THE EFFECT OF A SUPPLEMENT CONTAINING ß-ALANINE ON MUSCLE CARNOSINE SYNTHESIS AND EXERCISE CAPACITY, DURING 12 wk COMBINED ENDURANCE AND WEIGHT TRAINING

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ABSTRACT

Carnosine (Carn) occurs in high concentrations in muscle with a content ratio between types I and II muscle fibres of 1 to 1.5-2. With a pKa of 6.83 for the imidazole ring of the histidine residue, Carn is highly effective in buffering H^+ over the physiological pH range, and probably the only such active compound where the concentration can be changed by diet (and training). Synthesis of Carn occurs in muscle from ß-alanine (ß-ala) and histidine, of which the availability of the former appears limiting. We have recently shown that supplementation with ß-ala for 4 and 10wk increases muscle Carn by ~60% and ~80%, respectively, resulting in significant increases in anaerobic exercise capacity (Harris et al, 2006; Hill et al, 2006). Muscle Carn is increased by chronic training (Parkhouse et al 1985; Tallon et al 2005). The effect of short-term training is less clear. Suzuki et al (2004) reported a doubling in the Carn concentration with 8 wk sprint-training (3 d/wk) in contrast to Mannion et al (1994) where no effect of 16 wk isokinetic training (3 d/wk) was found. **AIM** To investigate the effect of a commercial supplement (Phosphagen Elite™, EAS, Golden) containing, per serving, 1.6g ß-Ala Carnosyn™, NAI, San Marcos), 5.25g creatine and 1g taurine (Tau) on muscle Carn synthesis during training. Tau has the potential to interfere with the uptake into muscle of ß-ala, and visa versa. **METHODS** Cyclists (20□(SD)1 yr; 78□8 kg) received either Phosphagen Elite (n=6) or Control (Phosphagen Elite less ß-Ala) (n=6), 3 x d (i.e. 4.8 g/d ß-Ala in the test group) during 12wk of combined endurance (5 h/d, 6 d/wk) and weight training (3 d/wk). Biopsies of the *v. lateralis* were taken at 0 and 12wk for fibre morphology and analysis of Carn and Tau. Subjects undertook an incremental cycle test to determine VO2 max, VO2 at ventilatory threshold (VT) and work time to exhaustion (WTE), and, total work done (TWD) during an isokinetic test of the knee extensors at 240o/s. **RESULTS** Type II cross sectional was increased with training in both groups, P<0.05. Carn was unchanged with training (23.9 vs 25.7 mmol/kg dm; P>0.05) but increased with ß-Ala supplementation (20.5 vs 30.0 mmol/kg dm; P<0.01). Tau did not change. VO2 at VT, WTE and TWD with isokinetic flexion were increased with ß-Ala supplementation. TWD with isokinetic extension was unchanged. **CONCLUSION** Carn was unchanged by training alone but was increased by ß-Ala supplementation (and to a similar extent seen in other ß-Ala supplementation studies undertaken without training). The increase in WTE and TWD are most probably the result of the increase in buffering capacity resulting from the increase in Carn.

INTRODUCTION

Carnosine (β-alanyl-L-histidine):

- high concentrations in muscle, particularly type II fibres (Harris *et al* 1998)
- pKa of 6.83 allows function as an intramuscular H^+ buffer (Harris *et al* 1990)

Recently shown that β-alanine (β-Ala) supplementation for 4 and 10 wks increases muscle Carn by ~60% and ~ 80% with significant increases in anaerobic exercise capacity (Harris *et al* 2006; Hill *et al* 2005).

Muscle Carn concentrations are increased in trained athletes (Parkhouse *et al* 1985; Tallon *et al* 2005). 8 wks sprint-training was reported by Suzuki *et al* (2004) to significantly increased skeletal muscle Carn (5.17±1.69 to 11.01±3.05 mmol.kg^{-1} wet muscle). This was associated with an increase in power output during a 30s Wingate test. In contrast Mannion *et al* (1994) found no effect of isokinetic training on muscle Carn concentrations.

