Body Energy Systems Comparison and Glutamine Supplementation in Handball Players

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Abstract
The aim of this study investigated the effects of glutamine supplementation on aerobic and anaerobic energy system. Handball players (n=80) volunteered for this study. Weight and height of the players were measured and the age range was between 17-24 years old (20.7±4.3). Forty players performed wingate test and 40 players performed cooper test. The Experimental Group (n=20) was given glutamine treatment of 0.3g/kg/day of glutamine for a period of six weeks and the Control Group (n=20) had no treatment that both of the groups were for the wingate test and cooper test, too. Cooper test and Wingate test was performed by the participants that selected as two groups. Peak power and mean power were determined as the highest and average power achieved during any 30s of the test. There was a significant effect (p<0.05) of the supplementation on VO2max and on Wmax producing a higher value post-test than the pre-test. The glutamine supplement had significant effects (p<0.05) on the mean and peak power under anaerobic circumstances. The study results confirm previous reports of a significant effect of glutamine supplementation on VO2max, peak power and mean power and concluded to examine different doses of glutamine.

Keywords: energy systems, glutamine, supplementation, handball players, peak power, mean power, wingate test, cooper test, aerobic, anaerobic.

Introduction
Handball is fast and body contact sports which require both aerobic and anaerobic endurance [1]. Players with high level of aerobic and anaerobic endurance enable them to perform quick action and sprints without getting fatigue, which have a crucial impact on match results. The game handball composed of repeated sprint of players for fast breaks and quick counter attacks which require great aerobic capacity. The players with greater aerobic capacity tend to show lower fatigue index which show negative correlation in handball players [2]. During anaerobic metabolism, characterized by the ATP-CP and glycolytic systems predominant in anaerobic activity, it is common that muscular fatigue occurs. During frequent periods of high intensity exercise in futsal and handball matches, muscular energy is generated by anaerobic glycolysis [3]. Glutamine is one of the most abundant amino acid in the body. The consumption of glutamine increases under stresses such as exercise and disease conditions. Glutamine has received attention, because
decreased plasma glutamine concentration is associated with both immune suppression after intense exercise and the over-training syndrome. So, was recommended glutamine supplementation for athletes [4]. High-output exercise produces a catabolic situation that promotes a decrease in the L-glutamine pool in the body [5]. Glutamine plays a role in many important biological processes and its availability can be limited during exercise [6]. Glutamine ingestion during acute dehydration stress is reported to enhance fluid and electrolyte absorption resulting from intestinal disorders [7]. During handball participation, for example a great number of rapid directional changes, starts, stops, jumps and landing occur [8]. The authors disclosed that the values for Wmax were similar in the international and national handball player groups and were also very similar to the values of the sprinters. When normalized for body mass or lean body mass, Wmax was greater in handball players when compared to untrained or endurance trained subjects [1]. The Wingate Test has been used as a major test of muscle power whereas isokinetic devices have been used to determine muscle strength [9]. The Wingate Test is commonly known as a method for measuring peak anaerobic power (PP) and mean anaerobic power (PM). Although anaerobic metabolism is considered the primary source of adenosine triphosphate (ATP) during the Wingate Test, there is evidence of a meaningful aerobic contribution, which might be as high as 40% [10]. The VO2 max has been shown to be a good discriminator of the aerobic performance potential of middle and long distance runners [11]. The 30-s Wingate Anaerobic Test (WAnT30) is frequently used for assessing anaerobic power and has been reported to be valid and reliable. Dahlstedt et al. (2001) have suggested that the high level of motivation required from the subjects performing the WAnT30 due to the test’s highly strenuous nature, could interfere with the observation on a diurnal basis. Although widely used, WAnT30 performance often induces mild to severe physical discomfort, such as nausea and vomiting, slight to severe headaches, localised muscle fatigue and dizziness or syncope (fainting) [12].

Objective:
Accordingly, the aim of this study was to assess the glutamine supplement loading effects on the peak, mean power of handball players during 30 seconds of performing exercise under anaerobic conditions and on the aerobic performance and power during 6 weeks general preparation period and the energy system comparison under these conditions.

Materials and Methods
Participants
Ethical approval was obtained from the University before the study commenced. Eighty male handball players who played in the Erzurum Aziziye Municipality handball team volunteered for this study that forty persons was selected to Wingate test and forty persons was selected to cooper test and all the players signed the consent forms for athletes. All players belonged to this handball team and did not play for any other team. Some physical characteristics of the players, such as weight and height were measured and their ages noted (Table). The mean age for the total group of handball players was 20.7±4.3 years and the ages varied between 17-24 years.

