Diet intake and endurance performance in Kenyan runners

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Abstract
Training and competing at elite as well as sub-elite level requires an optimal functioning of the body. This review looks at the case of the Kenyan runners, who consume a relatively high-quality diet based on vegetable sources with maize and kidney beans as the staple foods. The diet is high in carbohydrate and total protein, but low to borderline in a few essential amino acids. The timing of diet intake – immediately after training sessions – is optimal for skeletal muscle glycogen resynthesis that is enhanced without the help of insulin up to 60 min after cessation of exercise. Whether the total energy intake of the Kenyan runners is adequate is debatable. However, chronic undernutrition is not possible for athletes who engage in daily high-quality and -quantity physical exercise throughout most of the year. It is suggested that Kenyan runners participate in well-controlled, laboratory studies to investigate the quality of local foods and performance, as well as possible physiological adaptation mechanisms among athletes with a high habitual energy turnover.

Keywords: Kenya; runners; macronutrient intake; performance

Introduction
Training and competing at elite and even sub-elite level in the middle and long distances (800 m to marathon) requires an optimal functioning of the body, which relies on a nutritionally adequate diet providing sufficient energy, as well as an adequate content of macronutrients. Until a few years ago, little was known about the dietary intake of Kenyan runners despite them having been a dominating force in international athletics for several decades. Only anecdotal information and no scientific data on this subject were available until a decade ago, when Mukeshi and Thairu¹ evaluated the dietary intake of elite male Kenyan athletes including male long-distance runners. Unfortunately, the study was based on questionnaires only. However, a substantial body of dietary investigations in general have been carried out in Kenya over the past ~80 years²-⁴. These studies revealed several cases of malnutrition – especially protein-energy and micronutrient malnutrition – indicating a very limited availability of high-quality food sources. This indicates potential performance problems for Kenya-based athletes in training and competition. Based on the above, the present paper addresses the carbohydrate, protein and energy intakes of Kenyan runners to investigate whether they are adequate and to elucidate subsequent implications for physical performance.

Food and macronutrient intakes
The only investigation that has looked at the macronutrient intakes of Kenyan runners in detail, including collection and analysis of food samples, showed that their diet was based on a relatively small range of food items from mainly vegetable sources⁵. The staple foods were maize and kidney beans, both of which contributed essentially to protein intake. Furthermore, cabbage, curly kale, wheat bread, milk, coffee and meat were the remaining sources of daily food intake⁵. This investigation was carried out over a two-week period at Marakwet High School (formerly Marakwet Secondary School), a typical Kenyan boarding school situated in the western highlands at 2600 m above sea level. The adolescent male student-runners participating in the study (n = 12) were all Kalenjin, a Nilotic subgroup, and the most successful ethnic group in running from Kenya over time. All runners competed at the sub-elite level in the middle and long distances. The energy intake of the runners was mainly derived from vegetable sources, but surprisingly meat and milk

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consumption comprised only 10% of total energy intake (Table 1). Historically, the Nilotes have depended primarily on milk, but also on blood and meat as their staple foods. However, it is a misconception to regard Nilotes as pure pastoralists since most of them have supplemented their diet with grain foods, historically as well as presently. This is especially true for the Kalenjin. Still, we expected milk intake to play a more prominent role in the diet of the runners at Marakwet High School. But it was only a few weeks prior to important competitions that they were supplied with extra milk. As it turned out, the study made by our group showed that maize and kidney beans alone made up 81% of the total energy intake of the student-athletes at Marakwet High School. Furthermore, the energy distribution of their macronutrient intakes was 71% for carbohydrate, 15% for fat and 13% for protein.

### Carbohydrate intake, glycogen resynthesis and performance implications

In the literature there is an abundance of evidence showing that a high daily intake of carbohydrate is advantageous in post-exercise recovery as well as in performance (for recent reviews, see Burke et al.). However, some authors have questioned the official dietary guidelines, stating that the recommendation for carbohydrate intake (60–70% of total energy intake) is not consumed by athletes in training and that the carbohydrate intake of athletes has not increased over the past 50 years. This implies that athletes do not need such high carbohydrate intakes. While the statement is true for athletes in industrialized countries in general, at least the first part of the statement is not true when it comes to athletes in the developing world, as shown by studies carried out among ultra-distance runners in Mexico and Kenyan middle- and long-distance runners. It is, however, important to emphasize that a high intake of carbohydrate, expressed as a percentage of total energy intake, is crucial only when the diet is low in energy (such as shown in many studies on female endurance athletes) in order for the athlete to replenish his/her liver and skeletal muscle glycogen stores (for review, see Burke). More important is a high carbohydrate intake in relation to body weight, for which there are guidelines for short-term/single events as well as for long-term or routine situations. The Kalenjin runners from our study had a daily carbohydrate consumption of 8.7 g kg\(^{-1}\) body weight, which is well above the 6–7 g kg\(^{-1}\) body weight thought necessary for replenishment of liver and skeletal muscle glycogen stores after an hour’s daily training at 75% \(\dot{V}O_{2}\text{max}\). In spite of the fact that the Kalenjin student-athletes ran a daily average

