The Effects of Deer Antler Velvet Extract or Powder Supplementation on Aerobic Power, Erythropoiesis, and Muscular Strength and Endurance Characteristics

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To determine the effects of deer antler velvet on maximal aerobic performance and the trainability of muscular strength and endurance, 38 active males were randomly assigned in a double-blind fashion to either deer antler velvet extract (n = 12), powder (n = 13), or placebo groups (n = 13). Subjects were tested prior to beginning supplementation and a 10-week strength program, and immediately post-training. All subjects were measured for circulating levels of testosterone, insulin-like growth factor, erythropoietin, red cell mass, plasma volume, and total blood volume. Additionally, muscular strength, endurance, and VO$_{2\text{max}}$ were determined. All groups improved 6 RM strength equivalently (41 ± 26%, p < .001), but there was a greater increase in isokinetic knee extensor strength (30 ± 21% vs. 13 ± 15%, p = .04) and endurance (21 ± 19% vs. 7 ± 12%, p = .02) in the powder compared to placebo group. There were no endocrine, red cell mass or VO$_{2\text{max}}$ changes in any group. These findings do not support an erythropoetic or aerobic ergogenic effect of deer antler velvet. Further, the inconsistent findings regarding the effects of deer antler velvet powder supplementation on the development of strength suggests that further work is required to test the robustness of the observation that this supplement enhances the strength training response and to ensure this observation is not a type I error.

Key Words: ergogenic aid, training, erythropoietin, VO$_{2\text{max}}$, blood volume, muscle

Introduction

Deer antler products have recently gained popularity as beneficial supplements for both health and sport performance. In New Zealand two forms of deer antler
supplements are being manufactured that require different methods of processing: Deer antler velvet extract is made through both aqueous and organic extraction systems, while deer antler velvet powder is heat or freeze dried and then ground to a powder (16). Analysis of New Zealand deer antlers indicate that they contain the minerals calcium, phosphorus, sulfur, magnesium, potassium, sodium, manganese, zinc, copper, iron, selenium, and cobalt, as well as amino acids and free fatty acids (16). Insulin-like growth factors I and II have been isolated in deer antler velvet tips and aqueous extracts of deer antler velvet tips (15). In New Zealand, the recommended dose of dry powder is between 250–1200 mg/day, while the most common dose consumed is about 500 mg/day. There is no scientific basis for these recommendations.

A number of health and human performance effects have been ascribed to deer antler, most of which appear to be based largely on anecdotal reports rather than scientific research. In the literature available from Russian, Korean, and Chinese sources, there is constant reference made to the “tonic” effects of various deer antler preparations for humans (1). Specifically, it has been suggested that deer antler velvet has uses as an immunopotentiating agent based on studies of cultured lymphocytes; has anti-inflammatory properties based on research with mice; and has protein synthesis and anabolic qualities based on research with mice and rats (15, 17, 18). Antler products have also been referred to as “anti-fatiguing” agents, and it has been suggested that they contain a potent erythropoietic substance that may enhance muscular endurance, although this research is based on rabbit data (14).

Little research on the effects of supplementation with deer antler products has been reported in humans. One study suggested gonadotrophic effects from deer antler velvet and reported that deer antler velvet improved the athletic performance of sportsmen tested over a 3000-m run (20). No valid conclusions can be drawn from this poorly controlled study, however, since it was not of a double-blind design and the results were poorly reported and difficult to interpret. A recent double-blind placebo controlled study in New Zealand on the effects of deer antler velvet extract supplementation (70 mg/day) on the response of males (n = 8 each for supplement and placebo groups) to an 8-week strength training program resulted in a statistically non-significant but positive trend toward an improvement in muscular endurance in athletes, but the mechanism for this trend could not be explained (7). The dosages used in the pilot study were lower than those typically recommended to the public, and power analysis revealed that the sample size was insufficient.

