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The Effect of Five Weeks of *Tribulus terrestris* Supplementation on Muscle Strength and Body Composition During Preseason Training in Elite Rugby League Players

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Abstract. Rogerson, S., C.J. Riches, C. Jennings, R.P. Weatherby, R.A. Meir, and S.M. Marshall-Gradisnik. The effect of five weeks of *Tribulus terrestris* supplementation on muscle strength and body composition during preseason training in elite rugby league players. *J. Strength Cond. Res. 21(2):348–353. 2007.*—*Tribulus terrestris* is an herbal nutritional supplement that is promoted to produce large gains in strength and lean muscle mass in 5–28 days (15, 18). Although some manufacturers claim *T. terrestris* will not lead to a positive drug test, others have suggested that *T. terrestris* may increase the urinary testosterone/epitestosterone (T/E) ratio, which may place athletes at risk of a positive drug test. The purpose of the study was to determine the effect of *T. terrestris* on strength, fat free mass, and the urinary T/E ratio during 5 weeks of preseason training in elite rugby league players. Twenty-two Australian elite male rugby league players (mean ± *SD*; age = 19.8 ± 2.9 years; weight = 88.0 ± 9.5 kg) were match-paired and randomly assigned in a double-blind manner to either a *T. terrestris* (n = 11) or placebo (n = 11) group. All subjects performed structured heavy resistance training as part of the club's preseason preparations. A *T. terrestris* extract (450 $mg \cdot d^{-1}$) or placebo capsules were consumed once daily for 5 weeks. Muscular strength, body composition, and the urinary T/E ratio were monitored prior to and after supplementation. After 5 weeks of training, strength and fat free mass increased significantly without any between-group differences. No between-group differences were noted in the urinary T/E ratio. It was concluded that *T. terrestris* did not produce the large gains in strength or lean muscle mass that many manufacturers claim can be experienced within 5–28 days. Furthermore, *T. terrestris* did not alter the urinary T/E ratio and would not place an athlete at risk of testing positive based on the World Anti-Doping Agency's urinary T/E ratio limit of 4:1.

Key Words. dietary supplement, performance, drug testing, T/E ratio

Introduction

Tribulus terrestris is an herbal nutritional supplement that is claimed to have performance enhancing capabilities that has ensured the success of many top Bulgarian weightlifters (6). However, its availability in countries outside of Europe has been limited until recent years. Possibly due to its claimed ergogenic effects, *T. terrestris* has become an extremely popular nutritional supplement among athletes. Marketing campaigns claim that athletes supplementing with *T. terrestris* will experience large gains in strength in very short periods of time. One company has suggested that gains in muscle strength are evident after only 14 days of *T. terrestris* supplementation (15). Other companies claim that gains of up to 20 kg in 1 repetition maximum (1RM) bench press have been achieved after 3 weeks of *T. terrestris* supplementation in highly trained power lifters (2).

Marketing campaigns for the success of *T. terrestris* on gains in lean muscle mass also claim substantial benefits to the user in very short periods of time. It has been suggested that when *T. terrestris* is used in combination with an effective training program and a high protein diet, it is possible to gain several pounds of lean muscle mass in the first 3–4 weeks (15). Other companies promote even greater gains, with one company implying that its *T. terrestris* product can allow users to gain up to 10 pounds of muscle mass in 5 days (18).

The proposed mechanism for the claimed effects of *T. terrestris* on strength and lean muscle mass is an increase in the circulating concentrations of endogenous luteinizing hormone (LH) and testosterone. This effect is claimed to be mediated via steroidal saponins within the *T. terrestris*, which purportedly block central testosterone receptors (19). However, most manufacturers are very elusive when outlining the mechanism of action. Rather, companies that produce this supplement focus predominantly on marketing the ergogenic effects of *T. terrestris* while avoiding any detailed examination into the claimed mechanism(s) of action.

Despite the claims, very little scientific research has investigated the ergogenic effects of *T. terrestris*. Antonio and coworkers (1) reported that *T. terrestris* had no effect on body composition or a test of muscular endurance during an 8-week resistance training program. Similar results were reported by Brown and coworkers (3) who investigated the effect of a commercial product called ANDRO-6 containing *T. terrestris* combined with a number of other herbal products and the prohormones dehydroepiandrosterone and androstenedione. It was reported that ANDRO-6 had no effect on strength or body composition during an 8-week resistance training program (3).

