Prevalence of Iron Depletion and Anemia in Top-level Basketball Players

Gal Dubnov and Naama W. Constantini

Iron depletion, with or without anemia, may have a negative effect on physical and mental performance. Even with current recognition of the problem, its incidence among athletes remains high. Most studies describe iron status in endurance athletes. This study examined the prevalence of iron depletion and anemia among male and female top-level basketball players. Adolescents and adults (N = 103) from 8 national basketball teams were screened for anemia and iron stores status, which included a complete blood count and levels of plasma ferritin, transferrin, and serum iron. Iron depletion, defined by a ferritin level below 20 µg/L, was found among 22% of study participants (15% in males vs. 35% in females, p = .019). Anemia was found among 25% of athletes (18% in males vs. 38% in females, p = .028). Iron deficiency anemia, defined by the presence of anemia, ferritin levels below 12 µg/L, and transferrin saturation below 16%, was found among 7% of players (3% in males vs. 14% in females, p = .043). In summary, a high prevalence of iron depletion, anemia, and iron deficiency anemia was found among basketball players of both genders. We recommend screening ballgame players for blood count and iron store status, and providing nutritional counseling and iron supplementation when necessary.

Key Words: iron deficiency, anemia, ballgames, adolescent, athlete, sport

Introduction

Iron deficiency anemia (IDA) is known to impair physical work capacity (12, 13) and can therefore be detrimental to the competitive athlete. Several studies have shown that iron supplementation given to non-anemic subjects with low iron stores improved physical functioning (3, 11, 18, 20, 28). These subjects were not iron deficient, usually defined as serum ferritin levels below 12 µg/L plus a low transferrin saturation (22), and had ferritin levels at the lower limit of the normal range. This suggests that iron depletion without low hemoglobin levels, a condition much more prevalent than IDA, is an important factor that may limit performance. In the general
population, iron deficiency is found in about 8% of young Caucasian women and less than 1% of young Caucasian men (22). In athletes, however, its presence is much higher. The problem is well known but still persists: About 25–35% of athletes have been found to be iron deplete in several recent reports (8, 9, 24). Overt IDA in athletes is much less common than iron depletion without anemia, reaching up to about 3%, a prevalence similar to that of the general population (30).

Athletes have several risk factors for anemia and iron depletion, some overlapping with those of the general population, and some unique to the athletic setting (5, 30). These risk factors include poor nutritional intake of iron, hemolysis caused by repeated foot strikes, blood and iron loss through menstruation, gastrointestinal and urinary tracts, and iron loss through sweating. Iron store status, which is easily measured and corrected, is of major concern for the competitive athlete. While athletes engaged in individual endurance sports are generally aware of the necessity of screening blood tests and nutritional support, it seems that ballgame players and coaches are less aware of the importance of iron status monitoring. Indeed, most of the studies on this topic have examined endurance runners, swimmers, and skiers, whereas the exact prevalence of iron depletion with or without anemia in ballgame players is less known.

The purpose of this study was to examine the prevalence of iron depletion and anemia among male and female national basketball teams.

### Methods

Subjects were members of 8 national basketball teams, with an age range of 14–35 years. A total of 103 athletes (66 males, 37 females) participated in the survey.

Venous blood (10 ml) was drawn in the morning after an overnight fast and at least 12 hours post exercise for a complete blood count, serum iron, and transferrin and ferritin levels. The blood count was performed using a Technion H2 blood counter, and yielded values for red blood cell count (RBC), hemoglobin (Hb), hematocrit (Hct), mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH). Transferrin was measured by an immunoturbidimetric assay, and serum iron was measured by a colorimetric assay, both on the Olympus AU 2700 Clinical Chemistry System. Ferritin was measured using the Bayer ADVIA Centaur Automated Chemiluminescence System.