Given the limitations of this pilot work and the paucity of well-controlled research examining potential health and human performance benefits of deer antler velvet supplementation, the present study was undertaken with a larger sample size (increased from n = 8/group to n = 12/group) and using higher dosages of deer antler supplements. We were also interested in whether the two common methods for processing deer antler supplement—freeze drying (powder) versus organic and aqueous extraction (extract)—influenced the effect of this supplement. The purpose of this study was therefore to determine whether supplementation with deer antler velvet extract or powder (a) enhanced the extent of strength and muscular endurance adaptation resulting from a 10-week strength training program in male athletes and to determine whether changes in the levels of anabolic hormones occurred that could explain any alterations in muscular strength or endurance; and (b) to determine whether deer antler velvet extract or powder had erythropoietic properties that might enhance aerobic power.
Methodology

The Southern Regional Health Authority Ethics Committee approved this study. After giving informed consent, 51 active male subjects (3 groups of 17) between 19 and 24 years old were recruited for this randomized double-blind study. The majority of the participants were physical education students and were active in sports. None of the recruited subjects had been actively strength training over the last 3 months. Subjects were asked whether they were consuming any dietary supplements, and only those subjects self-reporting no dietary supplementation participated in the study.

Study Design

Physiological testing took place over a 2-week period of pre-training (weeks 1 and 2) and a 2 week period of post-training (weeks 13 and 14). Strength testing also occurred weekly to aid in the proper prescription of training load. All participants were asked not to participate in any strenuous activity for 24 hours prior to any testing. Participants were tested twice in order to minimize the learning effect associated with testing procedures and ensure that maximal scores were attained in each test. Immediately following completion of the pre-testing, the participants were split into 3 groups in a randomized double-blind procedure that ensured all groups had similar mean preliminary strength. Subjects were assigned capsules of either deer antler velvet extract (300 mg/day), deer antler velvet powder (1.5 g/day), or a placebo capsule containing hydroxypropyl methylcellulose, and consumed assigned pills once daily from week 3 until the end of the last physiological test (week 14). These dosages were higher than those we used in a pilot study (70 mg/day), and in the pilot study we only studied deer antler velvet extract. The velvet powder dosage levels were chosen in accordance with standard doses used in traditional Chinese medicine (1–2 g/day). The dose of velvet extract was based upon approximate extraction efficiency from velvet powder (~20%), and the extract used in the experiment was prepared from the same batch of velvet used in the powder capsules. The capsules were identical in appearance. We indirectly checked that the subjects consumed the capsules by allotting the capsules to the subjects on a weekly basis and requiring subjects to bring their capsule bottles to the laboratory once weekly for examination and re-filling.

Strength training started at the beginning of week 3 and continued for 10 weeks (week 3 to 12). All testing and training was identical for the three groups of participants. Thirty-eight subjects completed the study. The majority of the subjects that dropped out of the study felt the training and testing protocol was too intense and interfered with other activities and studies. Two subjects dropped out because of injury, and 2 others completed the study but did not complete the full physiological testing protocol because of injury.

Anthropometrics

Body mass and standing height were measured with the subjects wearing light clothing and no shoes. Eight skinfolds were lifted and measured using a skinfold caliper (Harpenden, Herts, UK) according to the International Society for the Advancement of Kinanthropometry (ISAK) protocol (11). The sum of the eight skinfolds (SO8S) was calculated and recorded.
Muscular Strength and Endurance

Muscular strength was assessed using two methods. First, subjects were tested using an isoinertial parallel squat exercise. The amount of weight that subjects could lift six but not seven times (six-repetition maximum = 6 RM) was assessed on a parallel squat machine (Smith machine, Fitness Works, Auckland, NZ). Second, concentric isokinetic strength of the knee extensors was tested on an isokinetic dynamometer (Biodex Corporation, Shirley, NY, USA) at an angular velocity of 1.05 rad · s⁻¹, and all torque measures were corrected for the effects of gravity using the manufacturers supplied software (v. 4.50). Strength was determined to be the maximum torque generated during three maximal voluntary contractions (MVC).