Tribulus terrestris is not listed specifically as a prohibited substance by the World Anti-Doping Agency (WADA) (20), and some manufacturers claim that it will not be detected in an athlete's urine (6). However, one company suggests that its *T. terrestris* product will increase the urinary testosterone/epitestosterone (T/E) ratio to 6:1 (14). The urinary T/E ratio is the key measure to detect testosterone abuse (20). Normal urinary T/E ratios are approximately 1:1 and if the ratio exceeds 4:1, an

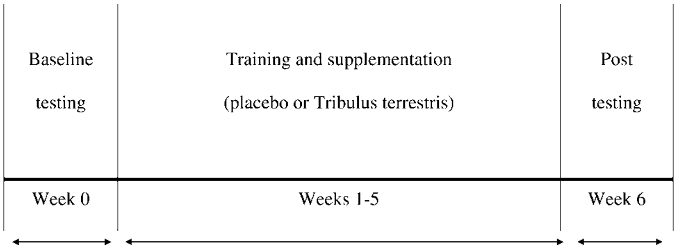

FIGURE 1. A schematic of the experimental design.

TABLE 1. Mean ± *SD* age, height, weight, and weight training experience of subjects (n = 22).

	Tribulus terrestris	Placebo
n	11	11
Age (y)	20.5 ± 3.8	19.0 ± 1.3
Weight (kg)	88.5 ± 10.5	87.6 ± 9.0
Height (cm)	182.5 ± 3.5	180.7 ± 5.0
Weight training experience (mo)	36.5 ± 29.4	33.3 ± 15.5

athlete is monitored for 3 months to determine if a doping infraction has occurred (20). Therefore, if *T. terrestris* can increase the urinary T/E ratio as is implied by one manufacturer, it may cause athletes to inadvertently test positive for testosterone.

Tribulus terrestris is now a very popular nutritional supplement among athletes, most likely as a result of its claimed ergogenic effects. At present, the claims that *T. terrestris* can produce large gains in muscle strength and lean body mass in less than 4 weeks (15, 18) appear to be unfounded. Furthermore, there is no scientific research that has investigated whether *T. terrestris* may increase the urinary T/E ratio and thus place an athlete at risk of a positive drug test. The purpose of this study was to determine if *T. terrestris* supplementation facilitated gains in strength and lean body mass during 5 weeks of preseason training in elite Australian rugby league players and to determine if *T. terrestris* could cause an athlete's urinary T/E ratio to exceed the 4:1 limit imposed by WADA.

METHODS

Experimental Approach to the Problem

The study utilized a double-blind, placebo-controlled 2-group design with random assignment. Baseline testing was conducted prior to supplementation and included assessment of muscle strength, fat free mass, body mass, and the urinary T/E ratio. Following baseline testing, subjects were match-paired based on physical characteristics, strength, and training background. Both groups of subjects followed the same 5-week strength and conditioning program, which was prescribed by the head strength and conditioning coach of the professional rugby league team to which the subjects were contracted. During training, group 1 received 450 mg of a *T. terrestris* extract (Body Science, Sydney, Australia) in capsule form consumed once daily for 5 weeks (Figure 1). According to the manufacturers, the *T. terrestris* extract was standardized at 60% steroidal saponins. Group 2 received an equivalent amount of placebo containing inert herbs identical in appearance to the *T. terrestris* and prepared at Southern Cross University. Subjects were retested postsupplementation (week 6) in a manner identical to baseline testing.

Because the research was investigating a supplement purported to increase muscle protein synthesis and anabolism, supplementary protein was allocated to both groups to control against inadequate protein intakes. The supplementary protein consisted of Whey Protein Concentrate (Body Science) administered at a dosage of 60 $g \cdot d^{-1}$. The protein was allocated in two 30-g sachets with instructions being that 1 sachet was to be consumed in the morning and the other in the evening. Compliance with prescribed supplement intakes of both the capsules and protein sachets was monitored by way of supplement diaries and through periodic assessment by the club's strength and conditioning coach.

