ABSTRACT

**Objectives** To compare laboratory test results and lung function of adolescent organised sports participants (SP) with non-participants (NP).

**Methods** In this cross-sectional study, laboratory tests (haemoglobin, iron status), and flow-volume spirometry were performed on SP youths (199 boys, 203 girls) and their NP peers (62 boys, 114 girls) aged 14–17.

**Results** Haemoglobin concentration <120/130 g/L was found in 5.8% of SP and 5.1% NP (OR 1.20, 95% CI 0.54 to 2.68). Ferritin concentration below 15 µg/L was found in 22.7% of both SP and NP girls. Among boys ferritin <30 µg/L was found in 26.5% of SP and 30.2% of NP (OR 0.76, 95% CI 0.40 to 1.47). Among SP iron supplement use was reported by 3.5% of girls and 1.5% of boys. In flow-volume spirometry with bronchodilation test, 7.0% of SP and 6.4% of NP had asthma-like findings (OR 1.17, 95% CI 0.54 to 2.54); those using asthma medication, that is, 9.8% of SP and 5.2% of NP were excluded from the analysis.

**Conclusions** Screening for iron deficiency is recommended for symptomatic persons and persons engaging in sports. Lung function testing is recommended for symptomatic persons and persons participating in sports in which asthma is more prevalent.

INTRODUCTION

Prevention of injury and illness is the cornerstone of sports medicine. Haemoglobin concentration is positively associated with maximal oxygen uptake which is an important determinant of an athlete’s performance potential, especially in endurance sports. Depleted iron stores are known to reduce haemoglobin mass. Studies have revealed low iron storage levels in up to 50% of adolescent females, and iron-deficiency anaemia in 5–10%, with anaemia being no more common among athletes than non-athletes. The effect of iron supplementation on exercise performance in athletes with iron deficiency varies between studies.

Asthma is a chronic respiratory disorder often coexisting with atopy, allergies and chronic rhinosinusitis. It is an inflammatory disease, causing difficulty in breathing and leading to increased energy expenditure. Twenty per cent of young Finnish adults report a history of allergies and/or atopy and 5% report physician-diagnosed asthma. Adults typically suffer 2–3 upper respiratory infections yearly, and athletes more often than others. The focus of this descriptive study is on clinical laboratory findings among adolescent sports participant (SP) with an emphasis on anaemia, iron deficiency and asthma detection.

METHODS

This cross-sectional study was a part of the Finnish Health Promoting Sports Club study conducted by the University of Jyväskylä together with six national Centres of
Excellence in Sports and Exercise Medicine located in different regions of Finland, as well as the UKK-institute. A total of 240 youth sports clubs active in the country’s 10 most popular sports were targeted, with the goal to produce a representative sample of the most popular individual and team youth sports. Both summer and winter sports were included. The data were collected over 14 months. Non-participant (NP) were recruited from schools (9th grade). The 578 adolescents were aged 14–17 (492 SP, 50% females and 179 NP, 64% females). All completed a medical history questionnaire at home with their parents. The questionnaire was reviewed at the beginning of a health examination by a sports and exercise medicine specialist.

Venous blood samples were taken after a ≥10-hour fast and haemoglobin was determined with a standard automatic haematology analyser. Serum was separated by standard procedures and stored at −75°C for future analysis. Anaemia was defined as Hb <120 g/L for all females and males under 15 years, the threshold for males ≥15 years was <130 g/L as recommended by the WHO. Blood chemistry, serum ferritin and transferrin receptor analyses were carried out on a Cobas 8000 modular analyser (Roche Diagnostics) in an SFS-EN ISO 15 189:2013 accredited laboratory. Subjects with C-reactive protein levels indicating inflammation, that is, >5 mg/L were excluded from the ferritin analyses. Additionally, subjects taking iron supplements who had normal ferritin levels (>30 µg/L) were excluded from ferritin and transferrin receptor analyses. Ferritin concentrations were obtained from 561 subjects, and transferrin receptor concentrations from 567 subjects. Two ferritin concentrations were used to indicate iron deficiency <15 µg/L and <30 µg/L. A lower ferritin threshold to indicate iron deficiency is commonly used for females. The laboratory-specific reference range for serum transferrin receptor was 5.0 mg/L for males and 4.4 mg/L for females.

