Topics in Sports Medicine

Laboratory Tests Ordered By a Chiropractic Sports Physician on Elite Athletes Over a 1-Year Period

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Abstract
Objective: The purpose of this study is to describe and discuss laboratory tests ordered on elite athletes in an interdisciplinary sports medicine clinic by a doctor of chiropractic over 1 calendar year.

Methods: A retrospective review of laboratory tests ordered during routine clinical practice as standard screening and diagnostic tests from November 1, 2009, to November 1, 2010 was performed. Data were collected during clinical encounters at one sports medicine clinic and entered into a database for analysis. Descriptive and frequency statistics were used to describe the tests ordered and the frequency of abnormal findings.

Results: Five hundred and thirty-nine studies were ordered for diagnostic and routine screenings on 137 athlete patients (86 males, 51 females), representing 49 types of tests. Sample sources included blood, urine, skin lesions, and fecal matter. The most commonly ordered tests were complete blood count, comprehensive metabolic panel, serum ferritin, creatine kinase, serum iron and total iron binding capacity, total cortisol, thyroid stimulating hormone, and lipid panels. There were 217 studies (40%) flagged as abnormal by the reporting laboratory.

Conclusion: This report provides greater insight into the diverse array of laboratory studies ordered over a 1-year period for diagnosis and screening of elite athletes. A high percentage of the results were flagged as abnormal by the laboratory. These findings show that the unique physiology of the elite athlete must be considered when interpreting laboratory findings in this population.

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Introduction

Quality health care requires a thorough assessment of each patient’s health status, including a detailed history and physical examination, as well as appropriate laboratory and diagnostic testing. It is accepted that the judicious use of laboratory tests coupled with thoughtful interpretation of the results of these tests is an important tool in clinical decision-making and patient management. Laboratory tests are commonly used in periodic evaluation of the healthy athlete. \(^1\)–\(^7\) Owing to the metabolic stress of training for sport, laboratory results in elite athletes may differ from the general population. \(^1\) The sports medicine clinician must be astute as to how training affects laboratory findings outside of the reference range has not been published. \(^1\)–\(^3\) Publication of test results in athletic populations may help clinicians better understand what is “normal” in this special population and the clinical significance of abnormal findings.

Practice patterns regarding the use of diagnostic laboratory tests by doctors of chiropractic have not been thoroughly described in medical literature, and no studies on this topic have been published in regards to chiropractic management of the athletic patient. Chiropractors are trained in laboratory testing and interpretation during their curriculum. Commonly ordered tests in chiropractic practice include complete blood counts (CBC), comprehensive metabolic panels (CMP), urinalysis, erythrocyte sedimentation rate, C-reactive protein, random and fasting serum glucose, hemoglobin A\(_{1c}\), serum lipid panels, vitamin B\(_{12}\), vitamin D, fecal occult blood tests, and allergen testing. \(^8\) It has been reported that chiropractors order diagnostic laboratory tests on a yearly basis and review laboratory data and interpret the results on a monthly basis. \(^9\) However, chiropractors have been reported to see a very low importance in regard to the collection and processing of laboratory tests, with importance of these skills being scored as 0.6 out of 20 (20 being the highest value). \(^9\)

The purpose of this study was to describe what tests were commonly ordered by 1 doctor of chiropractic in a sports medicine setting during 1 calendar year, to describe common abnormal findings in this population, and to discuss the clinical significance of these findings.

Methods

This retrospective observational study represents the analyses of 1 calendar year of laboratory data (November 1, 2009-2010) on all laboratory studies ordered by a sports medicine certified chiropractic physician in one clinic (United States Olympic Training Center, Colorado Springs, CO) with a patient population of elite athletes. Athletes with access to this clinic are involved in a wide range of sports divided into categories such as power, endurance, combat, and acrobat sport. The population studied was variable in regard to age, gender, and sport; however, only elite athletes have access to the clinic facilities and were therefore the target of this study. This clinic serves a resident population of 175 athletes and may serve an additional 200 to 300 athletes at any given time on a on a temporary basis throughout the calendar year, with an estimated 10,000 patient visits annually.

During the 1-year period observed, studies were ordered by the attending chiropractic physician for diagnostic testing during injury or illness, during routine physical examinations as a screening measures during periodic health examination, or as part of multidisciplinary management with sports performance or medicine consultants such as sport dietitians or exercise physiologists for performance purposes, and never as a means of screening for performance enhancing drugs.