Subjects

Twenty-four elite male rugby league players participating within a preseason strength and conditioning program and who were members of the cadet or premier divisions of an Australian National Rugby League club were recruited for this study. Injuries sustained during preseason trial matches precluded 2 subjects from completing the study. The characteristics for the remaining 22 athletes are outlined in Table 1. Subjects were informed of the experimental procedures and signed an informed consent document approved by the Human Research Ethics Committee of Southern Cross University (ECN-03-119). Prior to initial data collection and supplement allocation, each subject completed a medical screening questionnaire designed to evaluate current and previous health status and any current medication being utilized. Input from the head strength and conditioning coach and information from the club records were used to identify athletes who had a minimum of 12 months' resistance training experience, with particular emphasis on the athletes who were highly familiar with the lifts used to monitor strength changes. At the commencement of the study, subjects reported being free from the use of nutritional supplements and nonprescription drugs. All athletes included in the study were liable for random drug testing under Australian government regulation for sport.

Experimental Procedures

Body Composition and Body Mass. Fat free mass was monitored by way of multi-frequency bioelectric impedance (Maltron, Brisbane, Australia). National Institutes of Health standardization procedures for bioelectrical impedance were followed (13). Analysis was conducted at a standardized time after a 12-hour overnight fast. Prior to analysis, subjects emptied their bladders and body mass was recorded to 0.1 kg using electronic scales (Avery ctr, Australia). Height was measured to within 0.5 cm using a wall-mounted measure (Inter 16; Seca, Hamburg, Germany). Athletes then were directed to rest on a nonconducting table in a supine position with arms and legs slightly abducted for 20 minutes. Electrode sites were then prepared by shaving the site, exfoliating the outer skin surface, and wiping with an alcohol wipe. After the first analysis the electrodes were removed, the site was cleaned with an alcohol wipe, and a duplicate reading was attained within 5 minutes of the initial reading. The test-retest reliability for fat free mass (kg) using this protocol was deemed to be high (intraclass correlation [ICC], R = 0.994).

Isotonic Strength. The subjects were highly familiar with all of the exercises utilized in the strength testing, because they were part of a test battery traditionally used by the club to monitor strength changes throughout the

Table 2. Mean daily total energy and macronutrient intakes averaged from the 3-day dietary intakes recorded during weeks 1, 3, and 5.

	Protein ($g \cdot kg^{-1} \cdot d^{-1}$)	CHO* ($g \cdot d^{-1}$)	Fat ($g \cdot d^{-1}$)	Total energy ($kcal \cdot d^{-1}$)
Tribulus terrestris ($n = 11$)	2.7 ± 0.6	393 ± 91	157 ± 28†	4,025 ± 653
Placebo ($n = 10$)	2.7 ± 0.5	411 ± 69	128 ± 29	3,840 ± 351

* CHO = carbohydrate.
† Significantly different from placebo group.

training year. Two repetition maximum strength was established for the bench press, leg press, deadlift, and seated row exercises. The bench press was performed on a standard flat bench using an Olympic bar and free weights, whereas the remaining lifts were performed on machines able to be loaded with Olympic free weight plates. Following 2 standardized warm-up sets, each athlete attempted progressively heavier resistances until a 2RM was achieved. In order to minimize the potential effects of fatigue, resistance was selected and was applied to achieve the final 2RM load within 2–5 trials (4). This was facilitated by the utilization of each athlete's strength testing data from the previous season. Verbal encouragement and group testing were implemented to assist in ensuring maximal efforts (11). The test-retest reliability of the 2RM protocol was monitored in 15 subjects for the bench press (ICC, $R = 0.997$), leg press (ICC, $R = 0.999$), seated row (ICC, $R = 0.993$), and deadlift (ICC, $R = 0.998$), and was deemed to be highly reliable. An injury sustained in the days prior to the final testing sessions prevented 1 subject from completing the second strength testing session. Consequently, the strength analyses were conducted on only 21 subjects (*T. terrestris*, $n = 11$; placebo, $n = 10$).

Urinary T/E Ratio. A single urine sample was collected from each athlete at a standardized time of day during week 0 and week 6 of the experimental period. The sample was stored at −20° C prior to being analyzed via gas chromatography-mass spectrometry for the T/E ratio, according to the methods outlined previously (7). Samples were analyzed at the Australian Sports Drug Testing Laboratory, which is a WADA-accredited drug testing laboratory. One sample marginally exceeded the 4:1 cutoff at the pretesting (6.63) and posttesting time points (5.79). However, naturally high T/E ratios have been reported previously (7). The WADA rules state that a T/E ratio between 4 and 10 leads to an athlete being subject to further monitoring. If the T/E ratio does not remain constant, a doping infraction is incurred (20). In this case, although the T/E ratio was high, it was relatively stable between time points and therefore was considered appropriate for inclusion in the data set.