AIM: To investigate the effect of a commercial supplement (containing 1.6g β-Ala, 5.25g creatine and 1g Tau per serving), on muscle Carn synthesis during 12w combined endurance and weight training.

MATERIALS AND METHODS

SUBJECTS: 12 previously trained Korean cyclists who had undergone 6 wks of detraining immediately prior to the study

SUBJECT CHARACTERISTICS (MEAN ± SD)

Group	Age yrs	Height cm	Weight kg	Fat free mass kg	% Body fat
Test	20 ± 1.0	179.1 ± 3.6	76.1 ± 5.9	58.1 ± 4.1	18.2 ± 3.2
Control	19.8 ± 1.3	177.9 ± 7.4	79.8 ± 9.2	59.7 ± 6.4	20.5 ± 2.9

Test group: n = 6 given a commercial supplement (Phosphagen Elite™, EAS, Golden, Co) containing 1.6g per dose ß-ala (Carnosyn™, NAI, San Marcos, Ca).

Control group: n = 6 given the same commercial supplement less ß-Ala.

Subjects were given 3 doses per day (for Test subjects this contained 4.8 g/d ß-Ala), for 12 wks

Subjects undertook a program of endurance (5 h per day, 6d per week) and weight training (3 d per week).

COMPOSITION OF THE COMMERCIAL SUPPLEMENT (PHOSPHAGEN ELITE™)

	Amount per serving
ß-Alanine (Carnosyn™)	1.6 g
Creatine Monohydrate	5.25 g
Taurine	1 g
Carbohydrates	34 g
Sodium	200 mg
Potassium	80 mg
Phosphorus	200 mg
Magnesium	60 mg

ENDURANCE TRAINING 6d per week:

- ► 5 x 15 s accelerative sprinting;
- ► 2 x 25 s prolonged accelerative sprinting;
- ► 5 h evening cycling @ 80% HR on the roller

From 4 wks an uphill course was included and exercise intensity.

On day 6 (Saturday) training was reduced to 2 h cycling @ 70% HR.

WEIGHT TRAINING - 3d per week:

► chest press, ► leg extension, ► bench press, ► leg curl

► hip extension, ► butterfly, ► lateral pull down, ► leg press

performed at 8RM of 4 sets.

MUSCLE BIOPSIES of the *v. lateralis* were taken at 0 and 12wks for fibre morphology and analysis of Carn and Tau by HPLC.

CYCLE ERGOMETER INCREMENTAL TEST to determine

- ► VO_2 max
- ► VO_2 at the ventilatory threshold (VT)
- ► work time to volitional exhaustion (WTE)

The test was started at 1Kp, after a warm-up at 0.5Kp for 2 min. The resistance was increased by 0.5Kp every 2 min until exhaustion. VO_2 was determined using a Vmax 229 gas analyser (Sensomedics, USA)

ISOKINETIC TEST Total Work Done (TWD) summed over 30 maximal 90° extensions and flexions of the knee extensors performed @ 240°.s^{-1} using a KinCom isokinetic dynamometer.

RESULTS (Mean ± SD)

1. MORPHOLOGY

Type II cross sectional was increased with training in both groups (P<0.05)

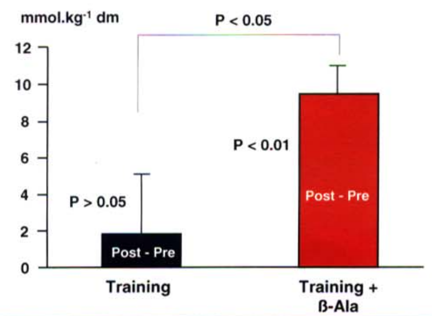
2. BIOCHEMISTRY (fig 1)

Carn was unchanged by training but increased with ß-Ala

Control: 23.9±6.3 before & 25.7±7.4 mmol.kg^{-1} dm after training

Test: 20.5±1.3 before & 30.0±3.7 mmol.kg^{-1} dm after training (P<0.01)