Concentric muscular endurance of the knee extensors was assessed using isolated knee extension exercise on the isokinetic dynamometer. Mean power generated over 25 MVCs at an angular velocity of 2.10 rad · s⁻¹ was the index utilized to quantify muscular endurance. A higher angular velocity (2.10 vs. 1.05 rad · s⁻¹) was used during the endurance testing to ensure that the endurance test was not too long since 25 repetitions at 1.05 rad · s⁻¹ would have taken double the time and could have compromised test reliability. The strength and endurance tests were performed in one testing session and were re-tested the following week at the same day and time of day as the first test. The maximum scores obtained over the two testing sessions were used for all subsequent data analyses. The isokinetic dynamometer was calibrated at the start of each testing session using standard procedures as recommended by the manufacturer.

Each strength and endurance testing session began with a 3-min warm-up on a rowing ergometer (Concept II Inc., Morrinsville, VT, USA) at a self-selected pace, followed by 10 squats with a 20-kg bar. Following this, eight squats were performed with a load of 40 kg, and if required six repetitions were also completed with an intermediate weight. The load was subsequently increased over the course of two to three sets in order to determine the 6 RM, and each set was separated by 2 min timed recovery. Following the 6 RM determination, participants cycled on an ergometer with no resistance for 5 min to facilitate recovery, then moved to the isokinetic dynamometer (Biodex Corp., Shirley, NY, USA). The right leg was tested, with participants restrained at the ankle, knee, waist, and across the chest, and the machine was adjusted for their limb lengths so that the lower border of the ankle pad was placed just proximal to the tibial malleoli. Each subject performed five familiarization repetitions on the dynamometer at an angular velocity of 1.05 rad · s⁻¹ gradually increasing effort from “easy” to “hard”. After a 2 min rest, the subjects were asked to perform three maximal concentric knee extensions at this angular velocity. Maximal torque (Nm) of the quadriceps was recorded. A 2-min recovery followed, and then subjects performed 25 MVCs at an angular velocity of 2.10 rad · s⁻¹. Peak torque (Nm) and average power (W) over 25 repetitions was recorded.

Aerobic Power

On a separate day, maximal aerobic power (VO₂max) was assessed using a graded incremental exercise test on a motorized treadmill (Quinton Q65, Series 90, Seattle, WA, USA). Following a 5-min warm-up, participants ran on a level treadmill for 2 min at a comfortable running pace. Starting velocity was estimated based on the participant’s sporting background and level attained during the warm-up. It averaged 13.9 ± 0.9 km · hr⁻¹ and ranged from 12.0 to 16.0 km · hr⁻¹. The velocity was
subsequently increased by 1 km · hr⁻¹ every 2 min until three 2-min stages had been completed. The treadmill then remained at this velocity, while the gradient was increased by 2% every minute until the participant experienced volitional exhaustion. The primary criteria used to indicate that $\text{VO}_{2\text{max}}$ had been reached was a plateau in the rise of oxygen consumption with a further increase in work. Secondary criteria included attainment of age predicted or known maximal heart rate, a respiratory exchange ratio > 1.15 or volitional exhaustion. During exercise, participants breathed through a mouthpiece and one-way valves (Hans Rudolph, Series 5710, Kansas City, MO, USA), while respiratory measures were determined every 20 s using open-circuit spirometry (Sensormedics 2900, Yorba Linda, CA, USA). For each test, the CO₂ and O₂ analyzers were calibrated against gases of known concentrations, and the flow meter was calibrated using a 3-L calibration syringe. Heart rate was monitored using a telemetric heart rate monitor (Polar Sport Tester, PE 4000, Kempele, Finland). Maximal running power was determined through calculating the derivative of vertical work performed on the maximal grade of the inclined treadmill. Re-testing following the 10-week supplementation and training program utilized an identical protocol to determine if any changes took place between testing sessions. All aerobic testing was performed at the same time of day pre and post training.

**Endocrine Response**

On a separate day at rest, blood was obtained from an antecubital vein; two samples were drawn into a 6-ml lithium heparinized tube and one into a 6-ml unheparinized tube. The lithium heparinized samples were centrifuged at 3000 rpm for 10 min, the serum was placed into two siliconized bullet tubes, and then placed into a –80 °C freezer. At the end of the study, all samples (pre- and post-training) were analyzed in one batch for erythropoietin (EPO), insulin-like growth factor-1 (IGF-1), and total testosterone (TT).

