Effect of Single L-Carnitine Dose Over Lactate Production During High Intensity - Short Volume Effort

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ABSTRACT
Chronic oral ingestion of L-Carnitine can increase muscle carnitine and alter muscle metabolism during exercise. Yet, few similar results are published regarding acute oral ingestion and performance improvement. Our hypothesis is that non-mitochondrial ATP resynthesize is increased along with Carnitine acetylation, influencing lactate metabolism, and individual performance over single oral ingestion. Therefore, our propose will be to test the current hypothesis by monitoring performance indicators, during 30 seconds Squad Jump Test, after 4.5 g of L-Carnitine oral ingestion. Fourteen football players (n = 14) with a median age of 19 years old (18 – 22), 71 kg (65 – 74.5) median body weight of and 170.9 cm (168 – 176.5) height were recruited in the study. Study protocol consisted of two 30 seconds Squad Jump Tests (SJT). The test were conducted before (Test 1) and after one single oral supplementation dose (4.5 g) with L-Carnitine (T2). Of the fourteen subjects (n = 14) all of them were allocated to L-Carnitine ingestion after T1 test. The ingestion consisted of 4.5 g/day. After 5 days the athletes re performed in T2 30 seconds SJT. To avoid circadian rhythm influence, similar conditions were respected. The statistical analysis were conducted by using SPSS 20. software. The level of significance was set at α=0.05. Comparative changes were measured between T1 and T2. During T1, 1th rep, Tf was not significant different (p=1.00) from Tf, T2, 1th repetition, as seen through 0.43 (0.38–0.48) vs. 0.43 s (0.38–0.48) and 0.46 s (0.42–0.50) values. Similar data was observed during 1th repetition between Ct: 0.66 (0.58 – 0.92) vs. 0.66 s (0.58 – 0.92) (p=0.826). An improved performance can be unlikely due to L-Carnitine, as seen through Lactate accumulation. Further on, we must take into account a possible effect over Lactate tolerance which might favoured improved performance over T2 unlike T1.

1. Introduction
Carnitine is found in the heart and skeletal muscles, whereas 3/4 of its content comes from food intake. (1) Acetyl L-Carnitine is one of the most frequently used ergogenic aid in both recreational and performance athletes. (2) Ingestion is proposed due to its role in recovery and endurance capacity. (3) Therefore, based on its
mechanism, L-Carnitine can be used as a positive factor in muscle mass improvement.

Less research is focused on L-Carnitine use during low volume high intensity effort. (4) L-Carnitine use in training or competition periods varies with individual effort capacity, intensity and effort volume. (5) It is well known that during low intensity effort L-Carnitine can improve fat oxidation and limit muscle glycogen use by activating fatty acyl molecules through mitochondria inner membrane. (6) However less specific data is available regarding short high intensity effort, with energy metabolism differences over athlete age. (7)

The use of large amounts of L-Carnitine is dependent on plasma and muscle glycogen gradient concentration. Yet, plasma concentration is lower in comparison to muscle content. As a result, Na⁺ dependent high-affinity active transport must occur in order to observe changes in the two compartments. (8) Increasing Na⁺ concentration can activate Na⁺ – K⁺ pump, whose function is enhanced via insulin. (6) Several research papers confirmed an increased Carnitine content due to improved insulin response, based on both L-Carnitine ingestion and carbohydrates. (9) Similar results show that lower respiratory exchange ratio (RER) is related to an increased fat oxidation and decreased Lactate accumulation during high intensity effort. (10,11)

Short period oral supplementation effect over anaerobic effort has been insufficient documented as in report with other supplements.(12) Chronic oral ingestion of L-Carnitine can increase muscle carnitine and alter muscle metabolism during exercise. Yet, few similar results are published regarding acute oral ingestion and performance improvement. From a practical day by day perspective many athletes use one single pre effort oral serving. The effect is not fully documented over functional adoptions, lactate production or related energy metabolism changes. As we have seen though the published data, L-Carnitine can alter muscle metabolism during steady state exercise. (13)

Through our hypothesis we believe that non-mitochondrial ATP resynthesize is increased along with Carnitine acetylation, influencing lactate metabolism, and individual performance over single oral ingestion. Therefore, our aim will be to test the current hypothesis by monitoring performance indicators, during 30 seconds Squad Jump Test, after 4.5 g of L-Carnitine oral ingestion.