All tests were ordered by a single practitioner and collected by the physician or clinic staff and sent to a local laboratory for analysis. A database of all test results ordered by the lead clinician was provided by the contracted external laboratory (Quest Diagnostics, Denver, CO) at the end of the calendar year and then stripped of all patient identifiers before analysis. No chart reviews were performed; the database served as the only source of patient information. The results of each test ordered were tabulated into summary tables, including whether each test result was considered normal or abnormal based on the laboratory’s reference ranges.

The clinical or scientific rationale for each study was not recorded in the retrospective database as reasons were too widely distributed and were all part of normal patient care over the 1-year period but included injury or illness evaluation and diagnosis, routine health screening, performance testing, or as part of multidisciplinary management of chronic conditions. Communication of the laboratory results and their clinical relevance was performed as a usual part of normal patient care over the 1-year period but included injury or illness evaluation and diagnosis, routine health screening, performance testing, or as part of multidisciplinary management of chronic conditions. Communication of the laboratory results and their clinical relevance was performed as a usual part of patient care. Owing to the retrospective nature of this project, no changes in patient management were made.
during the one year time period. This study was approved by the Southern California University of Health Sciences Institutional Review Board.

Results

Retrospective analysis of data revealed that 539 different laboratory studies were ordered on 137 athletes over a 1-year period, with an average of about 4 tests ordered per patient. The patient population who required laboratory evaluation for their clinic visit consisted of 86 male and 51 female athletes. The most commonly ordered tests were the CBC, CMP, thyroid stimulating hormone (TSH), serum ferritin, creatine kinase (CK), serum iron, and total iron binding capacity (TIBC), total cortisol, urinalysis, and lipid panels (Fig 1). The resulting laboratory reported 217 out of the 539 studies as abnormal (Table 1).

Discussion

Laboratory testing is an important component of the management of the athletic patient and should be considered by the clinician working in the sports medicine setting. Although not all chiropractic offices have the capability or desire to order and utilize these laboratory tests, this report describes the importance of these tests, how the results in the athletic population may differ from the general public, and the clinical significance of test results in this special population.

Laboratory testing of the elite athlete has been described as a routine part of health screening.\(^\text{1-7}\) However, detailed descriptions of the tests commonly ordered in the population for both diagnostic and screening purposes, the frequency of abnormal results, and the clinical utility of these findings have not been published in detail. Prior investigations have reported findings of specific screening tests, such as iron screening, in athletic populations; however, to the authors’ knowledge, a retrospective study describing the practice patterns in regard to types of tests performed in a sports medicine clinic over a time interval and percentage of abnormal tests has not been performed. This study provides new insight on tests that are used in the sports medicine setting and describes the results of this testing.

In the population studied, there were a high number of abnormal results (40%; 217/539). Tests with high numbers of abnormal results included the lipid panel, comprehensive metabolic panel, total cortisol, creatine kinase, complete blood count, iron panel, and serum ferritin. The studies ordered appear to be unique to the patient population studied, as tests such as creatine kinase and serum cortisol were ordered more frequently in this population than as described in past studies on practice patterns of doctors of chiropractic. The results suggest the utility of laboratory analysis is increased in a competitive sports environment to monitor health and performance. Biomarkers may be used to analyze adaptation to training and identify physiological explanations for changes in performance.\(^\text{10,11}\)
cortisol, serum iron, creatine kinase, and vitamin D are all studies that may help clinicians and sports scientists explain changes in performance and assess training status or may be used to monitor the effectiveness of nutritional intervention.1,10,11,13

The sports medicine patient population presents clinical challenges to the interpreting physician when analyzing athletes’ laboratory results as compared to normals.12 A thorough patient history, including recent training volume, past laboratory values, and a precise nutrition and hydration assessment may be required to accurately interpret laboratory data.11–13 The unique metabolic demands of elite athletes to excel in elite sport commonly result in abnormal laboratory findings when compared to the general population.1–7,14,15 Reference laboratory values often do not necessarily reflect what is normal or abnormal for an elite athlete in training.16

Review of Commonly Ordered Laboratory Studies

Based on the results of this study, laboratory tests that may be routinely considered when evaluating an athlete include the CBC, CMP, serum ferritin, serum iron and TIBC, TSH, vitamin D, lipid panels, creatine kinase, serum cortisol, and urinalysis.

CBC With Differential

The CBC is performed to determine a general health status and to screen for, diagnose, or monitor any one of a variety of diseases and conditions that affect blood cells, such as anemia, infection, inflammation, bleeding disorders, or cancer.17 The hematocrit and platelet count can sometimes be abnormally high in athletes, particularly if the athlete is dehydrated.17 Mean corpuscular volume is a measurement of the average size of red blood cells (RBC), mean corpuscular hemoglobin (MCH) is a calculation of the average amount of oxygen-carrying hemoglobin inside a red blood cell, MCH concentration is a calculation of the average percentage of hemoglobin inside a red cell, red cell distribution width is a calculation of the variation in the size of RBC, and a reticulocyte count is a measurement of the absolute count or percentage of young RBC in blood.17 These tests can assist the provider in determining certain types of anemia and assist with further work-up.

