THE EFFECT OF ß-ALANINE (CARNOSYN™) SUPPLEMENTATION ON MUSCLE CARNOSINE SYNTHESIS DURING A 10 WEEK PROGRAM OF STRENGTH TRAINING

Iain P Kendrick[1], Roger C Harris[1], Chang K Kim[2], Hyo J Kim[2], Viet D Hang[3], Thanh L Q[3], Bai B T[3] & John A Wise[4]

[1]University of Chichester, Chichester, UK; [2]Korea National Sport University, Seoul, Korea; [3]Natl University of Physical Education and Sport Science II, Ho Chi Minh City, Vietnam; [4]Natural Alternatives Intl, San Marcos, Ca, USA

UNIVERSITY OF Chichester

ABSTRACT

Carnosine (Carn) occurs in high concentrations in muscle and is highly effective in buffering H^+ over the physiological pH range. Carn is probably the only such active compound where the concentration can be changed by diet (or training). Synthesis of Carn occurs in muscle from ß-alanine (ß-ala) and histidine, of which the former is limiting. We have shown that supplementation with ß-ala for 4 and 10wk increases muscle Carn by ~60% and ~80% with significant increases in anaerobic exercise capacity (Harris et al 2006; Hill et al 2006). Muscle Carn concentrations [Carn] are 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 concentration with 8wk sprint-training (3 d/wk) in contrast to Mannion et al (1994) where no effect of 16wk isokinetic training (3 d/wk) was found. **AIM** To investigate the effect of ß-Ala supplementation on muscle Carn synthesis during a 10wk program of strength training. **METHOD** 26 male Vietnamese physical education students aged 20-26 yr, of normal body mass and height, were recruited to the study. None were vegetarians and all continued their normal dietary intake of meat and fish contributing an estimated 200-600 mg/d ß-Ala (in dipeptide form). Subjects were matched in pairs according to body mass and initial strength, and evenly randomised to receive [800 mg] x 8/d x 10wk of ß-Ala (Carnosyn™, NAI, San Marcos) or matching placebo capsules of maltodextrin. Subjects undertook 4 weight-training sessions per wk, 2 being lower body-dominant and 2 upper body-dominant, using a protocol based upon that of Hoffman & Stout (2004). The goal was to induce maximal strength and muscle mass gains in the 10wk. Biopsies of the *v. lateralis* were taken at 0 and 10wk for analysis of Carn and taurine. **RESULTS** Muscle Carn was unchanged with training alone (pre 29.2 ±SE 2.6 vs post 27.3±2.8 mmol.kg^{-1} dm; P>0.05) but increased when ß-Ala supplementation was included (23.6±1.4 vs 36.0±2.23 mmol.kg^{-1} dm; P<0.001). Tau did not change (training alone: 32.3±1.6 vs 36.1±3.3 mmol.kg^{-1} dm; P>0.05), (training + supplementation: 31.1±3.7 vs 34.0±2.4 mmol.kg^{-1} dm; P>0.05). **CONCLUSION** Carn was unchanged by 10wk training alone but was increased with ß-Ala supplementation, and to a similar extent seen in other studies undertaken without training. From the literature, chronically trained athletes, e.g. body-builders appear to have increased muscle Carn levels. In these the increased content may be a long-term effect of training or the result of a higher than normal ß-Ala content (including that in dipeptide form) present in the diet.

INTRODUCTION

Carnosine (β-alanyl-L-histidine) (Carn) has been shown to occur in high concentrations (~20 mmol.kg^{-1} dm) in skeletal muscle, particularly in type II fibres (Harris *et al*, 1998; Hill *et al*, 2006). A pKa of 6.63 allows Carn to function as an effective intramuscular H^+ buffer (Harris *et al*, 1990). Harris *et al* (2006) has demonstrated that 4 wk of β-alanine (β-Ala) can increase concentrations by ~60% and these increases can significantly improve anaerobic exercise capacity (Hill *et al*, 2006).