EPO was analyzed with a Photometric Enzyme-Linked ImmunoSorbent Assay (ELISA) kit (Boehringer Mannheim, Amsterdam, Netherlands). The EPO ELISA is an enzyme-linked immunosorbent assay for the quantitative in vitro determination of natural and recombinant human EPO in serum and plasma within antibody precoated microtiter plates. The assay is a two-step procedure. In the first step, EPO is simultaneously bound to the anti-EPO-coated surface of the microtiter plate and to the peroxidase-conjugated detection antibody. In the second step, the peroxidase bound in the complex is developed by the substrate tetramethylbenzidine and determined photometrically. The color intensity is proportional to the concentration of EPO. The coefficient of variation for the control pool was 7.12%.

IGF-1 was analyzed by radioimmunoassay after acid-ethanol extraction and cryoprecipitation (3) using antiserum B-71 provided by Dr. B.H. Breier (Research Centre for Developmental Medicine and Biology, University of Auckland, NZ). The coefficient of variation between assay at high concentrations of IGF-1 (approximately 700 µg/L) was 13.7%, and for medium concentrations (approximately 200 µg/L), 11.3%. The coefficient of variation within assay for high concentrations was 5.5%, and for medium concentrations, 13.0%.

Total testosterone was analyzed with a radioimmunoassay (Coat-A-Count Total Testosterone, Diagnostic Products Corp., Los Angeles, CA, USA). The Coat-A-Count® procedure is a solid-phase radioimmunoassay, based on a testosterone-specific antibody immobilized to the wall of a polypropylene tube.
\(^{125}\)I-labeled testosterone competes for a fixed time with testosterone in the patient sample for antibody sites. The tube is then decanted, to separate bound from free, and counted in a gamma counter. The amount of testosterone present in the patient sample is determined from a calibration curve. The Coat-A-Count® Total Testosterone kit included human serum-based calibration testosterone ranging between 20 to 1600 ng/dl, which was used to calibrate the equipment prior to sampling. The coefficient of variation for this assay was 6.8%.

**Blood Volume**

Blood volume was determined using a previously describe carbon monoxide (CO) re-breathing system, consisting of a closed-circuit and an open-circuit (4). Briefly, participants were asked not to participate in any strenuous activity for 24 hours prior to the test. A 3-ml blood sample was taken from the antecubital vein pre and post a 10-min CO re-breathing protocol to determine the percentage change in carboxyhaemoglobin (COHb). The pre- and post-CO re-breathing blood was injected into capillary tubes, the tubes were capped and spun in a micro-hematocrit centrifuge (A802, Hawksely, UK) for hematocrit (Hct) analysis. A Hemoximeter (Radiometer OSM3, Copenhagen, Denmark) was used for COHb, and total hemoglobin (THb) analysis (four replicates). The hemoximeter was calibrated before each analysis. Atmospheric pressure and ambient temperature were also recorded for each blood volume measurement. Blood, plasma, and erythrocyte volumes were calculated using the following equations:

1. Molar amount of haemoglobin (Hb) = (nCO × 25) / (COHb post – COHb pre)
2. Erythrocyte Volume (EV) = [(644 × Hct) / (Hb)] × nHb
3. Blood Volume (BV) = (EV × 100) / (Hct × Fcell ratio)
4. Plasma Volume (PV) = BV – EV.

**Training Protocol**

Participants trained three times per week, with a minimum of 48 hours between training sessions. Training sessions were monitored and recorded by a qualified strength training instructor, and participants had a goal of attending 24 out of 30 sessions (80% attendance) in order to complete the study and be re-tested. All training sessions were recorded. The leg muscles were trained utilizing parallel squats on a standard resistance training apparatus (Smith Machine), and knee extension was trained on the isokinetic dynamometer (Biodex Corp., Shirley, NY, USA) at an angular velocity of 1.05 rad · s\(^{-1}\). The training session began with a light 5-min warm-up on an exercycle and two progressive warm up squat sets (at a self-selected load), after which subjects performed three sets of 8RM squats with 2 min rest between sets. The training load was based on the 6RM testing results, and when subjects could squat more than eight repetitions, the load was increased so that they could squat eight repetitions only. Subjects trained in pairs, and alternated the work-rest intervals. The training load (mass) and number of repetitions squatted were recorded each training session, and subjects were encouraged to continually increase their training load.