White blood cell (WBC) counts are important in assessing for general inflammation or infection. The WBC count helps diagnose infection or inflammatory process and may be used to determine the presence of other diseases that affect WBCs such as allergies, bone marrow disease, or immune disorders.17 Highly trained endurance athletes may have a low WBC count due to training.18

Iron Panel

Iron-deficiency anemia is the most common cause of anemia in athletes and presents with common signs such as fatigue, headache, joint pain and weakness which could otherwise be overlooked as a sign of over-training or dehydration.7 It is therefore extremely important to screen for this type of anemia by utilizing a CBC and assessing the mean corpuscular volume, MCH, red cell distribution width along with a serum ferritin, serum iron and TIBC. Serum iron tests are typically ordered as follow-up tests when abnormal results are found on routine CBC, such as a decreased hemoglobin and hematocrit level. They may also be ordered when iron deficiency or iron overload is suspected. These secondary tests determine the levels of free and stored iron in the blood and are useful labs to determine potential causes of anemia. The TIBC helps assess the body’s ability to transport iron in the blood and is usually elevated with iron-deficiency anemia. As the iron level is low in the blood stream, the TIBC will be increased since transferrin saturation is very low.20 TIBC may be ordered along with serum iron when it appears that an athlete has iron deficiency or overload. and should be assessed for in all athletes with similar complaints.20

<table>
<thead>
<tr>
<th>Test</th>
<th>Abnormal</th>
<th>Total</th>
<th>Percentage marked as abnormal by the laboratory</th>
</tr>
</thead>
</table>
Comprehensive Metabolic Panel

The CMP includes testing for multiple electrolytes and metabolites such as sodium, potassium, chloride, bicarbonate, blood urea nitrogen (BUN), creatinine, fasting glucose, calcium, magnesium, albumin, aspartate amino transferase (AST), alanine amino transferase (ALT), alkaline phosphatase, and bilirubin.

Electrolytes such as sodium and potassium are frequently normal in the athlete and are routinely evaluated in the sports medicine clinic and emergency department settings. Sodium levels generally help determine if a disease or condition involving the brain, lungs, liver, heart, kidney, thyroid, or adrenal glands is causing or being exacerbated by a sodium deficiency or excess. Urine sodium levels are typically tested in athletes who have abnormal blood sodium levels to help determine whether an imbalance is from, for example, taking in too much sodium or losing too much sodium. A high blood sodium level is almost always due to inadequate water intake and dehydration, with symptoms including dry mucous membranes, thirst, agitation, restlessness, acting irrationally, and coma or convulsions if the sodium level rises to extremely high concentrations. In the athlete, sodium levels may be low with excess water intake and may be high with dehydration. Severely low sodium levels, or hyponatremia, may produce nausea, cramping, or neurologic problems and may quickly become a medical emergency if not addressed properly. This has been reported in up to 50% of marathon runners who collapse at the finish line and can be life-threatening if not managed appropriately. Potassium is evaluated to assess for hyper or hypokalemia. Hyperkalemia is often seen in kidney disease, but many drugs can decrease potassium excretion from the body and result in this condition. Hypokalemia can occur if an athlete has diarrhea, vomiting, or extreme sweating or drinks excessive caffeine and may cause weakness, cramping, and cardiac rhythm disturbances that can be fatal.?

BUN and serum creatinine are primarily used to evaluate kidney function, muscle breakdown, and to monitor athletes with acute kidney injury. It also may be used to evaluate a person’s general health status. In regards to the athlete, BUN and serum creatinine may be elevated due to a condition that results in decreased blood flow to the kidneys, such as shock, stress, severe sun burn, or dehydration. In athletes, creatinine has been shown to be directly related to body mass index, and this should be considered when interpreting creatinine levels in larger individuals.

Serum fasting glucose is a screen for diabetes, hyperglycemia and hypoglycemia. In the athletic population, glucose levels may be elevated acutely due to stress and demands of exercise causing symptoms such as sweating, hunger, confusion, and anxiety. Exercise-induced hypoglycemia has been reported in endurance athletes and, if encountered, should be treated immediately to prevent complications including seizure and permanent brain damage.