Dietary Intake. To monitor dietary intakes throughout the research period, athletes were provided with a dietary intake booklet in which they were required to record 3-day dietary intakes during weeks 1, 3, and 5. The food diaries required that athletes record all dietary intakes, including food and drink items, portions, and cooking methods. The 3-day intakes were analyzed using commercial nutritional software (SERVE Nutrition Management System; M and H Williams Pty. Ltd., St. Ives, Australia). The nutritional intakes were analyzed for their total energy and macronutrient intake (Table 2).

One subject in the placebo group reported being sick for 2 days during the first 3-day dietary monitoring period. This athlete's data were eliminated, because the low intakes corresponding to these days would have provided an inaccurate representation of the individual athlete's, and potentially the groups', typical daily intake. Therefore, the dietary analysis was conducted on only 21 subjects. The average daily fat intake was significantly higher in the *T. terrestris* group ($p < 0.05$). Average daily carbohydrate, protein, and energy intake was very similar among athletes, with no significant differences between groups.

Training. The study was conducted during the preseason, after athletes had undergone a 6-week off-season phase. The training program was designed by the club's head strength and conditioning coach; the emphasis during the research period was on developing muscular strength and hypertrophy. All athletes participated in 4 structured resistance training sessions per week.

Resistance training sessions were categorized as: (a) strength/hypertrophy; (b) strength/endurance; or (c) strength/power, depending on the primary focus. To achieve these training objectives, athletes were required to work within the following repetition ranges per set: 2–8 for strength/hypertrophy and 1–4 for strength/power. Interset recoveries were prescribed at 2 minutes for strength/hypertrophy sessions and 3–5 minutes for strength/power sessions. Once the athlete could lift more than the prescribed number of repetitions, he increased the load to ensure that he worked at the prescribed RM intensity. Strength/endurance sessions utilized 40 repetitions per set in a multiple-exercise, circuit-style protocol. This session utilized a standardized workload for all athletes and required athletes to complete the circuit format in the shortest possible time. Each strength/endurance session was timed, and athletes aimed to reduce the amount of time that was required to complete the circuit each week.

Resistance training was conducted on Monday, Tuesday, Thursday, and Friday of each week; sessions were cycled among upper body, lower body, and whole body emphasis. Because functional strength was a primary goal, multi-joint compound exercises such as deadlifts, squats, power cleans, bench presses, and chin-ups constituted the core of the program. During the 5-week training period, athletes were scheduled to complete 20 resistance training sessions. This consisted of 7 lower body strength/hypertrophy sessions, 5 upper body strength/hypertrophy sessions, 3 upper body strength/endurance sessions, and 5 total-body strength/power sessions. A sample session for each of the focus areas is presented in Table 3. All athletes were required to complete a minimum of 18 sessions in order for their data to be included in the analysis. All sessions were supervised closely by club strength and conditioning coaches; all subjects were required to complete club training diaries. The average training volume per session was calculated for each subject as resistance × sets × repetitions. The mean group training volumes for the upper body, lower body, and whole body resistance training sessions are outlined in Table 4. Training volumes over the 5 weeks were highly similar, and there were no statistically significant differences between the groups.

Blinding. At the termination of the study, athletes were provided with a questionnaire assessing how effective the blinding procedures had been. Eighteen of the subjects (82%) were unable to determine whether they had been in the *T. terrestris* or the placebo group. The remaining 4 subjects (18%) indicated they had an inkling

TABLE 3. An example of a typical session for upper body strength/hypertrophy, lower body strength/hypertrophy, whole body strength/endurance, and whole body power within the club's strength and conditioning program.

Lower-body strength/hypertrophy	Upper-body strength/hypertrophy	Whole-body strength/endurance	Whole-body power
4 sets of 2–8 reps Interset recovery: 2 min	4 sets of 2–8 reps Interset recovery: 2 min	2 continuous circuits (40 reps per exercise*)	4 sets of 1–4 reps Interset recovery: 3–5 min
Exercises	Exercises	Exercises	Exercises
Leg press	Bench press	Bench press 60 kg	Bench press
Hack squat	Shrug	Shoulder press 25 kg	Shoulder press
Free weight squat	Dumbbell rows	Shrugs 80 kg	Leg press
Hamstring curl	Lat pull-down	Dips (body weight)	Lat pull-down
Power clean	Jammer	Chin-ups narrow grip (body weight)	Deadlift
Calf raises	Chin-ups	Chin-ups wide grip (body weight)	

* The strength endurance session used a fixed load for all athletes, with the aim being to complete the circuits in the shortest possible time.