Following completion of the squats, subjects moved to the isokinetic dynamometer for knee extensor training. A self-selected comfortable warm up set of 15 reps was performed, then three sets of 10 maximal repetitions were performed at
1.05 rad · s$^{-1}$ with 2 min rest between sets. Both right and left legs were trained, and subjects trained in pairs and alternated work-rest intervals. Peak torque (Nm) and average power output (W) were displayed to the subjects during their sets to provide feedback. Subjects were encouraged to produce maximal torque each repetition, and peak torque and average power output were recorded after each training set.

Statistics

The mean and standard deviation (M ± SD) were utilized to describe all variables. Two-way analysis of variance (group × time [repeated measures]) were used to determine changes in mean values. A time contrast was included for the difference between pre- and post-training, as well as non-orthogonal treatment contrasts between (a) extract and placebo treatments and (b) powder and placebo treatments. Log transformation was used to stabilize the variance for EPO. A one-way analysis of variance was also used to determine whether differences existed between groups for training compliance. Type I error was protected at 5%.

Results

Training Compliance

The extract group attended a mean of 23.5 ± 1.4 sessions (78% attendance), the powder group attended 24.3 ± 1.4 sessions (81% attendance), and the placebo group attended 23.6 ± 1.5 sessions (79% attendance). Compliance rates were not significantly different between groups, and subjects had to attend at least two thirds of the training sessions to be included in the final analysis (minimum 20 sessions). Thirty-eight subjects completed the study, with final group sizes being 12, 13, and 13 in the deer antler velvet extract, powder, and placebo groups, respectively. In some cases, data points are missing for some variables, and this is reflected below by residual degrees of freedom of less than 35.

Muscular Strength and Endurance

There were no significant changes in body mass ($F_{1,35} = 3.47, p = .07$); or SO8S ($F_{1,35} = 0.046, p = .38$) in any group. When these data were collapsed across group height, body mass, and SO8S, at pre-training, they were, respectively, 178.1 ± 6.5 cm, 78.5 ± 8.5 kg, and 82 ± 30 mm, and at post-training, they were 178.2 ± 6.5 cm, 79.0 ± 8.3 kg, and 83 ± 26 mm. Although 6RM squat strength increased in each group by week 3 ($F_{1,33} = 94.4, p = .000$) and continued to improve significantly at each testing session over the 10-week training period (week 6 $F_{1,33} = 47.8, p = .000$; week 10 $F_{1,33} = 27.0, p = .000$, respectively), there were no significant differences in the extent of change between groups ($F_{2,33} = 1.04, p = .37$; Figure 1). The average increase in 6RM strength across groups over 10 weeks was 41 ± 26%. Similar to the 6RM results, isokinetic peak torque (21 ± 17%, $F_{1,33} = 76.1, p = .000$) and average power during 25 MVCs (13 ± 14%, $F_{1,33} = 34.5, p = .000$) increased in all groups by the end of the 10-week training program. There was a significantly greater increase in both peak torque (30 ± 21% vs. 13 ± 15%, $F_{2,33} = 4.42, p = .04$) and average power (21 ± 19% vs. 7 ± 12%, $F_{2,33} = 6.15, p = .02$) in the powder group compared to the placebo group (Figure 2). There were no significant differences in IGF-1 ($F_{1,31} =$
Figure 1 — 6RM squat strength performance pre-, mid-, and post-training (M ± SD) for the extract, powder, and placebo groups. *Significant change between pre-training and week 3, week 3 and 6, week 6 to post-training, and pre- to post-training for each group.

Figure 2 — Knee extension (A) peak torque and (B) average power over 25 repetitions pre- and post-training (M ± SD) for the extract, powder, and placebo groups. *Significant change over time for the group. #Significant difference in change score between powder and placebo groups.
1.37, \( p = .25 \)) or testosterone (\( F_{1,33} = 1.37, \ p = .25 \)) in any group as a result of the supplementation and strength training program (Table 1).

