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The effect of N,N-dimethylglycine on athletic performance at altitude in horses and mules

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Summary

N,N-dimethylglycine (DMG) is widely used to delay fatigue by inhibiting lactate production. DMG effects were examined in a paradigm of moderate exercise intensity that was potentially oxygen-limited. Performance in seven horses and four mules was assessed using blood lactate concentrations and heart rates. The experimental group was administered 2.2 g of DMG twice per day for four days. The exercise tests consisted of two exercise bouts, one starting at an elevation of 2635m and the other at 1960m. Work at the high altitude increased the total number of heart beats and recovery time in both horses and mules. There were no difference for peak heart rate (152±11 vs 141±2, p= 0.32), average heart rate, (99±2 vs 97±3, p=0.40) and blood lactates (0.62±0.05 vs 0.66±0.04 mM, p=0.78) between higher altitude and lower altitude tests, respectively. When data were pooled for species and altitude, DMG reduced blood lactates, (0.60±0.03 vs 0.74±0.06 mM, p=0.03).

Keywords: lactate, N,N-dimethylglycine, altitude, equid, performance

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Der Effekt von N,N-dimethylglycin auf die sportliche Leistung in Höhenlagen bei Pferden und Maultieren

N,N-dimethylglycin (DMG) wird weitverbreitet angewendet, um Erschöpfung zu verhindern, indem die Lactat-Produktion gehemmt wird.
DMG-Effekte wurden in einem Beispiel mit mäßiger Belastungsintensität untersucht, welches möglicherweise Sauerstoff limitiert war.
Die Leistung von 7 Pferden und 4 Maultieren wurde durch die Blutlactatkonzentration und die Herzfrequenz bestimmt.
Der Versuchsgruppe wurde 2,2 g DMG zweimal täglich für 4 Tage verabreicht.
Die Tests bestanden aus zwei Touren, die eine Tour startete bei einer Höhe von 2635 m und die andere Tour startete bei einer Höhe von 1960 m.
Arbeit in größer Höhe führte zu einem Anstieg der Gesamtzahl der Herzschläge und zu einer Verlängerung der Erholungszeit bei den Pferden und den Maultieren.
Es gab jedoch keine Unterschiede zwischen dem höherem Höhentest und dem niedrigerem Höhentest beim Peak der Herzfrequenz (152 ±11 vs 141±2, p= 0,32) , der Durchschnitts-Herzfrequenz (99±2 vs 97±3, p=0,40) und dem Blut-Lactat (0,62±0,05 vs 0,66±0,04 mM, p= 0,78).
Wenn alle Daten, unabhängig von der Spezies und der Tourhöhe, zusammen ausgewertet wurden, dann zeigte sich, daß die DMG-Gabe die Blutlactatkonzentration nach Belastung reduzierte (0,60±0,03 vs 0,74±0,06 mM, p=0,03).

Schlüsselwörter: Lactat, N,N-dimethylglycin, Höhe, Pferdeartige, Leistung

Introduction

N,N-dimethylglycine (DMG), identified in the late 1970's, is widely used in the United States with the aim of delaying fatigue by inhibiting lactate production. DMG has been theorized to act as a methyl donor and to increase oxygen utilization in test subjects when exposed to low oxygen environments (*Meduski* et al. 1980). There is a huge market and substantial use by sport horse enthusiasts of DMG particularly in long, slow-type work. This use of DMG stems from the suggestive opinions of trainers, owners and limited scientific studies. These scientific studies have produced conflicting results on lactate concentrations. *Levine* et al. (1982) indicated that DMG was responsible for a lower blood lactate concentration in racing Standardbred horses. However, *Rose* et al. (1989) in a very controlled study, reported that DMG did not produce any significant effects on lactate concentration in Thoroughbred horses.

In the study by *Rose* et al. the lowest exercise intensities still elicited blood lactate concentrations between 3–4 mM. The question arises as to how DMG may impact performance at lower exercise intensities. Currently, in the United States, there is substantial use of DMG on the endurance circuits. During these events, exercise intensities are substantially reduced and blood lactate concentrations are usually less than 2 mM (*Rose* and *Hodgson,* 1994). The current study examined DMG efficacy in another population of animals that perform extended periods of low intensity exercise with lactates usually less than 2 mM – mountain pack stock (*Wickler* et al. 1995).
The population of animals used in this study consisted of both horses and mules which afforded comparison between species. Despite a wealth of lay literature indicating that mules are superior athletes, there are few corroborating scientific studies.