Iron depletion was defined as a ferritin level below 20 µg/L (14). Transferrin saturation was calculated as serum iron divided by serum transferrin, multiplied by 100. Anemia was defined as a hemoglobin level below 12 g/dl for females and below 14 g/dl for males. Microcytosis was defined as a mean corpuscular volume (MCV) of 80 fL or lower, and macrocytosis as an MCV of 100 fL or higher (16). IDA was defined as ferritin below 12 µg/L, transferrin saturation below 16%, and anemia in the same subject. We refer to all subjects whose age is 18 years or older as adults, while those under 18 are categorized as adolescents, irrespective of the team.

Statistical comparisons between continuous variables were carried out using the t test, and those between categorical values using the chi square test. Bonferroni adjustment was made for the continuous variables, so a two-tailed p value smaller than .005 was considered statistically significant for these types of data. This adjustment was not performed for comparison of the categorical values.
Results

Mean values for RBC data and iron stores are presented in Table 1. The lowest values of hemoglobin, MCV, and ferritin encountered in the study were Hb of 10.7 g/dl, MCV of 69.1 fL and ferritin of 2.7 µg/L in a 17-year-old male, and Hb of 9.0 g/dl, MCV of 66.5 fL, and ferritin of 5.7 µg/L in a 16-year-old female. No subject had macrocytosis.

Comparing the continuous variables, statistically significant differences were found for several indices between adolescents and adult subjects. Among males, adults had lower mean transferrin levels \( (p < .001) \) and higher mean ferritin levels \( (p = .001) \) when compared with adolescents. No differences between mean hematological and iron store values were found between female adults and adolescents. Between genders, females had lower levels of mean Hb \( (p < .001) \), Hct \( (p < .001) \), and transferrin saturation \( (p < .001) \), and a higher level of transferrin \( (p = .005) \). Mean ferritin levels were lower among females, but this comparison did not reach statistical significance \( (31.1 \pm 21.5 \mu g/L \text{ for females, } 43.4 \pm 33.6 \mu g/L \text{ for males, } p = .034) \).

The prevalence of anemia, iron depletion, and IDA are presented in Figure 1. Within the same gender, no significant difference was found between adolescents and adults regarding the prevalence of iron depletion, anemia, or IDA (data not shown). Comparing these proportions across genders, females had a higher prevalence of anemia \( (p = .028) \), iron depletion \( (p = .019) \), and IDA \( (p = .043) \).

