The effect of water intake on body temperature during rugby matches

C. GOODMAN, I. COHEN, J. WALTON

Summary

The effect of drinking up to 1 litre of fluid on water deficit, sweat loss and rectal temperature was determined during three separate rugby matches played in thermoneutral environments. Each player was allotted a litre of fluid and encouraged to drink 500 ml before the start of the game and a further 500 ml at half-time. The players were weighed and rectal temperatures determined before and after the matches. Rectal temperatures were markedly elevated after all three matches and reached levels which may have been high enough to have impaired performance towards the end of the game. The volume of fluid ingested by the players had no influence on final rectal temperatures. The majority of players had sweat rate/rectal temperature relationships similar to those of heat-acclimatized subjects. It is concluded that, in a thermoneutral environment, the ingestion of volumes of fluid up to 1 litre has no significant beneficial effect on thermoregulation during rugby games, and that the role of the clothing worn may have a greater influence on thermoregulation than was hitherto envisaged.

Rectal temperatures have been recorded before and after rugby matches, and mean post-match rectal temperatures have been between 38,5°C and 40,5°C. The majority of players have had post-match rectal temperatures in excess of 39°C. Hyperthermia, particularly when rectal temperatures are in excess of 39°C, has been associated with an impairment of physical, mental and psychological functions. Water deficit during exercise is one important factor predisposing to hyperthermia.

In the only study which attempted to measure the relationship between water deficit and body temperature during rugby, a positive relationship was reported. Re-evaluation of the data, however, showed that there was no significant correlation between water deficit and final rectal temperature in players. Other important factors predisposing to hyperthermia in rugby players could include lack of heat acclimatization and inappropriate clothing.

The purpose of the present study was to determine the effect on rectal temperatures of drinking up to 1 litre of fluid during a rugby match.

Subjects and methods

The study was carried out during one match played in Johannesburg and two matches played in Durban. The players were members of the University of the Witwatersrand, Johannesburg, and Northlands Old Boys, Durban, first rugby teams. The University of the Witwatersrand team plays in the senior Transvaal Provincial league, while the Northlands Old Boys team plays in the Natal first reserve league. The players were aged between 20 and 36 years and weighed 63,8 - 107,7 kg.

The research was carried out during the 4th weekly fixture of the University team and the 7th and 9th weekly fixtures of the Northlands team.

During the game which took place on 29 May 1982, player 10 was severely injured and therefore investigations in this subject could not be completed. Players 4 and 12 refused consent for full investigation and results for them, together with those for player 11, who was also severely injured, are not fully represented in the data for the game played on 12 June 1982. Data on environmental conditions during the three matches are shown in Table I.

Each player was given a bottle containing 1 litre of fluid, which had a sugar concentration hypotonic to body fluid, and was encouraged to drink 500 ml during the 10 minutes before the start of each match and a further 500 ml at half-time. The volume of fluid remaining in each player's bottle after the match was recorded.

The methods of weighing the players and measuring rectal temperatures have already been described.

The statistical evaluations were carried out using Pearson's correlation coefficients and regression options.

Results

The mean rectal temperatures (± SEM) recorded immediately after the three matches were 39,2 ± 0,07°C, 39,2 ± 0,11°C and 39,2 ± 0,14°C respectively, ranging from 38,2°C to 40,0°C.

Mean water deficits for the three matches were 1,61%, 1,37% and 1,54% respectively with an overall mean of 1,51%. Sweat loss was between 0,8 and 3,1 litres with means for the three matches of 2,16, 1,74 and 2,25 litres respectively. Sweat loss was closely correlated with initial body mass, the correlation coefficient being 0,52, which is significant at the 0,1% level. The volume of fluid ingested just before and during the matches was between 200 and 1000 ml, with a mean of 751 ml. The volume of fluid ingested per kilogram initial body mass was 2,1 - 13,9 ml with a mean of 8,96 ml/kg.

The correlation between water deficit and final rectal temperature was not statistically significant. The correlation between water deficit and final rectal temperature in players with deficits between 1,7% and 2,9% was also not significant.

The correlation between the volume of fluid ingested per kg initial body mass and final rectal temperature was not significant. The correlation between those who ingested 10 ml/kg body mass or more and final rectal temperature was also not significant.
In Fig. 1 the final rectal temperatures are plotted against water deficits developed by the players, as well as Wyndham and Strydom's regression line of marathon runners. It shows that, with the exception of one player, rectal temperatures are higher in rugby players than in the marathon runners, at all levels of dehydration.

Fig. 1. Relationships between water deficit and final rectal temperature for marathon runners and for the rugby players (black dots) studied.

Fig. 2. Relationships between final rectal temperature and sweat rate. Continuous curve taken from Wyndham et al. The black dots indicate the data obtained for the rugby players in this study. Error bars indicate the mean ± SEM for the rugby players.

