Effects of training period on haemorheological variables in regularly trained footballers

Y Karakoc, H Duzova, A Polat, M H Emre, I Arabaci

Objective: To investigate the effects of one football training period on haemorheological variables in regularly trained footballers.

Method: Ten subjects were randomly selected from the reserve team of a football club in the Turkish Premier League. During the last week of the football season, one day before a standard training session and two days after the previous league match, venous blood samples were taken (pre-exercise). After 90 minutes of standard training, further blood samples were taken (post-exercise). Blood lactate, blood viscosity, plasma fibrinogen, blood clotting time, acid-base variables, and plasma Na⁺, K⁺, and Ca²⁺ were determined.

Results: Haemoglobin, packed cell volume, and mean corpuscular volume were all significantly decreased, whereas white blood cells and platelets were both increased after training. Blood viscosity decreased but the reduction was not significant. Blood lactate, plasma glucose, and Na⁺ content were significantly increased, but standard bicarbonate, actual bicarbonate, and Ca²⁺ were significantly decreased. Blood clotting time had shortened significantly after training. Blood viscosity was inversely correlated with plasma glucose concentration (r = −0.48 and p = 0.032).

Conclusions: The results show that blood viscosity tends to decrease as the result of this type of training. This is due to a reduction in packed cell volume and mean corpuscular volume. The increased blood lactate does not have an adverse effect on the blood viscosity of these subjects because protective mechanisms develop with regular training throughout the season.

MATERIALS AND METHODS
Ten subjects were randomly selected from the reserve team of a football club in the Turkish Premier League. They were regularly trained footballers. Their body mass indexes ranged from 18.9 to 23.0 (mean 21.7). All subjects were in good health and had had no noteworthy health or traumatic problems during the football season.

RESULTS
The mean (SD) age of the subjects was 18.4 (1.3) years, and their body mass indexes ranged from 18.9 to 23.0 (mean 21.7). All subjects were in good health and had had no noteworthy health or traumatic problems during the football season. Table 1 shows pre-exercise and post-exercise haematological variables and some haematological indices. Haemoglobin, packed cell volume, and mean corpuscular volume were all significantly decreased whereas white blood cells and platelets were both increased after training.

The effects of exercise and training have been extensively investigated in humans using different experimental protocols. It has been shown that whole blood viscosity and plasma viscosity increase in response to a variety of exercise protocols. The effects of training period of football on haemorheological variables in regularly trained footballers.

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Table 1  Haematological variables before and after exercise

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-exercise (n = 10)</th>
<th>Post-exercise (n = 10)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBCs (10^6/mm^3)</td>
<td>5.12 (0.27)</td>
<td>5.06 (0.28)</td>
<td>0.156</td>
</tr>
<tr>
<td>Hb (g/l)</td>
<td>154 (8.9)</td>
<td>150 (9.6)</td>
<td>0.016</td>
</tr>
<tr>
<td>PCV (μl/mm^3)</td>
<td>4.40 (0.02)</td>
<td>4.22 (0.03)</td>
<td>0.006</td>
</tr>
<tr>
<td>MCV (μm^3)</td>
<td>85.7 (3.49)</td>
<td>83.1 (3.58)</td>
<td>0.005</td>
</tr>
<tr>
<td>RDW (%)</td>
<td>12.0 (7.33)</td>
<td>12.6 (7.77)</td>
<td>0.899</td>
</tr>
<tr>
<td>PLTs (10^5/mm^3)</td>
<td>262 (34.6)</td>
<td>256 (55.3)</td>
<td>0.000</td>
</tr>
<tr>
<td>WBCs (10^3/mm^3)</td>
<td>8.5 (1.83)</td>
<td>12.4 (1.75)</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Values are mean (SD).

RBC, Red blood cell; Hb, haemoglobin; PCV, packed cell volume; MCV, mean corpuscular volume; RDW, red cell distribution; PLT, platelet; WBC, white blood cell.

Table 2  Blood viscosity, blood lactate, and other variables before and after training