Serum albumin is a non-specific screening that assists is diagnosis and management of several diseases. In an athlete low albumin levels can be seen with acute inflammation, shock or poor nutrition whereas high albumin levels may be due to dehydration. Additionally, low levels may be seen in conditions where the body does not properly absorb and digest proteins, such as Crohn’s disease or celiac disease or in which large volumes of protein are lost from the intestines. Athletes have been shown to have lower albumin levels than non-athletic control populations.

Two key important aspects of the liver panel include the AST and ALT enzymes, which help to detect liver injury, with ALT being a more specific marker of liver damage than AST. AST/ALT are often measured when signs and symptoms of liver disease are present including fatigue, weakness, loss of appetite, swelling or jaundice. In the athlete AST elevation is a routine finding associated with increased physical exertion and if found in isolation often does not require additional work up.

Lipid Panel

Lipid panels may also be a routine part of health screening of the athlete. The basic lipid panel includes such tests as total cholesterol, which measures all of the cholesterol in all of the lipoprotein particles, the low-density lipoprotein, often called “bad cholesterol” because it deposits excess cholesterol in walls of blood vessels, high-density lipoprotein, often called “good cholesterol” because it removes excess cholesterol and carries it to the liver for removal, and triglycerides, which are measures of all the triglycerides in all the lipoprotein particles. The high-density lipoprotein is typically high in athletes and is often abnormally high in well-trained athletes. Careful consideration should be given when prescribing statins to athletes, as it has been reported that only 20% of athletes can tolerate their use without muscular side effects.

Vitamin B12

Evaluating athlete’s vitamin B12 levels is commonly performed and may lead to supplementation
with intramuscular injection when deficient. Most athletes who eat a balanced omnivorous diet do not need to worry about vitamin B₁₂ deficiency, but those on energy-restrictive diets, those with heavy alcohol use for more than two weeks, and strict vegetarians should consider supplementation. An athlete who is deficient in vitamin B₁₂ may have decreased cognitive function causing impaired concentration, or compromised aerobic capacity resulting in decreased athletic performance.

**Vitamin D**
Assessing 25(OH) vitamin D levels may be an important factor to consider during as part of a routine screening assessment, particularly in the athlete with bone injury. Vitamin D levels help determine if bone weakness, bone malformation, or abnormal metabolism of calcium (reflected by abnormal calcium, phosphorus, and parathyroid hormone) is occurring as a result of a deficiency or excess of vitamin D. Recent literature suggests that athletic performance may be affected by vitamin D as well. Vitamin D has been shown to increase the size and number of type II fast twitch muscle fibers and is directly associated with musculoskeletal performance and the prevention of bone loss.

**Thyroid Panel**
Thyroid stimulating hormone is an excellent screening test to determine if chronic athlete fatigue, weakness, weight loss or gain, depression/anxiety, or sleep disturbances interfering with training may be related to thyroid hormone. If TSH level is abnormal, it should be followed with a test for total T₄ or free T₄ for further investigation on the cause and severity of thyroid dysfunction.

**Urinalysis**
Urinalysis provides valuable information when working with the athletic population. Dehydration not only reduces athletic performance, and places athletes at risk of health problems. Monitoring hydration has significant value in maximizing performance during training and competition. It also offers medical personnel the opportunity to reduce health risks in situations where athletes engage in intentional weight loss. Simple non-invasive techniques, including weight monitoring and urine tests can provide useful information. In-office dipstick urinalysis is routinely performed at this medical clinic for diagnostic, screening and sport science purposes. As a diagnostic screening, urinalysis may be ordered as a first line study in the management of urinary tract infection, abdominal trauma, hematuria, determining hydration status and for a number of internal medical conditions. An important example of monitoring hydration with urinalysis is its use in weight class sports such as boxing, wrestling or judo. Athletes in these types of sport often are required by sporting rules to have their hydration status simultaneously evaluated when their body weights are measured in an attempt to ensure increased accuracy in determining the athletes correct weight class. To accomplish this, urine specific gravity is used as an indicator of hydration status. In this clinic, digital refractometry is the preferred method to measure urine specific gravity. Digital refractometry has previously been described as a safe and accurate representation of urine specific gravity in athletes.

**Creatine Kinase and Serum Cortisol**
Creatine kinase and serum cortisol are tests that were routinely ordered in this study but are less frequently used in the general population. These tests have been previously described as possible predictors of overtraining. In this study, there were a high percentage of elevated creatine kinase and total cortisol tests, with 50% of total cortisol and 44% of creatine kinase results identified as being abnormal. In the athletic patient population the elevation of these specific studies may not define overtraining but is rather as a sign of acute muscle breakdown and stress seen with exercise or heavy training and serves as a small piece of the diagnosis of overtraining syndromes.