Haemoglobin <120/130 was present in 5.8% of SP and in 5.1% of NP (OR 1.20, 95% CI 0.54 to 2.68). Ferritin concentrations <15 µg/L was found in 22.7% of both SP and NP girls. Ferritin <30 µg/L was found in 26.5% of SP boys and 30.2% for NP boys (OR 0.76, 95% CI 0.40 to 1.47). The use of an iron supplement was rare in all groups (table 2).

Allergies and asthma
Recurrent skin rash was less common in SP than NP (15.1% vs 23.6%, OR 0.63, 95% CI 0.40 to 0.99). SP tended to use asthma medication more frequently NP (9.8% vs 5.2%), the difference was not statistically significant (OR 1.74, 95% CI 0.86 to 3.53). In baseline spirometry, a low FEV% suggestive of pulmonary obstruction was found in 16.5% of SP and 15.3% of NP. A significant bronchodilator response was observed in 7% of SP and 6.4% of NP (OR 1.17, 95% CI 0.54 to 2.54), those using asthma medication were excluded from the analysis. Girls who reported dyspnoea during exercise were more likely to have a significant bronchodilator response in flow-volume spirometry (OR 3.17, 95% CI 1.0 to 2.9). When looking at boys and girls together this finding was not statistically significant (OR 2.05, 95% CI 0.80 to 5.27). None of the 13 boys who reported dyspnoea during exercise had a significant bronchodilator response (table 3).

DISCUSSION
Iron deficiency was a common finding in both groups. However, iron supplement use was reported by only 3.5% of SP girls and 1.5% of SP boys. NP reported no
The use of iron supplements. The serum ferritin concentrations used to define iron deficiency vary between studies, frequently falling within the 15–30 µg/L range. Iron deficiency in athletes is thought to be caused by reduced dietary iron and increased requirements associated with exercise. Iron deficiency is more common in females than males across studies as well as in our study and it is known that the onset and duration of menstruation affect iron status. The roles of several minerals and trace elements in improving athletic performance have been studied, with iron and magnesium having the strongest evidence.

The use of allergy medication has previously been found to be common among athletes, but no difference between the groups was found in this study. It was found that only half of the athletes who reported allergic rhinitis reported using allergy medication within the past year. Among those who did not use asthma medication, a bronchodilator response consistent with asthma was found in 7% of SP and 6.4% of NP. We found no statistically significant difference in use of asthma medication between SP and NP, although other studies show that asthma is more prevalent among endurance athletes, especially those exposed to cold and dry air, and in swimmers. The strengths of this study were that both summer and winter sports and individual and team sports were equally represented. The prevalence of health conditions and problems was similar to those found in other studies indicating that the study sample represented typical adolescents. Our study also contained certain limitations. First, the questionnaire in the study was based on self-reported data, which is a potential issue for recall bias. However, sport and exercise medicine physicians reviewed all the questions with the study subjects, which should improve the accuracy of the collected data. Second, since the drop-out rate from sports participation is high in adolescence it is likely that a proportion of the NP group who dropped out from sports club activities thus blurring the difference between SP and NP. It should also be conceded that regarding SP as a single homogeneous group ignores the difference in the frequency and intensity of PA between individuals and between different sports.

| Table 1 | Basic characteristics |
|---------|-----------------------|
| Boys (n=261) | Girls (n=317) | Total (n=578) |
| | Sports participants (n=199) | Non-participants (n=62) | Coefficient (95% CI) | Sports participants (n=203) | Non-participants (n=114) | Coefficient (95% CI) | Sports participants (n=402) | Non-participants (n=176) | Coefficient (95% CI) |
| Age, mean | 15.7 | 15.7 | 0.00 (−0.09–0.09) |
| Weight, kg, mean | 64.5 | 62.5 | 0.03 (−0.01–0.08) |
| Height, cm, mean | 176 | 174 | 0.01 (0.00–0.02) |
| BMI, mean | 20.8 | 20.6 | 0.01 (−0.03–0.05) |

Statistically significant results are indicated in bold.