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Body mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wingate</td>
<td>Experimental Group (n=20)</td>
<td>20.1±4.5</td>
<td>180.4±4.7</td>
<td>77.3±2.8</td>
</tr>
<tr>
<td></td>
<td>Control Group (n=20)</td>
<td>21.1±4.1</td>
<td>180.5±4.4</td>
<td>77.3±3.1</td>
</tr>
<tr>
<td>Cooper</td>
<td>Experimental Group (n=20)</td>
<td>21.2±3.9</td>
<td>180.4±4.3</td>
<td>77.2±2.6</td>
</tr>
<tr>
<td></td>
<td>Control Group (n=20)</td>
<td>20.8±4.4</td>
<td>180.6±4.1</td>
<td>76.9±2.7</td>
</tr>
</tbody>
</table>

Testing Protocol
Kenneth H. Cooper conducted a study for the United States Air Force in the late 1960s. One of the results of this was the Cooper test in which the distance covered running in 12 minutes is measured. Based on the measured distance, an estimate of VO2 max [in mL/(kg·min)] is:

\[ \text{VO}_2\text{max} = \frac{d_{12} - 504.9}{44.73} \]

where \( d_{12} \) is distance (in metres) covered in 12 minutes.
Accurately measuring VO\textsubscript{2} max involves a physical effort sufficient in duration and intensity to fully tax the aerobic energy system. In general clinical and athletic testing, this usually involves a graded exercise test (either on a treadmill or on a cycle ergometer) in which exercise intensity is progressively increased while measuring ventilation and oxygen and carbon dioxide concentration of the inhaled and exhaled air. VO\textsubscript{2} max is reached when oxygen consumption remains at steady state despite an increase in workload.

The Wingate Test served as dependent variable. Each participant performed the Wingate test on a Monark 894e ergometer (Varberg, Sweden) using the Monark Anaerobic Test Software (Version 2.24.2, Vansbro, Sweden). The seat height was adjusted to fit each participant. The participants were asked to wear the same sportswear and shoes for all tests and to report any departures from this instruction to the experimenters. The Wingate protocol has five distinct periods: (1) prior exercise; (2) recovery interval; (3) acceleration period; (4) Wingate Test (Bar-or, 1983); and (5) cool-down/recovey period. As with all anaerobic tests and due to the stressful nature of this test, prior exercise was provided as a warm-up phase that included some all-out pedalling at the test F-setting to accustom the subject. After this period, a relief interval of 2-5 minutes was observed to allow for recovery but maintain muscle temperature (Table 2). Although the measurement period is 30 seconds, the actual test period is really 45 seconds as the 15-second acceleration phase is crucial. A standard Wingate 5-minute warm-up was performed at a resistance of 3% body weight with three 30-s sprints. During the warm-up, participants could adjust their horizontal position from the arm crank ergometer if necessary. Participants were instructed to keep their feet shoulder-width apart with their knees at 90° to the floor and not to move their feet during each exercise test. The Wingate test was performed under normal room temperature conditions.

Performance indices of peak power (PP) and mean power (MP) were calculated for each analysis system where PP was the highest power and MP was the average power achieved during any 30s-cycle of the test and the anaerobic power was measured. Minimum power was recorded and the Fatigue Index was calculated as a percentage.

\[
\text{Mean Power (MP)}: \text{Average anaerobic power over the 30-sec test}
\]

\[
\text{Fatigue Index}: \frac{(\text{PP output} - \text{Minimum power output})}{\text{PP output}} \times 100
\]

\[
\text{Work} = F \times D
\]

\[
\text{Torque: } T = (F_1 - F_2) r \text{ where } T_{\text{N.m}} \text{ is the brake torque; } r_m \text{ is the fly wheel; } F_1N \text{ is the tight side tension; } F_2N \text{ is the slack side tension}
\]

Research design:

The 80 players were randomly assigned to an Experimental (n=20) and a Control Group (n=20) for cooper test and an Experimental (n=20) and a Control Group (n=20) for wingate test. Both groups were exposed to a pre-test and six weeks later to a post-test testing session. All players in the same group were tested on the same day. The Experimental Group received glutamine treatment of 0.3g/kg/day for the six weeks, while the Control Group received no treatment. All subjects were asked to follow their normal diet for the duration of the study.

Statistical Analysis

Statistical software SPSS (version 17 for windows, Inc., Chicago, IL) was used for data analysis. Mean and standard deviation values were calculated for each variable. For the evaluation of the data, the Levene's Test of equality of error variances tests and Manova multivariate analysis was employed. To examine the variance error between the variables, Peak Power, Mean Power and VO\textsubscript{2}max amount, Levene's test coefficient test was used. The Manova multivariate analysis tests were applied for the repeated measures and glutamine treatment effect (Pre-test vs. Post Test) for the Experimental Group (EG) and the comparison of the groups (EG vs. CG) and for the cooper test and wingate test under the pre- and the post-test condition. Significance was accepted at the level of p<0.05, however, where greater significance (p<0.01) was attained, it was specifically noted.

Results

There was a significant and positive effect of torque factor × glutamine supplement on peak power output (F=3.1; p<0.05) under the post-test condition for the Experimental Group. The glutamine supplement had a significant effect (p<0.05) on peak power. Similarly, with measures of mean power output; there was a significant and positive effect of torque factor × glutamine supplement on mean power output (F=2.9; p<0.05). There was a significant effect on the Experimental Group regarding W\textsubscript{max} with glutamine producing a higher value at the post-test
than at the pre-test. The correlation between glutamine consumption and peak power ($r=0.92$) and glutamine consumption and mean power ($r=0.89$) were positive and significant.