**Aerobic Power and Erythropoiesis**

There were no significant differences in the extent of change in VO\(_{2\text{max}}\) between groups (\( F_{2,33} = 1.38, \ p = .27 \)), although VO\(_{2\text{max}}\) decreased significantly from pre- to post-training when the group data were combined (\( F_{1,33} = 7.42, \ p = .01 \)). Similarly, there were no significant differences in the extent of change between groups for maximum heart rate or RER (HR, \( F_{2,29} = 0.53, \ p = .60 \); RER, \( F_{2,33} = 0.60, \ p = .55 \)) but, when group data were pooled, the maximal heart rate (\( F_{1,29} = 10.95, \ p = .003 \)) and RER values (\( F_{1,33} = 5.5, \ p = .03 \)) recorded at the cessation of the VO\(_{2\text{max}}\) test were significantly lower. Similarly, there were no significant changes in maximal running power for either group (\( F_{1,31} = 1.79, \ p = .19 \); Table 2).

There were no significant differences in EPO (\( F_{1,34} = 0.608, \ p = .44 \)), BV (\( F_{1,34} = 1.37, \ p = .25 \)), PV (\( F_{1,34} = 1.37, \ p = .25 \)), or VRBC (\( F_{1,34} = 3.67, \ p = .06 \)) in any group as a result of the supplementation and/or strength training program (Table 3).

**Discussion**

**Muscular Strength and Endurance**

The main finding of this study was that isokinetic strength and muscular endurance improved to a greater extent in the group that was supplemented with velvet powder when compared with the placebo group. However, there was no difference in the extent of isoinertial strength adaptation (6 RM strength) between groups. Additionally, none of the mechanisms hypothesized to influence strength adaptation changed differentially between groups, so it is difficult to explain these significant differences. It is possible that the significant results are reflective of a type I error, but they could also indicate a physiological effect of velvet powder.

Strength changes as a result of resistance training generally occur through both neural and muscular adaptation (12, 13). The time-course of strength gains is generally bi-phasic, with rapid improvement occurring in the first 4–6 weeks of a training program followed by steady but slower improvement after this initial period. The early adaptations are generally considered to be neural, while muscular adaptations take 8–10 weeks before they become detectable and start to dominate over the initial early neural adaptation (10). In the present study, strength improved in all groups by week 3 and continued to improve over the 10-week period, thus both neural adaptations and muscular adaptations would have contributed to strength gains. In fact we have previously shown that a similar strength training program to that used in this study causes muscle hypertrophy over an 8-week training study (7). It was hypothesized that supplementation with either velvet extract or powder would enhance strength gains through stimulating anabolic hormone production, protein synthesis, and therefore muscle hypertrophy.

Although protein synthesis and muscle hypertrophy were not directly measured, there were small non-significant changes in body mass in all groups, possibly indicating that they did experience some hypertrophy as a result of the training, but no differential effect of treatment with velvet extract or powder was observed. Thus it does not appear that the supplementation regimes we used with deer antler velvet or powder stimulated muscle hypertrophy. Supplementation with aqueous deer
### Table 1 Total Testosterone and Insulin-like Growth Factor-1 (IGF-1) Pre- and Post-Study ($M \pm SD$) for the Extract, Powder, and Placebo Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Placebo</th>
<th>Powder</th>
<th>Extract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total testosterone (nmol/L)</td>
<td>17.6 ± 3.6</td>
<td>20.7 ± 5.1</td>
<td>17.6 ± 5.5</td>
</tr>
<tr>
<td>IGF-1 (ug/L)</td>
<td>216.5 ± 49.6</td>
<td>200.9 ± 34.8</td>
<td>233.6 ± 39.1</td>
</tr>
</tbody>
</table>