2. Method
3.1. Participants
Fourteen football players (n = 14) with a median age of 19 years old (18 – 22), 71 kg (65 – 74.5) median body weight of and 170.9 cm (168 – 176.5) height were recruited in the study by applying the following inclusion criteria: (1) male group, (2) aged between 18 - 25 years old, (3) residence in Târgu Mureș, Romania (4) enhanced effort capacity, (5) general health condition which allows the participation in high intensity effort, (6) participation consent. Study group exclusion was pre-set through the following criteria: (1) medical incompatibility with the pre-determined physical effort, (2) health condition that inhibits the study activity, (3) low effort capacity which alters the possibility to perform the test.

3.2. Materials
A group of football players were recruited to participate in an interventional study during January – February 2018. To perform the research we requested and obtained both the University Ethical Committee approval to conduct and apply the current methodology and the athletes’ written consent to participate in the study. The present study was conducted in accordance with the ethics rules and research standards from the Helsinki Declaration of 1964 and its amendments.

3.3. Procedure
Study protocol consisted of two 30 seconds Squad Jump Tests (SJT). The test were conducted before (Test
1) and after one single oral supplementation dose (4.5 g) with L-Carnitine (T2). The athletes recorded a 7 – 10
day diet program pre T1 and T2 tests. Pre-tests the athletes were instructed to avoid caffeine, other supplements
during the entire study period and to maintain an 8.7 g/kg Carbohydrate, 1.2 g/kg Protein and 1 g/kg Fat intake,
while reducing effort intensity with 48 hours (≤75% of \( \text{VO}_{2\text{peak}} \)) and 24 hours (≤65% of \( \text{VO}_{2\text{peak}} \)) pre evaluation.
Of the fourteen subjects (n = 14) all of them were allocated to L-Carnitine ingestion after T1 test. The ingestion
consisted of 4.5 g by using 2 g volume capsules, served during Breakfast, at 7:00 am. After 5 days, with
restricted training conditions at 48 hours (≤75% of \( \text{VO}_{2\text{peak}} \)) and 24 hours (≤65% of \( \text{VO}_{2\text{peak}} \)), pre-test the athletes
performed in T2 30 seconds SJT. In order to avoid circadian rhythm influence, T2 test began on the same day of
the week (Thursday), at the same hour (10:00 am), after a similar food intake, similar training conditions and the
same testing protocol, as described in Figure I - Figure II. Before and after each test lactate accumulation was
measured.

Pre SJT assessment

Ten days before SJT (T1) athletes came into the Physiology Department for baseline measurements that
confirmed individual capacity and health conditions. The screening consisted of general and surface
anthropometry, Heart Rate (b/min), ECG, Blood Pressure (Systolic Blood Pressure, \( sBD \) (mmHg); Diastolic
Blood Pressure, \( dBP \) (mmHg); Mean Blood Pressure, \( mBP \) (mmHg)) and Blood Lactate (mmol/l). Anthropometry evaluation was conducted by using ADE taliometer (Hambrug, Germany) and Cosmed plicometer (Rome, Italy), while Careshine EKG-903A3 12-lead Digital 3-channel Electrocardiograph was used for ECG. Heart rate was measured by using Polar H7 device, Omron BPU321OS Blood Pressure analyser and Nova Biomedical, Lactate Plus (Waltham, USA) device for Lactate measurements. Mean Blood Pressure was calculated by using the following formula:

\[
mBP = \frac{sBP + (2 \times dBP)}{3}
\]

General anthropometry

Body weight (kg) and inactive mass (%) were assessed during pre SJT assessments. The analyses were
carried out using ADE taliometer and Cosmed manual plicometer, as described earlier. Durnin and Womersley
(14) formula was applied to calculate inactive mass percentage (%) by using: bicipital (mm), tricipital (mm),
subscapular (mm), and suprailiac (mm) skinfolds, represented as \( \sum 4ST1 \). The body weight (kg), height (m),
age (years) and gender (14):

\[
\text{Body density} = 1.1765 - 0.0744 \log_{10}(4ST1)
\]

During pre STJ assessment athletes performed the testing protocol for familiarization and tasks understanding.