The research paradigm consisted of field exercise tests at two different altitudes, where animals were also faced with exposure to low oxygen partial pressure (*Schoene,* 1984). Although exercise intensities were only moderate, oxygen could be potentially limiting, and this could serve to potentiate the role of DMG in increasing oxygen utilization.

Materials and methods

Eleven pack animals, seven Quarter-type horses and four mules, acclimatized to altitude for 1.5 months, were utilized for this study. The animals, part of a commercial packing outfit, were judged to be in similar condition (based on the *National Research Council* guidelines, 1989) and in similar athletic conditioning. The age of the animals ranged from 6 years to 12 years for the mules, and from 8 years to 15 years for the horses. These animals were randomly divided into a control group (two mules and four horses) and an experimental group (two mules and three horses). The experimental group received 2.2 grams of DMG, (Vita Flex®, Staten Island, NY, USA), top dressed in the grain, twice per day for three days prior to exercise tests and then for the remainder of the study. The amount of concentrate fed was at 50% of the NRC estimated requirements for concentrate intake for adult horses working at moderate levels. In addition to concentrate, alfalfa cubes were fed at 1.5% of body weight, twice a day.
On exercise test days, the morning meal and DMG was given 90 min prior to exercise. On the third day of dietary treatment, the first exercise test was performed. The exercise test consisted of animals on the trail with tack and rider. The first test started at an elevation of 2635 meters and ceased 92 minutes later at an elevation of 3125 meters (490 meter ascent). The second exercise bout, two days later (day 5), started at an elevation of 1960 meters and concluded 71 minutes later at an elevation of 2340 meters (380 meter ascent). The study took place in the Sierra Nevada Mountains, California USA, during July 1995 in dry, clear weather. Both exercise tests started between 1300–1400 hours with ambient temperatures starting at 21°C. At the completion of the exercise test, barometric pressures (based on Vertech Ski®, Avocet", Newark, CA, USA) were 516 mmHg and 589 mmHg for the high and low tests, respectively. Power outputs were calculated based on the individual weights of rider, tack and horse, elevation gain and time of exercise bout. Calculated power requirements were 524 joules/sec and 522 joules/sec, respectively (fig. 1).
Equipment limitations permitted only nine of the animals to be fitted with heart rate monitors, (Ultra V-Max®, Equine Performance Technology; Seven Valleys, PA, USA). Heart rates were recorded during both exercise events, at intervals of 15 seconds, and downloaded using Polar Heart Rate Analysis Software®. Average heart rate, peak heart rate, total number of heart beats, and heart rate recovery were calculated for each exercise test. Heart rate recovery was defined as the time for the heart rate to decrease halfway from its immediate post exercise value to resting.
Within five minutes of the completion of the exercise tests, blood samples were collected from the jugular vein, using EDTA tubes. For lactate measurements, whole blood was immediately placed into cold 8% perchloric acid mixed and then stored in liquid nitrogen. After returning to the laboratory, samples were stored at -70°C. Blood lactates were measured spectrophotometrically, at 340 nm, using a Sigma Diagnostics® lactate kit (Sigma Chemical Company, St. Louis, MO, USA). To compare animals performance between the 1960m and 2635m starting altitudes, a

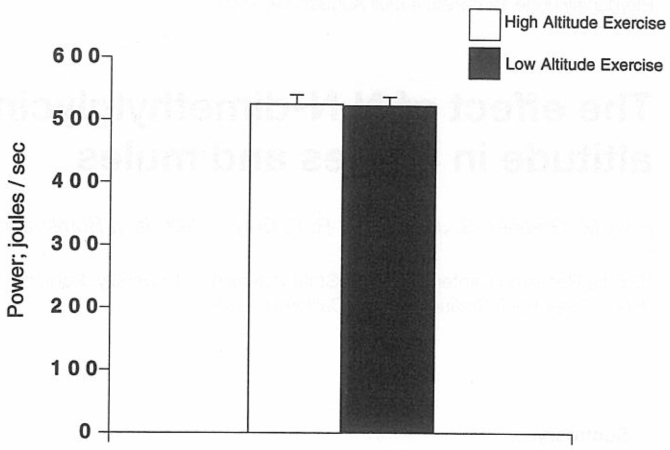

Fig. 1: Calculated power requirements based on weight of rider, tack and horse, the elevation gain and time of exercise bout (mean±SE). No significant differences between the high and low altitufe exercise tests. (P<0.05)

paired student t-test was used. An ANOVA was used to examine the effect of species and DMG on blood lactates, average heart rate during exercise, peak heart rate and heart rate recovery. Significance was set at $P<0.05$.