### Table 2 Maximal Aerobic Power ($\text{VO}_{2\text{max}}$), Maximal Heart Rate (Max HR), Respiratory Exchange Ratio (Max RER), and Running Power (Max Run Power) at Completion of the Graded Exercise Test Pre- and Post-Study for the Extract, Powder, and Placebo Groups and for All Subjects Combined ($M \pm SD$)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Placebo Pre</th>
<th>Placebo Post</th>
<th>Powder Pre</th>
<th>Powder Post</th>
<th>Extract Pre</th>
<th>Extract Post</th>
<th>Combined Pre</th>
<th>Combined Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{VO}_{2\text{max}}$ (ml/kg/min)</td>
<td>54.1 ± 6.5</td>
<td>50.9 ± 7.4</td>
<td>54.8 ± 8.2</td>
<td>53.4 ± 7.5</td>
<td>51.5 ± 5.6*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max HR (bpm)</td>
<td>200 ± 8</td>
<td>201 ± 6</td>
<td>199 ± 9</td>
<td>200 ± 7</td>
<td>197 ± 8*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max RER</td>
<td>1.17 ± 0.05</td>
<td>1.17 ± 0.04</td>
<td>1.17 ± 0.04</td>
<td>1.17 ± 0.05</td>
<td>1.15 ± 0.06*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max run power (w)</td>
<td>240 ± 63</td>
<td>184 ± 40</td>
<td>230 ± 52</td>
<td>221 ± 57</td>
<td>210 ± 60</td>
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</table>

*Note. *Significantly different from Pre ($p < .05$).
Table 3  Hematological and Endocrine Values Pre- and Post-Study for the Extract, Powder, and Placebo Groups

(M ± SD) or the Extract, Powder, and Placebo Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Placebo</th>
<th>Powder</th>
<th>Extract</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>Blood volume (ml/kg)</td>
<td>88.1 ± 9.4</td>
<td>87.8 ± 17.2</td>
<td>84.1 ± 9.0</td>
</tr>
<tr>
<td>Plasma volume (ml/kg)</td>
<td>53.7 ± 7.2</td>
<td>52.5 ± 10.2</td>
<td>51.0 ± 6.0</td>
</tr>
<tr>
<td>Erythrocyte volume (ml/kg)</td>
<td>34.4 ± 2.7</td>
<td>35.3 ± 7.3</td>
<td>33.1 ± 3.2</td>
</tr>
<tr>
<td>Erythropoietin (mU/ml)</td>
<td>7.5 ± 9.4</td>
<td>12.9 ± 13.3</td>
<td>5.9 ± 5.0</td>
</tr>
</tbody>
</table>
antler velvet extract has however been previously shown to increase the body weight of rats by 7–10% in a dose-dependant fashion within 2 weeks of the start of supplementation (15). Since rat body mass increased within the first 2 weeks of this experiment (too early for increased muscle mass), there was likely another mechanism behind the gain in weight (e.g., fluid retention). The rats were also not exercise trained, so these results are not really directly comparable to those of the present study.

Isokinetic muscular endurance showed similar patterns of change as isokinetic strength, since the powder group improved to a greater extent than the placebo group. This may have been because they showed larger improvements in strength and were therefore able to perform 25 repetitions at a higher absolute intensity even though their relative intensity was similar to that of the other groups. Previous strength training studies have demonstrated that this can occur (8). The finding that muscular endurance was improved in the powder group reinforces the positive trend towards greater improvement of muscular endurance with deer antler velvet than was previously observed in a pilot study (7), although as previously stated these results could also be due to chance.

In the present study, total testosterone levels in the blood were also measured pre- and post-training. No differences were detected in the levels of this hormone between groups, indicating that an up-regulation of protein synthesis caused by elevated levels of testosterone was an unlikely mechanism to account for the larger isokinetic strength gains experienced by the powder group. Previous research examining the influence of velvet supplementation on human performance has not examined whether changes occur in anabolic hormones such as testosterone. In some animal models, there is evidence that anabolic hormone levels are increased along with some increases in protein synthesis. For example, two separate studies have fed mice various doses (0–300 mg/kg/day) of antler extract for 8–20 days. Protein synthesis in the liver and kidney and plasma testosterone were dose dependently increased in male senescence but not normal mice, but there was no increase in protein synthesis in the testes, brain, or heart (18, 19). Additionally, these mice did not undergo any form of exercise training.