TABLE 4. Mean training volumes per session for lower body, upper body, and whole body training sessions during the 5-week resistance training period.*

	Lower body	Upper body	Whole body
Tribulus terrestris ($n = 11$)	15,143 ± 1,514 kg	6,817 ± 998 kg	8,204 ± 762 kg
Placebo ($n = 11$)	15,394 ± 2,085 kg	6,715 ± 569 kg	8,120 ± 1,207 kg

* Training volume = resistance × sets × repetitions.

TABLE 5. Group means for the strength measures.

Group	Bench press (kg)	Leg press (kg)	Deadlift (kg)	Seated row (kg)
Tribulus terrestris				
Week 0	108.0 ± 13.8	418.5 ± 41.2	208.0 ± 23.9	166.5 ± 24.9
Week 6	123.5 ± 10.6*	538.5 ± 41.9*	251.5 ± 23.3*	184.2 ± 17.6*
Placebo				
Week 0	108.6 ± 12.9	418.2 ± 62.5	211.8 ± 33.5	157.3 ± 21.5
Week 6	120.4 ± 10.5*	523.2 ± 55.3*	248.6 ± 32.7*	173.4 ± 14.7*

* Significantly different compared with week 0.

as to the group to which they had been assigned; of these 4, only 1 was correct. This suggests that the blinding procedures were successful and that this study was conducted under strict double-blind conditions.

Statistical Analyses

All data are reported as mean ± *SD* and all statistical analysis was performed using SPSS (version 9.0.1; SPSS, Inc., Chicago, IL). Statistical analysis was conducted using a 2 × 2 group (*T. terrestris*, placebo) × time (week 0, week 6) analysis of variance (ANOVA) with repeated measures. Statistical significance was set at $p \leq 0.05$. When a significant *F*-ratio was identified, a Fisher's least significant difference test was used to locate the pairwise differences between means. Effect sizes for strength and body composition were calculated according to methods outlined previously (16). Prior to beginning supplementation, subjects were match-paired and a 1-way ANOVA was applied to the potential groups to ensure there were no differences between groups on any variable. Dietary intakes and average training volumes were analyzed via a 1-way ANOVA.

RESULTS

Strength

In Table 5, the 2RM strength data are presented. The 2RM strength increased significantly ($p < 0.001$) from week 0 to week 6 in all 2RM strength measures with no significant differences between groups. The effect sizes for the changes in strength are outlined in Table 6.

Body Mass and Fat Free Mass

No statistically significant changes were noted in body mass (Figure 2). There was a strong trend toward an increase in body mass between week 0 and week 6 irrespective of group, however, this failed to reach statistical significance ($p = 0.07$). Fat free mass is presented in Figure 3. Fat free mass increased significantly ($p < 0.01$) from week 0 to week 6 with no significant differences between groups. The effect sizes for body mass and fat free mass are presented in Table 6.

Urinary Testosterone/Epitestosterone ratio

No significant changes were noted in the urinary T/E ratio between week 0 and week 6 (Figure 4).

DISCUSSION

It has been claimed that elite power lifters using *T. terrestris* have increased their 1RM bench press by an average of 20 kg in only 3 weeks (2). Other supplement manufacturers have indicated that *T. terrestris* can produce gains in lean muscle mass of up to 10 pounds (4.5 kg) in only 5 days (18). In the present study, 5 weeks of supplementation with *T. terrestris* did not have any significant effect on strength, body mass, or fat free mass in elite rugby league players. The significant gains in strength and fat free mass during the research period,

TABLE 6. The effect sizes for strength, fat free mass, and body mass.*

	Pre-Post effect size week 0 to week 6	Treatment effect size† (TT – P)
2RM bench press		
Placebo	0.9	
Tribulus terrestris	1.1	0.2
2RM leg press		
Placebo	1.7	
Tribulus terrestris	2.9	1.2
2RM deadlift		
Placebo	1.8	
Tribulus terrestris	1.1	0.7
2RM seated row		
Placebo	0.7	
Tribulus terrestris	0.7	0.0
Fat free mass		
Placebo	0.1	
Tribulus terrestris	0.1	0.0
Body mass		
Placebo	0.1	
Tribulus terrestris	0.1	0.0

* 2RM = 2 repetitions maximum.
† Treatment effect size is calculated by subtracting the Pre-Post effect size for the placebo (P) group from the Pre-Post effect size of the *Tribulus terrestris* (TT) group (16).

irrespective of group, indicate that the resistance training program was sufficient to promote a training adaptation. The calculated effect sizes for each 2RM strength measure were varied and were not consistent across the 4 exercises (Table 6). The finding of no significant effect on strength or fat free mass is in agreement with the two previous studies investigating the proposed ergogenic effects of *T. terrestris* (1, 3).