Figure 1 — Percentage of subjects with anemia, iron depletion (ID), and iron deficiency anemia (IDA), presented for males and females. Females had a higher prevalence of these conditions than males \( (p = .028, .019, .043, \text{ respectively}) \).
Table 1  Mean Values for Red Blood Cell Data and Iron Stores Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total</th>
<th>Adults</th>
<th>Adolescents</th>
<th>Total</th>
<th>Adults</th>
<th>Adolescents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
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<td>Males</td>
<td>Females</td>
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<td></td>
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<tr>
<td>n</td>
<td>66</td>
<td>34</td>
<td>32</td>
<td>37</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>17.8 ± 2.2</td>
<td>19.5 ± 1.0</td>
<td>15.7 ± 1.1</td>
<td>19.8 ± 5.1</td>
<td>22.4 ± 5.0</td>
<td>15.7 ± 0.8</td>
</tr>
<tr>
<td>Hb (g/dl)</td>
<td>14.7 ± 0.9†</td>
<td>14.8 ± 0.8</td>
<td>14.5 ± 1.0</td>
<td>12.3 ± 1.3†</td>
<td>12.4 ± 1.3</td>
<td>12.2 ± 1.3</td>
</tr>
<tr>
<td>Hct</td>
<td>43 ± 2†</td>
<td>44 ± 2</td>
<td>43 ± 2</td>
<td>37 ± 4†</td>
<td>37 ± 3</td>
<td>37 ± 4</td>
</tr>
<tr>
<td>RBC (Cells · 106)</td>
<td>5.0 ± 0.3</td>
<td>5.0 ± 0.4</td>
<td>5.0 ± 0.5</td>
<td>4.5 ± 1.7</td>
<td>4.2 ± 0.3</td>
<td>4.4 ± 0.4</td>
</tr>
<tr>
<td>MCV (fL)</td>
<td>86 ± 4</td>
<td>87 ± 4</td>
<td>88 ± 4</td>
<td>87 ± 6</td>
<td>88 ± 5</td>
<td>85 ± 6</td>
</tr>
<tr>
<td>MCH (pg)</td>
<td>29.0 ± 1.7</td>
<td>29.3 ± 1.4</td>
<td>28.7 ± 1.9</td>
<td>28.2 ± 2.3</td>
<td>28.3 ± 1.5</td>
<td>28.1 ± 2.7</td>
</tr>
<tr>
<td>Ferritin (µg/L)</td>
<td>43.4 ± 33.6</td>
<td>51.3 ± 28.7*</td>
<td>32.4 ± 17.8*</td>
<td>31.1 ± 21.5</td>
<td>33.8 ± 22.4</td>
<td>26.9 ± 20.0</td>
</tr>
<tr>
<td>Iron (µg/dl)</td>
<td>93 ± 34</td>
<td>88 ± 33</td>
<td>98 ± 36</td>
<td>78 ± 45</td>
<td>86 ± 52</td>
<td>68 ± 32</td>
</tr>
<tr>
<td>Transferrin (µg/dl)</td>
<td>275 ± 37††</td>
<td>261 ± 30*</td>
<td>292 ± 37*</td>
<td>299 ± 49††</td>
<td>290 ± 41</td>
<td>311 ± 58</td>
</tr>
<tr>
<td>Transferrin sat (%)</td>
<td>35 ± 14†</td>
<td>35 ± 14</td>
<td>34 ± 14</td>
<td>27 ± 17†</td>
<td>31 ± 19</td>
<td>23 ± 11</td>
</tr>
</tbody>
</table>

Note. Data presented as mean ± SD. Hb: hemoglobin; Hct: hematocrit; RBC: red blood cell; MCV: mean corpuscular volume; MCH: mean corpuscular hemoglobin; Transferrin sat: transferrin saturation. †p < .001 between males and females; ††p = .005 between males and females; *p ≤ .001 between adolescents and adults.
Discussion

Iron depletion, with or without anemia, can negatively affect physical performance. Several studies have shown that iron supplementation to non-anemic iron deficient subjects improved their aerobic function (3, 11, 18, 20, 28), although others could not demonstrate such a benefit (10, 19, 25). This may be due to methodological differences, such as baseline fitness, ferritin or Hb levels, type and length of supplementation, and the measured outcomes. While many articles on this matter recommend screening for iron status and iron supplementation, the prevalence of iron depletion among athletes is still remarkably high, considering the fact that this is an easily modifiable obstacle to improving performance.

In this survey, a high prevalence of iron depletion was noted, especially among the female teams. In one team, this rate was as high as 50%. A report from Spain found iron depletion among a similar percentage (45%) of female basketball players (26). Data from Italy on 181 males from various sport types revealed that about 10% had ferritin levels below 20 µg/L (2). A survey done in Israel on 114 Olympic level athletes of different individual sports showed that 23% of females and 8% of males had iron depletion, and 3.5% had IDA (9). These percentages are much lower than those found in our current study (35%, 15%, 7%, respectively), conducted among a similar population of Israeli athletes. These differences support our concern that competitive athletes of various sport types should be more systematically screened for iron depletion.

Regarding the adolescent sub-group, our results are comparable with another study on elite adolescent athletes in Israel (8), which found iron depletion in 33% of female gymnasts, swimmers, and tennis players, in 36% of male gymnasts, and in about 20% of male swimmers and tennis players. Similar frequencies were found in our sample: Among the 15 female adolescent basketball players, 33% had iron depletion; among the 32 adolescent male basketball players, 19% had iron depletion. Additionally, in the study by Constantini et al. (8), none of the 43 male adolescent gymnasts, swimmers, tennis players, and table-tennis players had anemia (defined as Hb lower than 13 g/dl), while our sample had only 1 subject whose Hb level was lower than this threshold. The higher prevalence of anemia reported in our survey is probably due to a different cut-off point, and in those athletes with normal iron status could perhaps be attributed to plasma expansion (“dilutional pseudoanemia”), which probably has no negative effect on the athlete (30). Among females, while 40% of our adolescent population had anemia, the study by Constantini et al. reported anemia in only 4% (8).