Health is an important determinant of sports performance and to maximise the amount of healthy training days and to minimise the amount of health conditions and problems, medical conditions should be identified and managed adequately. Iron deficiency is common and managed inadequately. Iron deficiency should be identified and iron supplementation recommended for persons with a history of iron deficiency. Health conditions and problems found in other studies were similar to those found in our study.

The prevalence of asthma-like symptoms and persons participating in sports in which asthma is more prevalent, asthma medication as well as iron deficiency in athletes is thought to be caused by reduced dietary iron and increased requirements associated with exercise. Iron deficiency is more common in females than males across studies as well as in our study and it is known that the onset and duration of menstruation affect iron status. The roles of several minerals and trace elements in improving athletic performance have been studied, with iron and magnesium having the strongest evidence.

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Table 2  Clinical laboratory data and iron supplement use

|                         | Boys (n=261) | Girls (n=317) | Total (n=578) |
|-------------------------|--------------|---------------|--------------|
|                         | Participants | Non-participants | Participants | Non-participants | Participants | Non-participants | Participants | Non-participants | Participants | Non-participants | Coefficient/ | OR (95% CI) | Coefficient/ | OR (95% CI) | Coefficient/ | OR (95% CI) |
| **Number of missing results in brackets** |                  |               |              |                  |               |               |              |                  |               |               | Coefficient/ | OR (95% CI) | Coefficient/ | OR (95% CI) | Coefficient/ | OR (95% CI) |
| Haemoglobin, mean (6)   | 147          | 149           | -0.01        | (-0.03-0.004)   | 132          | 132           | -0.00        | (-0.02-0.01)   | 140          | 138           | 0.01         | (-0.01-0.02) |                  |               |                  |               |
| Hb <120/130             | 7 (3.5)      | 1 (1.6)       | 1.34         | (0.31-5.79)     | 16 (8.1)     | 8 (7.1)       | 1.19         | (0.49-2.92)    | 23 (5.8)     | 9 (5.1)       | 1.20         | (0.54-2.68)  |                  |               |                  |               |
| Ferritin, mean (17)     | 47           | 44            | 0.08         | (-0.07-0.24)    | 31           | 32            | -0.03        | (-0.19-0.13)   | 39           | 36            | 0.08         | (-0.04-0.19) |                  |               |                  |               |
| Ferritin <30, n, (%)    | 49 (26.5)    | 19 (30.2)     | 0.76         | (0.40-1.47)     | 117 (60.3)   | 62 (56.4)     | 1.15         | (0.71-1.86)    | 166 (43.8)   | 81 (46.8)     | 0.86         | (0.60-1.23)  |                  |               |                  |               |
| Ferritin <15, n, (%)    | 9 (4.9)      | 5 (7.9)       | 0.67         | (0.23-1.99)     | 44 (22.7)    | 25 (22.7)     | 1.02         | (0.58-1.79)    | 53 (14)      | 30 (17.3)     | 0.77         | (0.47-1.27)  |                  |               |                  |               |
| Transferrin receptor, mean (11) | 3.28       | 3.18          | 0.03         | (-0.04-0.10)    | 3.14         | 3.09          | 0.01         | (-0.08-0.11)   | 3.35         | 3.30          | 0.01         | (-0.05-0.08) |                  |               |                  |               |
| Elevated transferrin receptor, n, (%) | 7 (3.7)        | 1 (1.6)       | 1.37         | (0.32-5.97)     | 29 (14.9)    | 11 (10.0)     | 1.52         | (0.73-3.18)    | 36 (9.4)     | 12 (6.9)      | 1.30         | (0.67-2.51)  |                  |               |                  |               |
| Use of iron supplement (%) | 3 (1.5)      | 0             | 1.30         | (0.24-6.97)     | 7 (3.5)      | 0             | 1.75         | (0.49-6.28)    | 10 (2.5)     | 0             | 1.56         | (0.56-4.34)  |                  |               |                  |               |