Muscle Carn concentrations ([Carn]) are increased after chronic training (Parkhouse *et al*, 1985; Kim *et al*, 2005; Tallon *et al*, 2005). Tallon *et al* (2005) reported [Carn] in UK bodybuilders of 43.0±8.3 mmol.kg^{-1} (dm) whilst Kim *et al* (2005) showed Korean speed skaters to have [Carn] of 36.2±9.8 mmol.kg^{-1} (dm). Parkhouse *et al (1985)* demonstrated that sprint trained athletes had greater [Carn] than endurance or un-trained subjects. Suzuki *et al* (2004) reported that 8 wk of sprint training significantly increased [Carn] (5.17±1.69 to 11.01±3.05 mmol.kg^{-1} wet muscle) and these increases correlated to significant improvements in mean and peak power output during a 30s Wingate test. However, Mannion *et al* (1994) found no effect of isokinetic training on muscle [Carn]. It is therefore unclear as to the effect of short duration training on muscle [Carn].

AIM: To investigate the effect of 10 wk whole body resistance training, and β-Ala supplementation on skeletal muscle [Car], whole body strength (WBS), isokinetic force production (F) and changes in body composition.

MATERIALS AND METHODS

SUBJECTS: 26 Vietnamese PE students

Subject Characteristics (Mean ± SD)

Group	Height (cm)	Mass (kg)	Age (yrs)	Body fat (%)
β-Ala	170.6 ± 5.1	60.4 ± 5.7	21 ± 2	10.5 ± 3.1
Placebo	167. 8± 6.3	59.2 ± 5.3	22 ± 2	9.8 ± 2.9

Supplementation

β-ala group: n = 13 received **800mg x 8/d x 4wk β-Ala (Carnosyn™, NAI, San Marcos, Ca).**

Placebo goup: n = 13 were given matching doses of maltodextrin.

Exercise Testing

Pre and post training subjects where assessed by 3 protocols;

1) *Whole body strength* (**WBS**)*;* subjects performed one repetition maximum (1RM) on the box-squat (lower boy), bench-press (upper body) and dead-lift (upper + lower body). Whole body strength was determined by totalling the 1RM of all 3 lifts.
2) *Isokinetic force production* (**F**)*;* subjects performed 90˚ isokinetic extension of the knee at 180˚/s to determine peak force.
3) *Upper arm curl test* (**CT**). Subjects performed one high repetition set (20 - 40 reps) of concentration curls. The maximum no of repetitions was performed at a set weight until momentary concentric fatigue occurred.

Fat free mass (FFM)

Mass and calliper assessments of skin-fold were taken pre and post training to measure body compositional changes.

Training

- 1) Subjects trained 4d/wk for 10 wk.
- 2) Two day-sessions were upper body dominant training, two were lower body dominant training.
- 3) All sessions comprised of multiple exercises for multiple sets executed close to concentric failure.
- 4) 3 sessions utilised the exercises listed in the above section (box-squat, bench-press and dead-lift).
- 5) Training was performed in a progressive overload manner over time.

TRAINING PROGRAM (reps x sets)

Day 1 (Lower Body dominant)	Day 2 (Upper Body dominant)
Box Squat 5x5	Bench press 5x5
Leg press 10x3	Pull ups 5x5
Leg extension 15x3	Lateral raises 10x3
Lunges 8x3	Bicep Curl 12x3
Abdominal work 6x4	

Day 3 (Lower Body dominant)	Day 4 (Upper Body dominant)
Deadlift 3x8	Power clean and press 6x4
Front squat 20x2	Barbell row 8x4
Reverse back extensions 10x4	Close grip bench press 10x3
Leg curl 8x4	Hammer curls 10x3
Abdominal work 10x4	

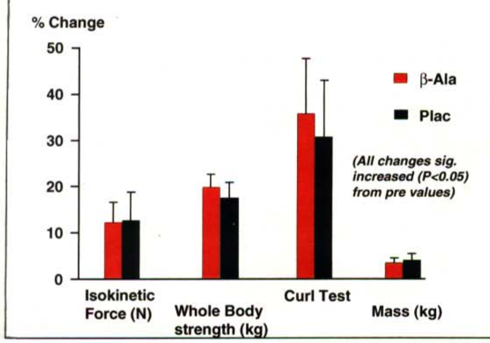
RESULTS (means±SE)

Exercise data:

➤There were significant increases (P<0.05) in both groups for **F** (*β-Ala 67.7±13.2N, 13.2%; Plac 61.7±15.7N, 12.5%*), **WBS** (*β-Ala 50.6±3.2kg, 19.7%; Plac 46.3±5.35kg, 17.5%*), **CT** (*β-Ala 7.6±1.3, 35.6%; Plac 6.7±5.35, 30.6%*) and **FFM** (*β-Ala 2.0±0.3kg, 3.4%; Plac 2.2±0.4kg, 4.0%*).

