Original Research

The Effect of Lecithin Supplementation on Plasma Choline Concentrations During a Marathon

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Background: Previous studies have shown that plasma and urinary free choline concentrations decrease significantly during a marathon, and that these decreases may be associated with decreased performance.

Objective: In a pilot study, we sought to determine whether lecithin supplementation prior to a marathon would maintain plasma free and urinary choline concentrations and improve performance versus placebo.

Methods: 12 accomplished marathon runners, males (7) and females (5), 21 to 50 years of age were randomized to receive lecithin (4 capsules BID; PhosChol 900) or placebo beginning one day prior to the 2000 Houston-Methodist Health Care Marathon. The lecithin supplement provided approximately 1.1 g of choline on a daily basis (2.2 g total). Runners estimated finish time based on recent performance and training. Fasting, pre- and post-marathon plasma and a five-hour urine collection were analyzed for free choline and plasma for phospholipid-bound choline. Pre-race predicted, as well as the actual finish time, were recorded.

Results: All subjects completed the marathon. Plasma free choline decreased significantly in the placebo group and increased significantly in the lecithin group (9.6 $\pm$ 3.6 to 7.0 $\pm$ 3.6 nmol/mL *vs.* 8.0 $\pm$ 1.2 to 11.7 $\pm$ 3.6 nmol/mL, $p = 0.001$ for the Δ between groups). No significant changes in plasma phospholipid-bound choline concentration were observed. There was a non-significant decrease in urine free choline in both groups. Actual finish time was 256.3 $\pm$ 46.3 minutes for the lecithin group *vs.* 240.8 $\pm$ 62.0 for the placebo group and the actual:predicted time was 1.03 $\pm$ 0.06 (lecithin) and 1.07 $\pm$ 0.08 (placebo), $p = 0.36$.

Conclusion: Short-term lecithin supplementation prior to a marathon maintains normal plasma free choline concentration during the race, but failed to improve performance.

INTRODUCTION

Several studies have shown that plasma free and phospholipid-bound choline concentrations decrease significantly (approximately 25%) during a marathon run [1–4]. In addition, urinary free choline losses are significantly decreased, indicating conservation of choline [5,6]. A correlation with performance was demonstrated [1,3,4]. Decreased plasma choline has been associated with decreased acetylcholine and delayed muscle contraction [4,7]. Because choline is the precursor of the neurotransmitter acetylcholine, involved in skeletal muscle innervation, we hypothesized that choline is more rapidly metabolized in marathon runners and that choline supplementation would prevent the decrease in plasma free choline we and others had observed. Because of its role in skeletal muscle innervation, we further hypothesized that choline supplementation would result in improved or increased neuromuscular transmission reflected in improved performance.

Two previous studies have reported on the results of choline supplementation in runners. Von Allworden *et al.* found that 90% pure lecithin (approximately 12% choline), when used at a dose of 0.2g/kg body weight one hour prior to a 30 to 60 minute cross country run, resulted in a stable plasma free choline concentration at baseline level while runners who received placebo experienced a mean 17% decrease ($p < 0.01$) [8], although performance data was not reported. Sandage *et al.* reported the preliminary results of choline citrate supplementation in ten long distance runner [3]. These investigators found

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that a small choline supplement (2.8 g choline citrate; approximately 1.4 g choline) consumed one hour before the race resulted in improved performance *versus* placebo, although the finish times were not actually reported. In addition, the investigators stated the choline supplement maintained plasma free choline concentrations, although, again, actual data were not reported. We sought to determine if a lecithin supplement could maintain plasma free choline concentration and lead to improved performance.

METHODS

Twelve runners, males (7) and females (5), 21 to 50 years of age, who had successfully completed a marathon race within the preceding 12 months were recruited via newspaper advertisements. Subjects who consumed lecithin or choline supplements were excluded. Subjects signed informed consent forms approved by the University of Texas Houston Center for the Protection of Human Subjects. They were randomized using sealed envelopes to receive lecithin (4 capsules BID; PhosChol 900, American Lecithin Co., Oxford, CT) or placebo beginning one day prior to the 2000 Houston-Methodist Health Care Marathon. The lecithin supplement provided approximately 1.1 g of choline on a daily basis (2.2 g total).

Subjects fasted overnight and samples were obtained before any exercise on the morning prior to the marathon. Subjects were asked their estimated finish time based on recent performance and training. A blood sample (2mL) was collected in an EDTA-containing Vacutainer tube, centrifuged at 4°C. at 3000 × g for 10 minutes, the plasma decanted off and frozen at −70°C prior to analysis. Subjects collected their subsequent five hours of urine. The urine was kept refrigerated during the collection period. Following this, the subjects took their first dose of study medication (four capsules). A second dose of four capsules was taken at bedtime, and a third dose with breakfast on the morning of the marathon. Blood and urine sampling was repeated as described above just after the finish line. Actual finish time was recorded and also expressed as a ratio to the predicted time. This ratio was used as an index of performance enhancement.