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| Number of missing results in brackets | Boys (n=261) | Girls (n=317) | Total (n=578) |
|-------------------------------------|-------------|--------------|--------------|
|                                     | Sports participants (n=199) | Non-participants (n=62) | OR (95% CI) | Participants (n=203) | Non-participants (n=114) | OR (95% CI) | Participants (n=402) | Non-participants (n=176) | OR (95% CI) |
| Asthma in family, n, (%), (15) | 83 (43.2) | 30 (50.0) | 0.76 (0.43–1.37) | 99 (49.7) | 66 (58.9) | 0.69 (0.43–1.10) | 182 (46.5) | 96 (55.8) | 0.72 (0.50–1.03) |
| Regular use of allergy medication*, n, (%), (5) | 42 (21.3) | 13 (21.3) | 0.99 (0.49–2.00) | 39 (19.3) | 15 (13.3) | 1.51 (0.78–2.92) | 81 (20.3) | 28 (16.1) | 1.26 (0.78–2.05) |
| Regular use of asthma medication, n, (%), (5) | 16 (8.1) | 4 (6.6) | 1.20 (0.40–3.58) | 23 (11.4) | 5 (4.4) | 2.65 (0.97–7.27) | 39 (9.8) | 9 (5.2) | 1.74 (0.86–3.53) |
| Recurrent respiratory tract infections†, n, (%), (9) | 63 (32.1) | 21 (35.0) | 0.88 (0.48–1.62) | 80 (40.0) | 42 (37.2) | 1.13 (0.70–1.82) | 143 (36.1) | 63 (36.4) | 1.03 (0.71–1.50) |
| Recurrent skin rash, n, (%), (7) | 21 (10.7) | 10 (16.4) | 0.60 (0.26–1.36) | 39 (19.4) | 31 (27.4) | 0.64 (0.37–1.11) | 60 (15.1) | 41 (23.6) | 0.63 (0.40–0.99) |
| Dyspnoea during exertion, n, (%) | 18 (8.4) | 9 (14.8) | 0.62 (0.26–1.46) | 45 (23.1) | 21 (18.8) | 1.30 (0.73–2.33) | 63 (16.3) | 30 (17.3) | 1.04 (0.64–1.69) |
| Pulmonary obstruction (FEV% z-score <−1.65, n, (%), (63) | 33 (18.9) | 13 (22.8) | 0.75 (0.36–1.56) | 25 (14.1) | 12 (11.3) | 1.29 (0.62–2.71) | 58 (16.5) | 25 (15.3) | 1.07 (0.64–1.78) |
| Significant bronchodilator response (FEV1 or FVC ≥+12%, (84) | 13 (7.6) | 3 (5.6) | 1.43 (0.38–5.41) | 11 (6.4) | 7 (6.9) | 0.95 (0.37–2.43) | 24 (7.0) | 10 (6.4) | 1.17 (0.54–2.54) |

*Antihistamine in the spring, for example, nasal corticosteroid if used together with antihistamine, allergy eye medication, medication for hyposensitisation.
†Common cold, sore throat, rhinitis, bronchitis more than three times per year.
Statistically significant results are indicated in bold.
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Competing interests None declared.

Patient consent for publication The adolescents and their guardians provided written consent to participate in the study, and the adolescents were told that they could retract their consent at a later date.

Ethics approval The study conforms to the declaration of Helsinki. A positive statement from the Ethics Committee of healthcare District of Central Finland was received (record number 23U/2012). Before the start of this study, we requested permission from all the sports clubs to take part. This permission was granted freely.

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Data availability statement The data may not be shared because permission was not requested from the participants or their parents.

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