Fig 1: CHANGE IN MUSCLE CARNOSINE



3. PERFORMANCE / INCREMENTAL TEST (fig 2)

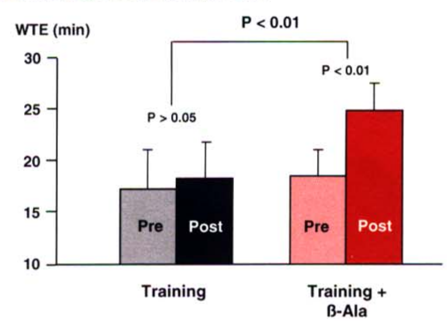
VO_2 max was unchanged by training or supplementation

VO_2 at VT increased in **Test** (P < 0.05) but not in **Control** subjects.

WTE was increased in **Test** (P < 0.01) but not in **Control** subjects.

Test vs **Control** was significant (P < 0.01)

Fig 2: WORK TIME TO EXHAUSTION (WTE) DURING THE INCREMENTAL WORK TEST.



4. PERFORMANCE / ISOKINETIC TEST

TWD Extension was unchanged in both **Test** and **Control.**

TWD Flexion was increased in **Test** (L: P < 0.01; R: P < 0.05).

		Test		Control	
		Pre	Post	Pre	Post
EXTENSION joules	L	2148 ± 163	2282 ± 399	2038 ± 314	2261 ± 647
	R	1833 ± 96	2095 ± 84	2222 ± 362	2062 ± 370
FLEXION joules	L	1777 ± 43	2182 ± 123**	1778 ± 203	1875 ± 411
	R	1779 ± 316	2063 ± 109*	2051 ± 151	1919 ± 703

CONCLUSIONS:

12 wks training did not change the muscle Carn content. This is in contrast with Suzuki *et al* (2004) but in agreement with Mannion et al (1994).

ß-Ala supplementation resulted in a significant increase muscle Carn but this was similar to that seen in previous studies with ß-Ala supplementation without training (Harris *et al*, 2006).

The increase in muscle Carn with ß-Ala supplementation did not appear to be reduced by the presence of Tau (or creatine) present in the commercial supplement.

β-Ala supplementation resulted in significant gains in VO_2 at VT, and WTE.

The study indicates that the increase Carn (= increase in buffering capacity) with β-Ala ingestion may contribute to both aerobic and anaerobic exercise performance.

Harris RC, Marlin DJ, Dunnett M, Snow DH, Hultman E (1990) Muscle buffering capacity & dipeptide content in the thoroughbred horse, greyhound dog & man. Comp Biochem Physiol 97A: 249-251

Harris RC, Dunnett M, Greenhaff PL (1998) Carnosine & taurine contents in individual fibres in human vastus lateralis muscle. J Sports Sci 16: 639-643.

Harris RC, Tallon MJ Dunnett M, Boobis L, Coakley J, Kim HJ, Fallowfield JL, Hill CA, Sale C, Wise JA (2006) The absorption of orally supplied ß-alanine and its effect on muscle carnosine synthesis in human vastus lateralis. Amino Acids X: xx-xx.

Hill C A, Harris R C, Kim H J, Boobis L, Sale C, Wise J A and Kraemer W J (2005) The effect of beta-alanine and creatine monohydrate supplementation on muscle composition and exercise performance. Med. Sci. Sports Exerc., 37, Supplement 5.

Mannion AF, Jakeman PM, & Willan PLT (1994) Effects of isokinetic training of the knee extensors on high-intensity exercise performance and skeletal muscle buffering. Eur J Appl Physiol 68: 356-361.

Parkhouse WS, McKenzie DC, Hochachka PW, Ovalle WK (1985) Buffering capacity of deproteinized human vastus lateralis muscle. J Appl Physiol 58:14–17.

Suzuki Y, Ito O, Takahashi H, Takamatsu K (2004) The effect of sprint training on skeletal muscle carnosine in humans. Intl J Sport Health Sci 2: 105-110

Tallon MJ, Harris RC, Boobis L, Fallowfield J, Wise JA (2005) The carnosine content of vastus lateralis is elevated in resistance trained bodybuilders. J Strength & Condit Res 19: 725–729.