Plasma was analyzed for free and phospholipid-bound choline, and urine for free choline only, by gas chromatography and mass spectrophotometry [9,10]. Plasma phospholipid-bound choline was determined following extraction as described by Folch *et al.* [11] and hydrolysis as described by Jope and Jenden [12].

Data are expressed as mean ± standard deviation (SD). Student's *t* test was used to compare mean absolute and percent changes within groups (paired *t* test) and between groups (unpaired *t* test). The Fisher's exact test was conducted to compare the proportions of each gender between groups. Pearson correlation coefficients were determined where appropriate.

RESULTS

All subjects completed the marathon. This included three males and three females in the lecithin groups and two females and two males in the placebo group (p = NS). The environmental temperature at the beginning of the race was 68°F.

Plasma free choline increased significantly in the lecithin group when compared to placebo ($p = 0.001$), which exhibited a decrease that approached statistical significance ($p = 0.09$, Table 1). No significant change in plasma phospholipid-bound choline concentration was observed in either group, although there was a trend towards a small increase in the lecithin group (Table 1). Urine free choline decreased in both groups with a non-significant trend towards a lesser decrease in the lecithin group (Table 1).

Actual finish time was 256.3 ± 46.3 minutes for the lecithin group vs. 240.8 ± 62.0 for the placebo group ($p = 0.89$). The actual:predicted finish time was 1.03 ± 0.06 for the lecithin group compared with 1.07 ± 0.08 for the placebo group ($p = 0.36$). There was no correlation between either the absolute or percent changes in plasma free or urinary free choline and the actual:predicted finish time ratio. There was no significant correlation between the change (absolute or percent) in plasma

Table 1. Plasma and Urine Choline Concentrations Before and After the Marathon

	Lecithin Group		Placebo Group	
	Baseline	Post-Race	Baseline	Post-Race
Plasma Free choline (nmol/mL)	8.0±1.2	11.7±2.5*$^{+}$ (45.8±18.8%)	9.6±2.5	7.0±3.6 (−26.2±28.9%)^
Plasma Phospholipid-Bound Choline (nmol/mL)	2135±522	2443±927 (16.5±35.4%)	2021±356	1991±529 (−0.8±25.8%)
Urine Free Choline (μmol/5hr)	13.2±6.8	11.9±10.8 (−14.3±43.4%)	9.6±3.7	7.5±4.6 (−25.9±28.9%)

* $p = 0.001$, Δ plasma free choline from baseline (lecithin) *vs.* Δ plasma free choline from baseline (placebo).

$^{+}$ $p = 0.002$ *vs.* baseline (absolute Δ), $p = 0.0004$ *vs.* baseline for %Δ.

^ $p = 0.09$ *vs.* baseline.

free or phospholipid-bound choline and the decrease in urine choline, between the plasma free and phospholipid-bound choline concentrations or between the decrease in plasma or urine free choline and the ratio of actual:predicted finish time (all r values ≤ 0.29).

DISCUSSION

Our study confirms that plasma free and urinary free choline concentrations fall significantly during a marathon run and that choline supplementation ameliorates the decrease in plasma free choline [1–4]. The 26% decrease in plasma free choline was virtually identical to that we had observed in a previous study [1], which was significantly greater in two other, earlier studies [2,8]. The trend towards less urinary choline loss in the placebo group also suggests there was less need for the kidneys to conserve choline in the lecithin-supplemented group [5,6,13]. However, given that urinary choline loss still decreased even in the lecithin-supplemented group, the possibility exists that we provided a sufficient amount of choline to permit the maintenance of a constant plasma free choline concentration, but insufficient to prevent the need for renal choline conservation.

A single runner in the lecithin group had a very small increase in his plasma free choline concentration. It was interesting that he exhibited a significant *increase* in his urinary choline excretion during the study. This unique observation has not been reported previously and could represent a choline wasting phenomenon whereby his normal renal homeostatic mechanism for choline concentration was defective [5,6]. Whether this was related to underlying and unknown renal disease or to marathon effects on the kidney tubules is unknown. Normally, very little urinary choline excretion occurs relative to an ingested dose [13].

We studied accomplished marathon runners who could accurately predict their finish time, and we therefore concluded that a significant deviation from this time in the absence of injury, weather factors or other obvious variable would represent a performance effect from our supplement. Although our study was insufficiently powered to detect improved performance, the actual:predicted finish time was virtually identical in both groups. It is possible the amount of choline may have been insufficient to improve performance despite maintenance of plasma free choline concentration. In our previous study we found the percent decrease in urinary choline concentration correlated with our index of performance in non-supplemented runners [1]. However, the previous finding may have been misleading as we failed to measure the total urinary choline loss.

The effect of lecithin supplementation on performance during a marathon will require a much larger study with a greater lecithin dose.

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