30 Seconds SJT

By performing the test we analysed anaerobic power through: contact time (\( C_t \), seconds), flight time (\( F_t \), seconds), height (cm), and power ratio (Watt per kilo) by using OptoJump System. The test was performed over three reps (x3) each lasting 30 seconds. Recovery periods, lasting 60 seconds, were conducted after each repetition, as illustrated in Figure I, while maintaining phase I position (Figure 2).
Performance analysis was commenced by 10 minute warm-up that included both static and dynamic exercises of which intensity reached between 65 - 85% of VO\textsubscript{peak} during short (5 – 20 s) high intensity intervals. In order to perform the test, the subjects were placed between the two OptoJump System device's arms with the legs width apart and hands on the hips. During each squad jump, the device recorded the height of the Target Centre (Height, cm), Ground Contact Time (C\textsubscript{t}, seconds), the Flight Time (F\textsubscript{t}, seconds) and Power Ratio (Power, watt per kilo). Tracking was performed in real time, stored and used in comparison during analysis, as shown in Figure 2.

**Statistical analysis**

The statistical analysis were conducted by using SPSS 20. software. The level of significance was set at α=0.05. By using Shapiro-Wilk test the data was checked for normal distribution. All descriptive data were presented as Median, Minimum, Maximum and Interquartile Ranges. For inferential analysis, the Wilcoxon Signet Rank Test and Manova Test were used to analyse subjects' performance improvement over T1 and T2.

**4. Results**

**Pre SJT assessment results**

Subject median height was 170.9 cm (168 – 176.5). The body weight was measured at a median value of 71 kg (65 – 74.5), while inactive mass was determined at 13.97% (8.89 – 15.5). By using pre 30 seconds SJT assessments, sBP values were measured at 118 mmHg vs 113 mmHg during T1 vs. T2 SJT; dBP was measured at 60 vs. 66 mmHg. Median mBP was 81.67 vs. 85.3 mmHg, whereas median HR reached 73 vs. 72 b/min.

**30 seconds SJT Performance Analysis (T1 - T2)**

During T1 test, 1th rep contact time was 0.66 s (0.58 – 0.92). Changes were observed over the second and the third repetition: 0.63 s (0.55 – 0.94), 0.57 s (0.52 – 0.88). Contact time improvement was correlated to power (p = 0.08) without being linked to flight time (p = 0.45) or jump height (p = 0.62). Table 1. shows changes over T1 performance parameters.

**Table 1.** T1 performance analysis over 1th – 3th repetition
Table 2. T2 performance analysis over 1th – 3th repetition

<table>
<thead>
<tr>
<th>Performance analysis</th>
<th>1th Repetition</th>
<th>2th Repetition</th>
<th>3th Repetition</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_f, \ s )</td>
<td>0.43 (0.38 – 0.48)</td>
<td>0.46 (0.42 – 0.50)</td>
<td>0.47 (0.41 – 0.53)</td>
<td>13.187</td>
<td>0.001**</td>
</tr>
<tr>
<td>( C_t, \ s )</td>
<td>0.69 (0.54 – 0.80)</td>
<td>0.65 (0.50 – 0.78)</td>
<td>0.64 (0.46 – 0.71)</td>
<td>11.400</td>
<td>0.002**</td>
</tr>
<tr>
<td>Height, cm</td>
<td>23.7 (18.9 – 29.2)</td>
<td>26.9 (21.7 – 30.7)</td>
<td>28.1 (21.2 – 35.6)</td>
<td>10.745</td>
<td>0.002**</td>
</tr>
<tr>
<td>Power, watt/ kg</td>
<td>17.8 (15.1 – 22.3)</td>
<td>19.2 (15.6 – 24.1)</td>
<td>20.6 (16.2 – 28)</td>
<td>7.181</td>
<td>0.009**</td>
</tr>
</tbody>
</table>

**p < 0.01; *p > 0.05

Basal Lactate measurement resulted in 1.2 mmol/l (1.1 – 1.5) value, whereas post effort a median value of 12.1 mmol/l (8.4 – 12.8) was reached. 

During T2 30 seconds SJT, \( C_t \) reached 0.69 s (0.54 – 0.80 s) without being significant differed from T1 value (\( p > 0.05 \)). Similar to T1, an improved performance was seen during second and third repetition: 0.65 s (0.50 – 0.78), 0.64 s (0.46 – 0.71). During T2 contact time was correlated to power (\( p = 0.01 \)) and height (\( p = 0.01 \)), unlike T1 results. Significant changes were seen over flight, contact, height and power during T2 30 seconds SJT, as shown in Table 2.

