESISTANCE TRAINING (N=8)

Variables and group	Week 0	Week 8	<i>p</i> for time effect
Bench press (kg)			
P	63.3 ± 1.7	69.2 ± 3.8	0.051
CS	62.0 ± 3.0	70.0 ± 3.5	
Leg press (kg)			
P	250.0 ± 9.3	290.0 ± 13.8	0.004
CS	266.0 ± 8.2	301.0 ± 13.8	
Seated rowing (kg)			
P	85.0 ± 1.8	89.2 ± 2.4	0.016
CS	81.0 ± 2.6	90.5 ± 2.7	

Legend: All values are mean ± SEM. Two-factor ANOVA for the effect of group, time, and time × group interactions was applied; only the time effect was significant (*p* < 0.05) in both groups for the variables indicated on the right.

mass and body composition, and result in increased muscle strength. We therefore postulated that blood testosterone concentration, fat-free mass, and muscle strength would increase more in our CS group than in the placebo group. However, the results of the present study showed no effect of CS on any of the dependent variables measured. This result suggested that the effect of CS supplementation in animals to increase testosterone production may not be similar to that in humans. Consequently, this experiment clearly showed that this commercial product provides no androgenic, anabolic, or ergogenic effect during eight weeks of supplementation in young adult males.

We are not dealing with the ergogenic effect of CS on endurance exercise; but it is interesting to note that we are aware of three published studies that have reported the effects of CS supplementation during endurance exercise [2,3,11]. These studies show in full detail that CS has no ergogenic benefit for endurance exercise. All the findings including our present study appear to contrast with the studies conducted on animals as well as marketing claims that CS supplementation may possess ergogenic value for endurance and resistance exercise performance. Moreover, Herda's recent study also showed that a single dose of *Cordyceps sinensis* commercial formula supplement 1 hour prior to exercise did not increase muscle strength or muscle endurance [4].

On the other hand, results of the kidney and liver enzyme analyses performed in the present study reveal that CS supplementation is comparatively safe and does not expedite clinical changes in general markers of health. In other words, it is evident that CS supplementation has no detrimental effect on the kidney and liver.

Millions of power lifters and strength athletes use ergogenic aids, which are substances that purport to improve lean mass and increase strength during training. Unfortunately, these ergogenic aids are not effective. A recent review of the literature by Kreider *et al.* [8] indicated that some have been marketed as supplements to increase strength during training and are apparently ineffective. Such ineffective supplements include boron, chromium, *Cystoseira canariensis*, gamma oryzanol, glutamine, isoflavones, *Smilax officinalis*, and *Tribulus terrestris* [8].

Previous research indicated that CS supplementation increased testosterone concentrations in both plasma and testes of test animals [5,7]. Theoretically, if CS supplementation produced similar effects in humans, CS supplementation might allow circulating testosterone levels to be increased. The results of the current investigation do not agree with previous studies in animals. We conclude that CS does not appear to possess significant ergogenic value for resistance-trained young male adults.

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