A larger proportion of females had iron depletion, anemia, or IDA, compared with males. Fourteen percent of the females in our sample had IDA, compared to only 3% of males. These proportions for females are very high; among both the general and the athletic populations, IDA approximates 3% in prevalence (22, 30). In a recent report, the frequency of IDA in the United States was estimated to occur in 2% of adolescent females (21). The fact that females are more vulnerable to these conditions than males, let alone female athletes, is well known and is mainly attributed to both menses and a lower dietary intake of iron (5). Another mechanism of anemia and iron loss in athletes is “foot strike hemolysis,” traditionally associated with long distance running (7). In a study that included women engaged in several
sports, basketball and handball players had low haptoglobin levels (a marker of hemolysis), similar to runners (26). Hence, a mechanism of anemia usually related to running can also be expected in ball players. Additional reasons for anemia and/or iron depletion in athletes exist, and these have been reviewed extensively (1, 5, 30). Dilutional pseudoanemia, caused by exercise-induced plasma volume expansion, might be the case in those players with Hb levels just below the lower range and with normal iron parameters. Blood and iron losses through the gastrointestinal tract, the urinary tract, and by excessive sweating can cause iron loss in a few cases. An infectious cause for iron deficiency in athletes has recently been identified as *Helicobacter Pylori* (6). Eradication of the bacteria without iron supplements resulted in improvement of iron store status.

Regarding iron status, ferritin level is accepted as a reliable marker for iron store depletion, as it is well correlated with bone marrow iron stores (14, 17). As marrow iron stores were shown to be low in distance runners (31), the use of serum ferritin is a much less invasive and therefore more practical method. There is growing interest in the soluble transferrin receptor as a marker for iron deficiency, as it has been shown to be less influenced by physical activity (23, 29). Iron deficient subjects, as defined by low ferritin values, improved their performance, depending on the status of the transferrin receptor, suggesting the latter to be a good marker of iron status in the athletic setting (3). Several definitions for iron deficiency exist, utilizing one or more abnormal values of ferritin, serum iron, transferrin, transferrin saturation levels, erythrocyte protoporphyrin, or RDW. Yet studies using only a single ferritin cut-off value for the definition of iron depletion did show physical improvements after iron supplementation (11, 18, 20, 28), providing evidence that this may be a suitable marker for our purposes, while maximizing cost-effectiveness. The fact that there are several studies that show improved performance following iron supplementation of subjects with ferritin levels of 20 µg/L or under perhaps makes this the threshold for defining, and treating, iron deficiency in the athletic setting.

The high prevalence of iron depletion encountered in this study warrants iron store screening, appropriate nutritional education, and iron supplementation where necessary for ballgame players. Iron repletion has been shown to have a positive effect on physical performance as discussed, in addition to improving overall vitality and mental health and decreasing fatigue (27), all factors crucial to competitive players. A randomized trial in non-anemic iron deficient adolescent girls showed that iron supplementation improved some aspects of cognitive functioning, along with improvements in ferritin and Hb levels (4). The preferred method of iron repletion is giving iron supplements, though there is a growing potential for iron-rich diets (15, 27). For prevention, these athletes should be educated regarding proper nutrition and the choice of iron-rich foods.

In summary, this study has shown a high prevalence of iron depletion and anemia among both male and female basketball players, reaching extreme levels in some individuals. Because intense physical activity and inadequate nutrition may cause iron depletion and anemia, and because these, in turn, may hinder performance, we recommend routine screening of Hb and ferritin levels in all basketball players, along with proper nutritional education. Further surveys of other ballgame sports are needed.
References

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