Cortisol is a glucocorticosteroid produced in the adrenal cortex that plays an important role in metabolism of macronutrients. In normal conditions, cortisol follows a diurnal pattern of secretion, with elevated levels in the morning and lower levels in the evening. Adrenal or pituitary dysfunction and stress can disrupt normal cortisol...
Elevated cortisol can be associated with increased physical or emotional stress, or with Cushing’s syndrome. In athletes, if Cushing’s syndrome is not suspected, increases in cortisol are associated with increased physiological strain.

Creatine kinase is an enzyme present in numerous tissues in the human body. In particular, there are high levels of creatine kinase in skeletal muscle, the heart and brain. A CK test measures the breakdown of this enzyme in the body. Laboratory tests have been developed for specific isozymes of CK to differentiate whether a high CK is specifically due to brain (CPK [creatine phosphokinase]-1), heart (CPK-2) or skeletal muscle (CPK-3) damage. CK is elevated 1 to 2 days after strenuous physical activity, and remain elevated for several days. CK is often elevated in athletes due to normal training, ranging from 7% to 137% higher in athletes than in the general population. Monitoring CK in the athletic population may be a useful tool in evaluation of acute muscle damage in the athlete, and prevention of injury due to muscle damage and fatigue. Isolated CK elevation, however, is not diagnostic of overtraining syndrome and can occur in numerous other conditions in which training occurs beyond the body’s ability to recover (Table 2).

**The Use of Laboratory Tests in This Sports Medicine Clinic Setting**

The routine use of laboratory diagnostic studies in this clinic, as compared to other studies showing DCs rarely directly order laboratory tests, may be explained by the collaborative form of multidisciplinary medicine practiced at this facility and the level of training of the chiropractic physicians. The chiropractic physician who directs the clinic and the attending chiropractic physician are both Diplomates of the American Chiropractic Board of Sports Physicians with advanced training in Sports Medicine diagnosis and treatment. In addition to the clinics consulting physi-
cians, many other outside providers are routinely called upon for co-management of cases. During the 12-month period in which this data was collected, medical doctors, osteopaths, physical therapists, athletic trainers, a podiatrist, and an optometrist performed clinical rotations in this facility. The high utilization of laboratory studies in this study may be descriptive of the potential role of the chiropractic sports physician in multidisciplinary sports medicine.

Limitations

The data recorded were a retrospective analysis of studies ordered by only 1 provider over a time period of 1 year in a unique sports medicine setting. Therefore, the results cannot necessarily be generalizable to other locations or practices. Utilization of laboratory diagnostic tests by doctors of chiropractic with sports medicine certification cannot be assumed to represent general chiropractic practice. Identification of clinical or scientific rationale for each laboratory study or panel was not collected; therefore, this study did not report on the reasoning behind each test. Future studies comparing laboratory values in different sports or training programs (eg, endurance vs power sports, male vs female performance) would be beneficial in learning more about sports injury management, prevention and recovery.

Conclusion

This retrospective study describes the variety of tests ordered for diagnosis and screening of elite athletes by 1 doctor of chiropractic in an interdisciplinary sports medicine clinic over a 1-year period. A high percentage of the results were flagged as abnormal by the laboratory. These findings suggest that the unique physiology of the elite athlete must be considered when interpreting laboratory findings in this population.

Funding Sources and Conflicts of Interest

No funding sources or conflicts of interest were reported for this study.

References


### Table 2 Creatine Kinase Values Found in Some Muscular Pathology.

<table>
<thead>
<tr>
<th>Muscular Pathology</th>
<th>CK Value Increases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duchenne and Becker dystrophies</td>
<td>25-200-fold</td>
</tr>
<tr>
<td>Limb-girdle muscular dystrophy</td>
<td>10-100-fold</td>
</tr>
<tr>
<td>Facioscapulohumeral dystrophy</td>
<td>3-fold</td>
</tr>
<tr>
<td>Distal myopathy</td>
<td>3-fold</td>
</tr>
<tr>
<td>Endocrine myopathy</td>
<td>Up to 10-fold</td>
</tr>
<tr>
<td>Congenital myopathies</td>
<td>Slight increase</td>
</tr>
<tr>
<td>Metabolic myopathy</td>
<td>Slight increase</td>
</tr>
<tr>
<td>Mitochondrial myopathy</td>
<td>Slight increase</td>
</tr>
<tr>
<td>Drug-induced myopathy</td>
<td>Slight or no increase</td>
</tr>
</tbody>
</table>

CK, creatine kinase.

Elevations in creatine kinase are a common occurrence in the training athlete, as well as in several musculoskeletal conditions listed above. Clinical correlation should be made when interpreting CK values.