The strength values observed in this study are in line with those reported previously for professional rugby league players (12). The strength gains were higher than anticipated, given the training status of the athletes (Table 5). This may be a consequence of the timing of the research in relation to the competition year. Previous research has reported that a loss of strength occurs across the competitive season in football players (17). Furthermore, the present study was conducted during the preseason, which was preceded by a 6-week off-season break. Although athletes remained active during the off-season break, formal structured training was not implemented during this period. Hence, some loss of training adaptations may have occurred during both the former competitive season and the 6-week off-season break. Although the strength gains were higher than anticipated, gains were of very similar magnitude between groups, indicating that the groups were well matched at the beginning of the study.

The present study was designed in an attempt to overcome several of the limitations of the two previous *T. terrestris* studies. It is known that tests with poor test-retest reliability are unsuitable for monitoring performance between trials (9). Neither Brown and coworkers (3) nor Antonio and coworkers (1) reported the test-retest reliability of the strength tests in the populations they tested or how familiar the subjects were with the testing protocol implemented. In an attempt to reduce measurement error in the present study, the club's standard performance test

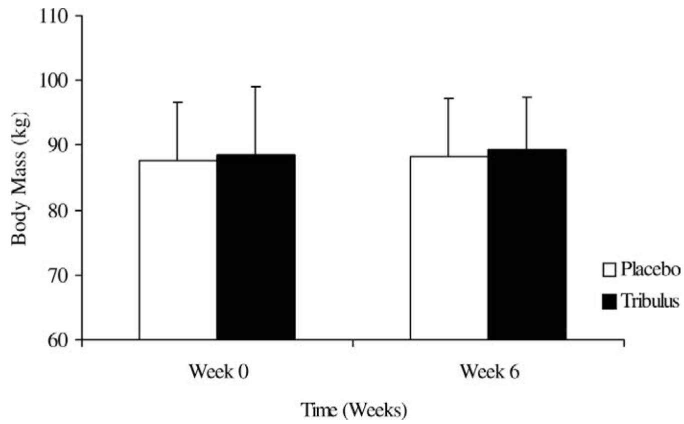

FIGURE 2. Mean body mass (kg) for 5 weeks *Tribulus terrestris* (n = 11) and placebo (n = 11) administration at week 0 and week 6. Error bars are ± *SD*.

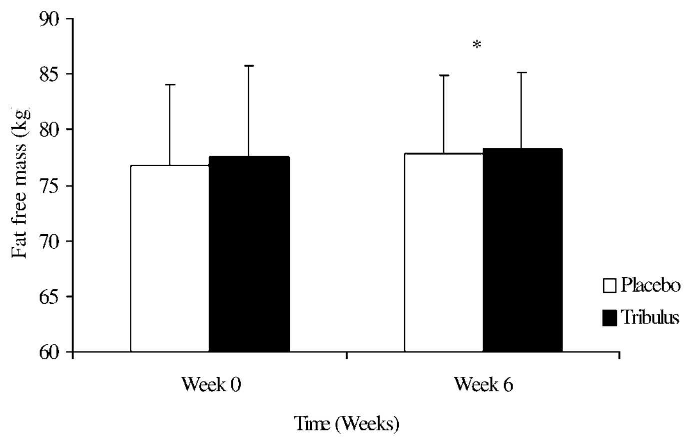

FIGURE 3. Mean fat free mass (kg) after 5 weeks *Tribulus terrestris* (n = 11) and placebo (n = 11) administration at week 0 and week 6. * Significantly different compared with week 0. Error bars are ± *SD*.