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-exercise (n = 10)</th>
<th>Post-exercise (n = 10)</th>
<th>p Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood viscosity (mPa.s)</td>
<td>2.84 (0.75)</td>
<td>2.40 (0.20)</td>
<td>0.133</td>
</tr>
<tr>
<td>Blood lactate (mmol/l)</td>
<td>1.45 (0.96)</td>
<td>3.60 (1.41)</td>
<td>0.000</td>
</tr>
<tr>
<td>Fibrinogen (mg/dl)</td>
<td>265.6 (79.12)</td>
<td>283.3 (29.9)</td>
<td>0.557</td>
</tr>
<tr>
<td>Blood clotting time (s)</td>
<td>20.3 (1.56)</td>
<td>17.9 (0.93)</td>
<td>0.000</td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>81.2 (9.1)</td>
<td>111.5 (16.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>pH</td>
<td>7.417 (0.017)</td>
<td>7.425 (0.018)</td>
<td>0.244</td>
</tr>
<tr>
<td>Std HCO3 (mEq/l)</td>
<td>25.4 (2.1)</td>
<td>19.8 (0.8)</td>
<td>0.000</td>
</tr>
<tr>
<td>Act HCO3 (mEq/l)</td>
<td>26.0 (3.2)</td>
<td>16.1 (0.8)</td>
<td>0.000</td>
</tr>
<tr>
<td>Plasma Na+ (mEq/l)</td>
<td>142.0 (3.8)</td>
<td>151.7 (2.8)</td>
<td>0.000</td>
</tr>
<tr>
<td>Plasma K+ (mEq/l)</td>
<td>4.1 (0.3)</td>
<td>3.9 (0.6)</td>
<td>0.303</td>
</tr>
<tr>
<td>Ca2+ (mmol/l)</td>
<td>1.15 (0.93)</td>
<td>0.93 (0.12)</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Values are mean (SD).

Pre, Standard; Act, actual.

Table 1 shows whole blood viscosity, blood lactate, and other variables before and after exercise. Blood viscosity appeared to decrease after training, but the difference was not significant. Blood lactate, plasma glucose, and Na+ were significantly increased, whereas plasma standard bicarbonate, actual bicarbonate, and Ca2+ concentrations were significantly decreased. We found no significant change in plasma fibrinogen. However, the blood clotting time had shortened significantly after training. It is noteworthy that blood viscosity was inversely correlated with plasma glucose concentration (r = −0.48, p = 0.032).

DISCUSSION

Most metabolic and hormonal alterations play a role in exercise induced haemorrhological changes. Of these, blood lactate appears to have opposite effects according to the training status, as it generally impairs erythrocyte fluidity. Body composition as well as the major hormonal regulating systems are both considerably modified by training, and these modifications are correlated with haemorheology.1

In our study, blood lactate concentrations were significantly increased after training. In fact, they are above baseline values. Increased white blood cell number in response to exercise in these subjects may be attributed to a demargination process caused by exercise or adrenaline (epinephrine) administration. Normally about half of the blood leucocytes are in a marginal pool—that is, loosely adherent to the vascular endothelium or trapped in the microcirculation. With exercise or adrenaline administration, these cells are released into the circulating pool and the leucocyte count rises, a process called demargination.11

In this study, the increase in plasma glucose concentration after training may be due to raised blood lactate concentration. We also found a positive correlation between blood lactate and plasma glucose concentrations (r = 0.538, p = 0.010). Excess lactic acid accumulation inhibits further ATP production. Although the excess lactic acid causes fatigue during exercise, this inhibitory effect is a protective response, as excess acidity can lead to cell death. After exercise, excess lactate is converted back into glucose in the liver. This newly made glucose can then be used for resynthesis of the glycogen depleted during exercise. The rate of lactic acid removal is faster active compared with passive recovery.12

The decrease in plasma Ca2+ after training is similar to the results of previous studies. This finding may be related to the effects of the training conditions on Ca2+ homoeostasis. Bauassa et al13 showed that the Ca2+ concentration during the 7th and 21st minutes and at the end of high intensity exercise had decreased significantly compared with the pre-exercise values in two exercise protocols in physically active men. A significant decrease in Ca2+ and significant increase in parathyroid hormone have also been observed after moderate endurance exercise in young women.14 Azizawa et al15 found that urinary Ca2+ excretion significantly increased on the day of a single bout of resistance exercise in untrained young men.15 Parathyroid hormone and urinary excretion of Ca2+ seem to be two major factors in Ca2+ homoeostasis during and at the end of training.

CONCLUSION

Our results show that one standard 90 minute training session has the middle term effects of exercise on the regularly trained footballer. Blood viscosity tends to decrease after this type of training due to a reduction in red blood cell volume and packed cell volume. This may be a protective measure against the high shear rate conditions that occur at the end of a day’s standard training. At the end of the football season, an increase in blood lactate concentration does not have an adverse effect on blood viscosity because a protective mechanism develops with regular training throughout the season.
ACKNOWLEDGEMENTS

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Competing interests: none declared

REFERENCES


What is already known on this topic

Whole blood viscosity and plasma viscosity increase in response to a variety of exercise protocols.

What this study adds

In highly trained footballers, the increase in blood lactate at the end of a 90 minute training session (middle term effect) does not have the usual adverse effect on blood viscosity because of protective mechanisms that develop with regular training.

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