Lactate measurement during T2 resulted in 1.2 mmol/l (0.8 – 1.5) basal value and 12.9 mmol/l (9.4 – 14.5) in the end of the effort, reported as different in T2 as against T1.

Figure 4. Changes in Blood Lactate in T1 and T2 (\( p = 0.028 \)) - illustrated as median with range (min - max)

T1 – T2 Squad Jump Test Analysis

During T1, \( T_f \) reached a median value of 0.42 s (0.36 – 0.51), unlike 0.46 s (0.38 – 0.53) during T2. Over T1, \( C_t \) was measured at 0.60 s (0.52 – 0.94) as against 0.65 s (0.46 – 0.80) during T2. Associated values for height: 22.43 (16.55 – 32.14) vs. 26.92 cm (18.94 – 35.63); and power 17.17 (13.42 – 24.40) vs. 18.85 w/kg (15.13 - 28) were obtained, and illustrated in Figure 3.
Comparative changes were measured between T1 and T2. During T1, 1th rep, Tf was not significant different (p = 1.00) from Tf/T2, 1th repetition, as seen through 0.43 (0.38 – 0.48) vs. 0.43 s (0.38 – 0.48) and 0.46 s (0.42 – 0.50) values. Similar data was observed during 1th repetition between C/t: 0.66 (0.58 – 0.92) vs. 0.66 s (0.58 – 0.92) (p=0.826). Changes regarding height and power during 1 - 3th repetitions are illustrated in Table 3.

**Table 3.** Related Samples Wilcoxon Signed Rank Test results between T1 and T2

<table>
<thead>
<tr>
<th>STUDY PARAMETERS BETWEEN T1 – T2</th>
<th>Moment</th>
<th>T1 Median value (min - max)</th>
<th>T2 Median value (min - max)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tf, s</td>
<td>1th</td>
<td>0.43 (0.38-0.48)</td>
<td>0.43 (0.38-0.48)</td>
<td>1.000*</td>
</tr>
<tr>
<td></td>
<td>2th</td>
<td>0.42 (0.40-0.46)</td>
<td>0.46 (0.42-0.50)</td>
<td>0.005**</td>
</tr>
<tr>
<td></td>
<td>3th</td>
<td>0.43 (0.38-0.51)</td>
<td>0.47 (0.41-0.53)</td>
<td>0.005**</td>
</tr>
<tr>
<td>Ct, s</td>
<td>1th</td>
<td>0.66 (0.58-0.92)</td>
<td>0.69 (0.54-0.80)</td>
<td>0.826*</td>
</tr>
<tr>
<td></td>
<td>2th</td>
<td>0.63 (0.55-0.94)</td>
<td>0.65 (0.50-0.78)</td>
<td>0.196*</td>
</tr>
<tr>
<td></td>
<td>3th</td>
<td>0.57 (0.52-0.88)</td>
<td>0.64 (0.46-0.71)</td>
<td>0.637*</td>
</tr>
<tr>
<td>Height, cm</td>
<td>1th</td>
<td>22.02 (16.5-23.8)</td>
<td>23.77 (18.9-29.2)</td>
<td>0.002**</td>
</tr>
<tr>
<td></td>
<td>2th</td>
<td>22.28 (20.3-26.8)</td>
<td>26.92 (21.7-30.7)</td>
<td>0.008**</td>
</tr>
<tr>
<td></td>
<td>3th</td>
<td>24.41 (18.5-32.1)</td>
<td>28.81 (21.2-35.6)</td>
<td>0.004**</td>
</tr>
<tr>
<td>Power, watt/ kg</td>
<td>1th</td>
<td>17 (13.4-18.2)</td>
<td>17.8 (15.1-22.3)</td>
<td>0.002**</td>
</tr>
<tr>
<td></td>
<td>2th</td>
<td>17.4 (14.7-20.5)</td>
<td>19.29 (15.6-24.1)</td>
<td>0.009**</td>
</tr>
<tr>
<td></td>
<td>3th</td>
<td>17.97 (15.5-24.4)</td>
<td>20.66 (16.2-28)</td>
<td>0.009**</td>
</tr>
<tr>
<td>Lactate (mmol/l)</td>
<td>Pre Effort</td>
<td>1.2 (1.1 – 1.5)</td>
<td>1.2 (0.8 – 1.5)</td>
<td>0.298*</td>
</tr>
<tr>
<td></td>
<td>Post Effort</td>
<td>12.1 (8.4 – 12.8)</td>
<td>12.9 (9.4 – 14.5)</td>
<td>0.028**</td>
</tr>
</tbody>
</table>