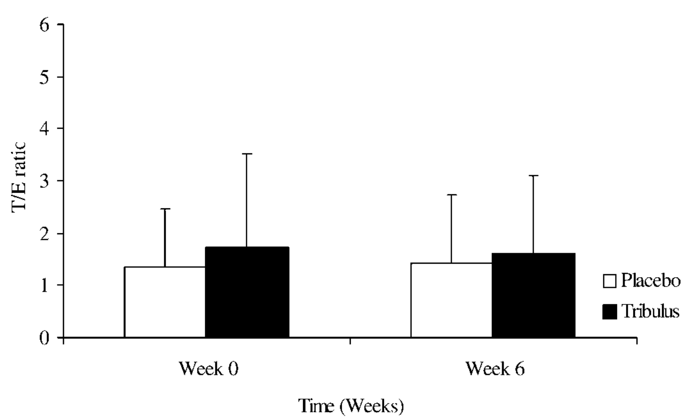

FIGURE 4. Mean urinary testosterone/epitestosterone (T/E) ratio for 5 weeks of *Tribulus terrestris* (n = 11) and placebo (n = 11) administration at week 0 and week 6. Error bars are ± *SD*.

battery was utilized. This ensured that the athletes were highly familiar with the testing procedures and reduced the potential measurement errors originating from learning effects. The test-retest reliability for the 2RM strength tests was deemed to be very high (ICC, R = 0.993–0.999). This is likely a consequence of the fact that all athletes were highly familiar with the testing protocols. Consequently, the inability to detect an effect of *T. terrestris* on strength in the present study is unlikely to be attributed to measurement error originating from poor test-retest reliability of the performance tests.

Some companies claim that *T. terrestris* should be supplemented with a high-protein diet to maximize its anabolic potential (15). Antonio and coworkers (1) suggested that the protein intakes of the subjects in their study may have been insufficient to promote gains in lean muscle mass. To control for inadequate protein intake in the present study, supplementary protein was allocated to all athletes. It has been suggested that minimum daily protein intakes for athletes involved in heavy resistance training may need to be as high as $1.7 \text{ g}\cdot\text{kg}^{-1}\cdot\text{d}^{-1}$ (10). The average daily protein intake of the subjects in both the placebo and *T. terrestris* groups was $2.7 \text{ g}\cdot\text{kg}^{-1}\cdot\text{d}^{-1}$ (Table 2). Therefore, insufficient protein availability would not seem to be an explanation for the inability of *T. terrestris* to increase fat free mass in the present study.

It has been suggested that one of the factors that has discouraged controlled investigations of the effects of herbal supplements on physical performance is the difficulty in identifying the active components of herbs (5). An increase in blood LH and testosterone concentrations as a consequence of steroidal saponins binding to central testosterone receptors is the proposed mechanism of action by which *T. terrestris* increases strength and lean body mass. However, no data from any independent scientific research (1, 3), including this study, have provided support for the claims that *T. terrestris* can produce gains in strength and lean muscle mass.

The urinary T/E ratio is the key measure to detect exogenous testosterone use in athletes (20). Normal urinary T/E ratios are approximately 1:1, and if the ratio exceeds 4:1, an athlete is monitored for 3 months to determine if a doping infraction has occurred (20). One company implies that its *T. terrestris* product increases the ratio to 6:1 (14). This claim suggests that *T. terrestris* supplementation may place athletes at risk of inadvertently testing positive for testosterone. This study is the first to investigate the effect of *T. terrestris* on the urinary T/E ratio. In the current study, urinary T/E ratios were in line with those reported previously (7). The T/E ratios remained stable across time with no significant differences in either the placebo or *T. terrestris* group (Figure 4). Therefore, these data do not support the claim that *T. terrestris* increases the urinary T/E ratio.

PRACTICAL APPLICATIONS

The use of *T. terrestris* at the dosage investigated in the present study does not appear to produce the large gains in muscle strength or lean muscle mass that many manufacturers claim can be experienced in 5–28 days (15, 18). Furthermore, although *T. terrestris* did not alter the urinary T/E ratio in the present study, the purity of commercial nutritional supplements can vary among manufacturers. Contamination of nutritional supplements with prohibited substances not stated on the label has been reported previously (8). Therefore, the data presented in this study do not guarantee that an athlete purchasing a commercial *T. terrestris* product will not test positive for a prohibited substance.

It is advised that coaches and athletes wanting to increase strength and lean muscle mass utilize training and nutritional practices that are supported by independent scientific studies. At this point in time, *T. terrestris* has no scientific evidence to support claims that it can produce large gains in muscle strength and lean body mass in very short time periods.

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