➤There was no significant difference between group effects

Fig 1: CHANGE IN EXERCSIE PERFORMANCE AND FFM



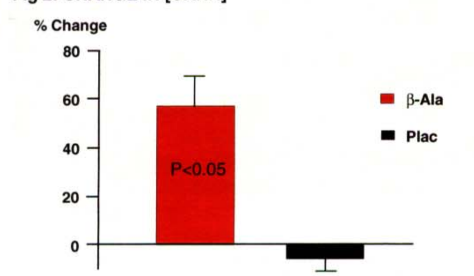
Biochemistry:

Carnosine

➤[Carn] increased in *β-Ala* group (23.6±1.4 vs 36.0±2.23 mmol.kg^{-1} dm, P<0.001).

➤There was no effect of training on [Carn] in the *Plac* group (pre 29.2±2.6 vs post 27.3±2.8 mmol.kg^{-1} dm, P>0.05)

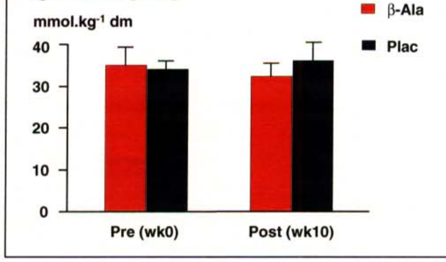
Fig 2: CHANGE IN [CARN]



Taurine

➤ There was no significant change in Taurine concentrations [T] after training for both *β-Ala* (31.09±3.67 vs 34.00±2.37 mmol.kg^{-1} dm) and *Plac* (32.30±1.55 vs 36.09±3.33 mmol.kg^{-1}) groups.

Fig 3: MEAN [TAU]



CONCLUSIONS

[Carn] unchanged by 10 wks of resistance training, but increased *52.5% by training + β-Ala supplementation.*

Results are in agreement with Mannion *et al* (1994) and Kendrick *et al* (2005 – this conference).

From the Henderson-Hasselbach equation there is a 1:1 relationship between [Carn] and the contribution of Carn to buffering capacity (β_{Carn}). *Consequently* β_{Carn} *will also be increased by 52%.*

Assuming that Carn accounts for 12.5% of β_{Total}, *- a conservative estimate* - then supplementation would increase β_{Total}, by *a minimum of* a 6.6%.

The resistance-training program resulted in significantly increased force production, and FFM. There was no effect of β-Ala.

The absence of group differences may be due to inadequate time of training after [Carn] elevation. Previous research has shown [Carn] is increased by 4 wks of supplementation. Thus the effective training period where subjects trained with increased β_{Total} may have been only 6 wks.

In summary β-Ala supplementation increased [Carn] and therefore also β_{Carn} whilst training alone did not affect [Carn]. It seems that the high [Carn] reported by (Parkhouse *et al*, 1985; Kim *et al*, 2005; Tallon *et al*, 2005) is a result of prolonged adaptation. We suggest that to *best demonstrate* any training benefits of β-Ala supplementation, training should be instigated *after* [Carn] increase had been attained.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the long-term funding provided by Natural Alternatives, San Marcos, California for the programme of studies on ß-alanine

REFERENCES

Harris RC, Marlin DJ, Dunnett M, Snow DH, Hultman E (1990) Comp Biochem Physiol 97A: 249-251. Harris RC, Dunnett M, Greenhaff PL (1998) 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) Amino Acids (E-publication). Hill C A, Harris RC, Kim HJ, Harris BD, Sale C, Boobis LH, Kim CK, Wise JA (2006). Amino Acids (accepted). Mannion AF, Jakeman PM, & Willan PLT (1994) Eur J Appl Physiol 68: 356-361. Parkhouse WS, McKenzie DC, Hochachka PW, Ovalle WK (1985) J Appl Physiol 58:14–17. Suzuki Y, Ito O, Takahashi H, Takamatsu K (2004) Intl J Sport Health Sci 2: 105-110. Tallon MJ, Harris RC, Boobis L, Fallowfield J, Wise JA (2005) J Strength & Condit Res 19: 725–729.