Discussion

The present study took place in thermoneutral environments (Table I) which were similar to those of a previous study. It is of interest to note that rectal temperatures and sweat losses were statistically similar to those previously reported (Table II). However, water deficits were statistically lower ($P < 0.05$).

<table>
<thead>
<tr>
<th>Match 1</th>
<th>Match 2</th>
<th>Match 3</th>
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<tbody>
<tr>
<td>Before</td>
<td>After</td>
<td>Before</td>
</tr>
<tr>
<td>Air temperature ($^\circ$C)</td>
<td>20.4</td>
<td>17.8</td>
</tr>
<tr>
<td>Wind speed (m/s)</td>
<td>3.5</td>
<td>0</td>
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<tr>
<td>Relative humidity (%)</td>
<td>18</td>
<td>20</td>
</tr>
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**TABLE II. COMPARISON BETWEEN RECTAL TEMPERATURE, SWEAT LOSS AND WATER DEFICIT (MEAN ± SEM) IN A PREVIOUS STUDY AND THIS STUDY**

<table>
<thead>
<tr>
<th></th>
<th>Previous study</th>
<th>This study</th>
</tr>
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<tbody>
<tr>
<td>Final rectal temp. ($^\circ$C)</td>
<td>39.41 ± 0.14</td>
<td>39.17 ± 0.06</td>
</tr>
<tr>
<td>Final sweat loss (l)</td>
<td>2.10 ± 0.18</td>
<td>2.05 ± 0.09</td>
</tr>
<tr>
<td>Final water deficit (%)</td>
<td>2.52 ± 0.18</td>
<td>1.51 ± 0.10</td>
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</table>
Despite playing in thermoneutral environments, the majority of the players developed body temperatures which may have been high enough to have impaired their performances towards the end of their matches. Hyperthermia may detract from performance during the second half of a rugby match by impairing maximum oxygen uptake and the ability to carry out simple mental tasks and by behavioural changes.

An important factor influencing the rise in body temperature during exercise is the level of dehydration which sportsmen allow themselves to develop. Wyndham and Strydom reported that when dehydration is greater than 3% of body mass, a linear relationship between dehydration and rectal temperature occurs. For subjects with dehydration less than 3%, no relationship between dehydration and body temperature is found. In the present study, water deficit did not exceed 2.9% and no relationship was found between dehydration and body temperature (Fig. 1), which is in agreement with the previous studies.

The volume of fluid ingested by our players had no influence on final rectal temperatures, which is contrary to a supposition made in our previous study. Even when there was a large volume of fluid ingested per kg body mass, there was no influence on rectal temperature. We must therefore conclude that in a thermoneutral environment, the ingestion of volumes up to 1 litre has no significant beneficial effect on thermoregulation during rugby.

Wyndham et al. have shown that the sweat rate response to an increase in rectal temperature is much more sensitive in heat-acclimatized than in unacclimatized subjects, and that the greatest differences in sweat rate between acclimatized and unacclimatized men are observed during the 1st and 2nd hours of heat exposure. The authors state that the measurement of sweat rate responses discriminates significantly between acclimatized and unacclimatized men.

The similarity of the mean sweat rate/rectal temperature responses (Fig. 2) of the players and those of heat-acclimatized subjects suggests that the players are at least partially acclimatized to heat under the conditions in which this study took place, i.e. participation in an 80-minute rugby match with environmental temperatures of up to 23°C.

In our previous study, as well as in the present one, rectal temperatures were higher in the rugby players than in the marathon runners at any given level of water deficit (with one exception) (Fig. 1). We have previously suggested that three major factors predisposing to the relative hyperthermia in rugby players may be: (i) the degree of dehydration; (ii) lack of heat acclimatization; and (iii) inappropriate clothing. Under the conditions of our present study, we have largely eliminated dehydration and lack of heat acclimatization as major factors causing the observed increase in body temperatures during rugby.

Our findings therefore suggest that the role of clothing worn during rugby may have a greater influence on thermoregulation than was hitherto envisaged. Noakes (as well as ourselves) has previously suggested that the fabric and design of rugby jerseys should be altered to enhance thermoregulation; the length of rugby jerseys should be restricted to waist level and the length of the sleeves to the level of the elbows. Rugby socks are often worn so that they cover a large surface area which has a high potential for evaporative cooling. The thermoregulatory advantages which could be obtained from wearing ankle-length socks probably outweigh the disadvantage of a potential increase in superficial abrasions of the lower leg.

This present study emphasizes the need for further research under controlled laboratory conditions so that the effect of clothing on thermoregulation during rugby matches can be determined.

We wish to thank the first-team rugby players of the University of the Witwatersrand and of Northlands Old Boys, Durban, for their co-operation, and Mr P. Fridjihan of the Department of Statistics, University of the Witwatersrand, for assistance with the statistical analysis.

REFERENCES