Results

Altitude Effect
Altitude had a significant effect on total number of heart beats and heart rate recovery time. Horses and mules working during the higher altitude exercise test had an increase in the total number of heart beats (fig. 2), for the same power requirements, and an increase in heart rate recovery time (fig. 3). However, there were no differences in peak heart rate (152±11 vs 141±2 bpm, p= 0.32) and average heart rate (99±2 vs 97 ±3 bpm, p=0.40) between higher and lower altitude tests, respectively. In addition, there was no difference in blood lactates (0.62±0.05 vs 0.66±0.04 mM, p=0.78) between higher altitude and lower altitude tests, respectively. There were no differences in any parameters between DMG treatment and control, and no differences between species.

Species and Treatment Effect
When all cardiovascular and lactate data for both high and low altitude exercise tests were pooled and analyzed for effect of treatment and species, there were no differences for any variable but DMG. DMG treated animals did have a significantly reduced blood lactate concentration, (0.60±0.03 vs 0.74±0.06 mM, p=0.03).

Discussion

The effect of altitude and low pO_2 was not apparent in lactate concentrations. These values clearly indicated that the animals were at a modest work load and are consistent with lactate concentrations observed earlier in pack animals (*Wickler* et al. 1995). The low lactate concentrations are also consistent with the low average heart rates and the low maximal heart rates. However, for similar power requirements, high altitude required a greater number of heart beats and longer cardiovascular recovery times (fig. 2 and 3). None of these assessments of performance were affected by DMG.

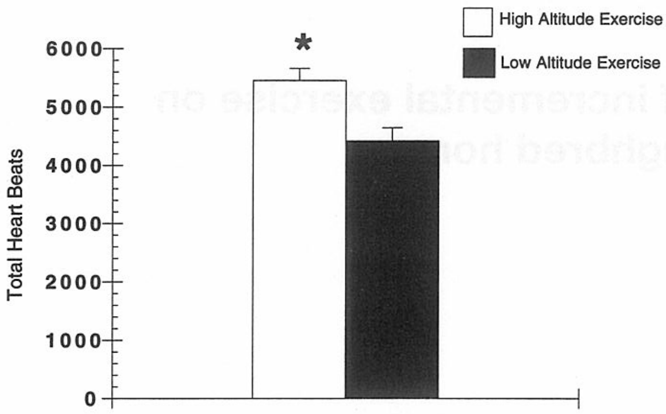

Fig. 2: Total number of heart beats (mean±SE) calculated for high and low altitude exercise tests. Total number of beats are

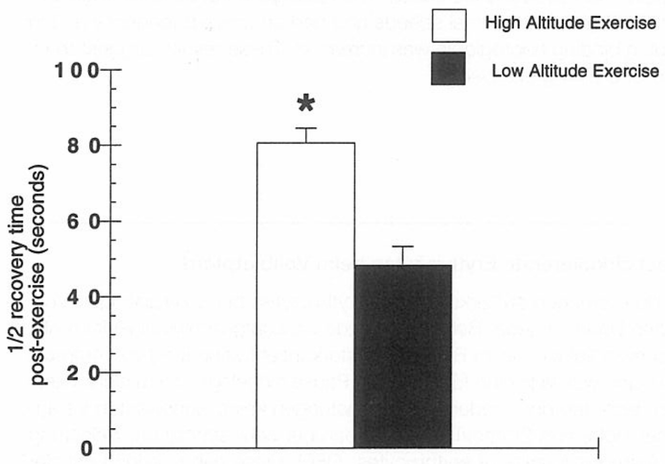

Fig. 3: Heart rate recovery (mean±SE) calculated for high and low altitude exercise tests. Recovery rates for high altitufe are significantly greater (*=P<0.05)

When data for all animals were pooled, DMG had a positive effect on lactate concentration. However, the efficacy of DMG is not supported by heart rate parameters, which appear to be a more sensitive indicator of performance in the present paradigm. Further, the concentration of lactates were substantially less than 4 mM, and the biological significance of a differences in lactates is questionable. The current study did not support the use of DMG for practice in submaximal exercise.

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