**p < 0.01; *p > 0.05**

### 5. Discussion and Conclusion

Performance during 30 seconds SJT was studied through Lactate accumulation and Power Ratio improvements over an anaerobic effort, conducted by trained participants. Through the applied methodology our objective was to minimize training influence over final results, similar to other research papers. (7)

Based on our outcomes, power ratio changed, unlike other outcomes which failed to identify individual performance improvements. (15) L-Carnitine is suggested to alter muscle metabolism during steady state exercise. (16) Various papers are published regarding endurance training while lack of specific data is related to...
high intensity and intermittent effort, as a result of one single L-Carnitine dose administration. (17,18) Topics related to L-Carnitine supplementation are covered through papers which confirm recovery improvements, cellular damage prevention and hypoxic stress regulation over chronic ingestion (3,12,19,20), as opposite to our findings.

**L-Carnitine influence over high intensity Anaerobic Power Ratio and Blood Lactate Accumulation**

Overall use of L-Carnitine ingestion over both low and high intensity effort is related to insulin response, (21) whose effect has not been studied in the current work. Over nine weeks of L-Carnitine supplementation changes were seen in Lactate response, oxidative stress and peak power during resistance training, unlike our findings over acute single dose intake. (22) Based on our outcomes, improved fat oxidation through increased glycogen storage which inhibits carbohydrate oxidation (5,6,23) can result due to chronic ingestion but unlikely due to acute L-Carnitine supplementation, as in our case. From a physiological standpoint, higher pyruvate dehydrogenase complex, due to maintain Coenzyme A (CoA), can improve Lactate accumulation and delay fatigue. (3) No similar findings were identified in our paper based on T2 response as against T1 30 seconds SJT. Lactate accumulation during T2 30 seconds SJT was increased due to a reduced hydrogen ion buffering process, due to Lactic Acid breakdown. However, Leelarungrayub et al. published a paper which suggested that one single dose can improve blood Lactate response and pyruvate dehydrogenase activity, along with VO_{peak} value, in comparison to our outcomes. (11) Yet, several papers failed to identify a drop in Lactate level despite changes in plasma and muscle Carnitine. (12)

Improved performances are related to Lactate accumulation and tolerance during effort. Based on Lactate increase in T2, one single dose administration will not induce L-Carnitine mediated improvements over pyruvate dehydrogenase flux and activation. Through Burrus M. et al. research, L-Carnitine supplementation, during lower Lactate levels, failed to influence RER value. (10) As we can see that the main effect is not entirely related to fatty acids oxidation, but to muscle Carnitine content. (24) This practical element can be further on confirmed through our nonspecific, anaerobic, testing protocol, which insures an anaerobic energy pathway, limiting fat metabolism while increasing Lactate accumulation, as against Majid Kashef et al. which reported a lower Lactate accumulation. (25)

We consider that the subjects’ number and the lack of muscle and plasma carnitine measurement, represent study limitations. However, our study strength points were related to Lactate values, which were higher in T2 as against T1, despite performance improvement. Yet, pre-test training volume and intensity along with food intake, supplementation and recovery phase can influence the final result. Through the current study methodology, all influencing factors were standardized over T1 and T2 testing, as against other papers which studied chronic L-Carnitine supplementation. (25)

In future perspectives, the main outcomes, using a similar hypothesis will be included in a control and placebo double blind study, following several methodology changes: larger study group (1), more dynamic study group with participants from several sports fields (2), muscle and plasma Carnitine evaluation (3).

**Conclusions**

After one single L-Carnitine dose we obtained an improved power ratio and jump height during 30 seconds Squad Jump Test next to an increased Lactate accumulation. During the second test Lactate levels was higher unlike the first test, while an improved performance was seen during the second as against the first test. Through the current results, we conclude that an improved performance can be unlikely due to L-Carnitine, as seen through Lactate accumulation. Further on, we must take into account a possible effect over Lactate tolerance which might favoured improved performance over T2 unlike T1. Many other factors must be taken into
account, including the placebo effect.

Acknowledgments

The authors of this paper state that there are no conflicts of interest regarding the hypothesis, objective, results or the conclusion drawn. The authors will like to thank the coaches and the athletes for their professionalism and involvement in the current research.

References