Figure 1. Experimental group: Effect of glutamine supplementation on (A) peak and (B) mean power output during a series of 30s-sprints for pre- and post-test condition.
The correlation between blood lactate and glutamine consumption was negative and significant ($r = -0.76$). The increase of torque did not have a significant effect on the peak power and mean power in the case of no glutamine supplementation. At the post-test, the change point of peak power and mean power under the glutamine supplementation condition is 0.8 N.m.Kg$^{-1}$ of torque for the Experimental Group. After this point, there is a steep increasing trend with a high slope (Figure 1). For the Control Group, there is no stable changing point of peak power and mean power. Based on the torque increasing, the power changes are different for both the pre- and post-test conditions. For the Control Group, there was no indication of an increasing trend for neither the pre-test or the post-test for peak and mean power. The absence of glutamine usage was the reason that there was no significant change for the Control Group under both the pre and post-test conditions (Figure 2).
There was significant difference between the amount of VO$_2$max between control group and experimental group at 5% probability level under post-test condition. The results showed the glutamine effects on the aerobic energy system and increasing of VO$_2$max for the experimental group (Fig.3). The results of the VO$_2$max for the control group and experimental group under pre-test condition did not have significant difference at 5% probability level and for the two groups received similar results. Also, according to the results for the comparison of glutamine supplementation on two energy systems (anaerobic and aerobic) was shown that glutamine had not significant effects on the energy systems for control groups under pre-test condition, so that there was not significant changing for VO$_2$max for control group under pre-test and for the peak and mean power of control group the trends were irregular under pre-test condition. Glutamine supplementation had significant and positive effects on the anaerobic energy systems and peak and mean power and also on the aerobic energy system and VO$_2$max of experimental group under post-test condition.

**Discussion**

Babij et al. observed an increase in glutamine concentration from 575 μmol/L at rest to 734 μmol/L during exercise at 100% of maximum oxygen uptake (VO$_2$ max). Plasma glutamine concentration decreased from 557 μmol/L at rest to 470 μmol/L immediately after 3.75 h of cycling at 50% VO$_2$ max. The plasma glutamine concentration reached a minimum of 391 μmol/L after 2 h of recovery and remained depressed at 482 μmol/L immediately after 4.5 h of recovery. Large declines in plasma glutamine level following a marathon race from 592 μmol/L (prerace) to 495 μmol/L immediately postrace were reported in 24 club standard athletes. Continuous cycling at 55% VO$_2$ max for 3h in 18 healthy males resulted in a decrease in plasma glutamine concentration from 580 μmol/L preexercise to 447 μmol/L after 1h recovery. However, continuous cycling to exhaustion at 80% VO$_2$ max (mean endurance time was 38min) in the same subjects did not alter the plasma glutamine concentration compared with preexercise [13]. In a randomized, cross-over, placebo-controlled study, Rohde et al. had subjects perform 3 successive bouts of cycle ergometer exercise at 75% VO$_2$ max for 60, 45, and 30 min with 2h rest between each bout. Subjects were fed glutamine (0.1 g/kg bm) 30 min before the end of each exercise bout and 30 min after each exercise bout [14]. Even when participants engage in carefully controlled exercise training regimens, the nature of the training response is remarkably heterogeneous, allowing the classification of non-, low, and high responders and even adverse responders This interindividual variability includes a strong genetic component with, for instance, a maximal heritability estimate.
of ~50% for the response of VO₂max when adjusted for age, sex, baseline VO₂max, and body composition [15]. The peak, mean and minimum anaerobic power of the Experimental Group (EG) increased significantly after the six weeks of the consumption of the glutamine supplement when compared to the Control Group (CG) [16]. National and international handball players and sprinters have produced significantly higher peak power in the legs Wingate test compared to that produced by endurance athletes and untrained subjects [17]. There was no significant improvement, under the control condition without any supplementation, in the basic mechanical variables, such as total work (Wₜₒₜ) and maximal power (Pₘₚₓ) achieved in the Wingate test for the handball players [18]. Glutamine supplementation managed to prevent a decrease of maximum and minimum power. It has been shown that ingestion of pure glutamine promoted muscle glycogen re-synthesis during recovery from exhaustive exercise [19]. Although the decreases in anaerobic power and field goal percentage did not reach significance, the results suggest that the combination of high intensity, moderate duration exercise, and fluid restriction might be detrimental to performance [20].

**Conclusion**

The results of this study confirm previous reports of the significant and positive effect of glutamine supplementation on VO₂max, aerobic energy system and anaerobic energy system. The intake of glutamine had a regulating effect on the peak and mean power and brought about positive changes in exercise. As studies about the effect of glutamine intake on anaerobic power are limited, it is recommended that more research should be done on the effect of glutamine supplementation during exercise using the Wingate test of anaerobic power. The study suggested that other dosages of glutamine should be investigated. Further research could assess the influence of glutamine intake and intensive physical exercise involving athletes of other sports and using other performance traits, such as athletic skill elements or level of performance.

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**References:**


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