Since the results suggest little anabolic enhancement through the endocrine system as a result of velvet supplementation, a more likely mechanism for the bigger strength gains observed in the powder group is that they had lower isokinetic strength levels than the other groups at the start of the training program. It is well known that individuals with lower levels of physiological function will adapt to a greater extent than those starting at a higher level when exposed to a similar training stimuli (2). When these data are matched with the 6 RM strength test that showed no differential strength response between groups, it makes it unlikely that the primary reason for the enhanced strength adaptation in the powder group was the powder itself, although this cannot be discounted.

Another possibility that may explain the improved muscular endurance is that the velvet powder may have provided an analgesic effect and masked the pain experienced by the athletes during the muscular endurance test. Anecdotal reports have suggested deer antler velvet powder to have some analgesic properties. Alternatively, because of the numerous growth factors present in velvet (6), velvet supplementation might cause qualitative changes in muscle such as capillary neogenesis that woulddelay fatigue, but again this is purely speculative. It is therefore difficult to explain the mechanisms behind the extra enhancement of isokinetic endurance
performance observed in the deer antler velvet powder group, especially when there were no effects of deer antler velvet extract. However, it is possible that the two different processing methods used to create the powder and extract forms of deer velvet could have influenced the “active” properties of the supplements.

**Aerobic Power and Erythropoiesis**

The main finding of this study in relation to aerobic power was that supplementation with either deer velvet extract or powder did not have an erythropoietic effect nor did it improve aerobic performance as suggested by earlier literature (14, 18, 20). To our knowledge, this is the first double-blind study to rigorously address this issue. In fact, VO\(_{2}\text{max}\) decreased in all groups by a small amount, which may be reflective of a lack of aerobic activity in the subjects as a result of their participation in regular strength training or reduced effort in the post-test. The latter is unlikely since, when compared to pre-testing, there were no substantial changes post-supplementation in maximum heart rate, maximum RER values, or maximal run power at the cessation of the incremental treadmill test. It is possible that for deer antler products to have an ergogenic effect on aerobic performance, then the subjects would need to be actively aerobically training, but this remains to be determined.

We also directly determined the volume of red cells present in the blood and measured blood volume and found that these values also did not change in any group. Supporting these findings, there was no change in either the powder or extract groups in the level of the circulating hormone erythropoietin, the stimulus required for increasing red cell production. There was a trend for an increase in plasma erythropoietin in the placebo group, but the magnitude of this effect was very small when compared to the increases in erythropoietin reported with acute exposure to altitude (5), and the change was probably of little physiological significance. Since serum erythropoietin displays diurnal variation (9), it is also possible that this accounted for the trend towards an increase in the placebo group or masked any treatment effect that may have been present in the other groups, as we did not control for this.

Our findings are in contrast to the erythropoietic effect of deer velvet that has been vigorously promoted through the Chinese herbal medicine literature (1). One of the only studies to examine erythropoietic effects of deer velvet injected rabbits daily with 2.5 ml/kg of an alcohol extract of deer horn (40 mg/ml) over the course of 5 days (14). Plasma erythropoietin was significantly elevated after the deer horn treatment when compared to the control rabbits. This study injected the velvet extract, whereas the subjects in the present study consumed the velvet orally. It is therefore possible that the gut may have inactivated any erythropoietic activity of the velvet, if these properties were present at all. It is also possible that deer antler velvet may help to reverse anemia rather than raise erythropoietin activity in healthy individuals, but this was not studied.

**Conclusions**

Although oral supplementation with New Zealand deer antler velvet powder appeared to enhance the isokinetic muscular strength and endurance training response of males to a greater extent than those males receiving placebo or velvet extract treatment, these results must be interpreted with caution, since isoinertial strength did not improve differentially between groups. Additionally, no mechanisms could
be identified that explained these observed differences. It is possible that the lower starting levels of isokinetic strength and endurance in the velvet powder group contributed to the greater changes observed with training and that the powder supplement had little effect. There is no evidence that supplementation with deer velvet powder or extract increases erythropoietic activity, oxygen carrying capacity, or $\text{VO}_{2\text{max}}$ in males that are not currently aerobically training. Future research should examine whether these products are ergogenic when accompanied by aerobic training and investigate the effect of supplementation in a female sample.

References


Acknowledgment

This study was funded by Velvet Antler Research New Zealand.