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Amount (SE)</th>
<th>Range</th>
<th>SE</th>
<th>Nutrient</th>
<th>Amount (SE)</th>
<th>Range</th>
<th>SE</th>
</tr>
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<tbody>
<tr>
<td>Energy (kJ)</td>
<td>12211 (283)</td>
<td>11,860–14,648</td>
<td>1.8</td>
<td>Protein (g)</td>
<td>88 (1.8)</td>
<td>80–96</td>
<td>8</td>
</tr>
<tr>
<td>carbohydrate (g)</td>
<td>476 (1.0)</td>
<td>405–538</td>
<td>1.7</td>
<td>Fat (g)</td>
<td>45.2 (1.0)</td>
<td>33.9–50.6</td>
<td>35</td>
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<tr>
<td><em>Table modified from study published by Christensen et al.</em></td>
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*Including food sources which each contribute less than 1%."
of only 10 km at the time of our study, the intensity of their training was probably higher than 75% $\dot{V}O_{2\text{max}}$. This is indicated by an earlier study on Kenyan runners, also including student-athletes based at Marakwet High School, who trained at intensities between 72% and 98% in nine out of ten training sessions. It is reasonable to assume that the very high training intensity elicits glycogen depletion to the same extent as exercise of longer duration and lower intensity.

The most optimal glycogen replenishment after training is obtained within the first 30–60 min after exercise, due to initial post-exercise synthesis of skeletal muscle glycogen that does not require the presence of insulin. Interestingly, we found that the Kalenjin runners were fed breakfast and dinner immediately after their early morning run and late afternoon training session, respectively, indicating optimal conditions for skeletal muscle glycogen replenishment. Furthermore, maize has a high glycaemic index, and as this food source was consumed at almost all main meals and alone made up 64% of total energy intake, the glycogen resynthesis conditions may be close to perfect for the adolescent runners while based at the boarding school.

**Intakes of protein and essential amino acids**

There is disagreement in the research literature concerning the protein intake necessary for an endurance athlete. Using amino acid oxidation, nitrogen balance, or metabolic tracer methodology, several studies indicate an enhanced protein requirement of greater than the 0.8 g kg$^{-1}$ body weight per day recommended by the Food and Agriculture Organization/World Health Organization/United Nations University (FAO/WHO/UNU). In a study using strict energy balance control, Forslund et al. showed that an increased energy turnover after aerobic exercise was not due to increased rates of urea production and/or protein synthesis. In our study on adolescent Kalenjin runners, the total daily protein intake was 1.6 g kg$^{-1}$ body weight, or twice the amount recommended by FAO/WHO/UNU. This was higher than the amount suggested by studies that investigated the effect of aerobic training on protein oxidation and protein requirements, indicating that the total protein intake of the Kalenjin runners was more than sufficient to cover their needs. High intakes of total protein were also found in the studies of elite Kenyan runners as well as ultra-distance Mexican runners. Thus, for runners based in developing countries, including Kenyan athletes, there was no malnutrition at the total protein level.

While the total protein intake was adequate, the intake of essential amino acids, especially isoleucine and histidine, was low to borderline among the adolescent Kalenjin runners. This is based on the fact that adolescents are growing and therefore have higher needs than adults. However, currently there are no recommendations on essential amino acid requirements for the adolescent age group above 12 years of age and younger than 18. The deficit of some essential amino acids could be a limiting factor in performance, but it is also possible that a physiological adaptation to low essential amino acid intakes has taken place, in which a high protein turnover has resulted in an enhanced re-utilization of essential amino acids.

Such a physiological compensation might have been necessary only for limited periods throughout the year, since the runners were supplied with extra milk prior to important competitions, thereby adding extra isoleucine and histidine as well as other essential amino acids to their diet.

**Physiological adaptation to low energy intake?**

The first diet study including Kenyan elite male runners reported a very low energy intake (9790 kJ). Unfortunately the authors did not report data on energy output during the study period, which covered six days over a three-month period. This makes it impossible to verify energy balance. But even at an estimated low body weight of 55–60 kg, there is not much energy left for training at the elite level assuming the runners are in energy balance. It is therefore tempting to theorize that these runners had adapted physiologically to low energy intakes in order to carry out their high-quality and quantity training as reported by Saltin et al. However, one has to approach such a theory carefully, especially if chronic undernutrition is assumed to take place. Only during the first 2–3 weeks of energy restriction does a marked decrease in basal metabolic rate (BMR) occur that can be attributed to an increase in ‘metabolic efficiency’ of the active tissue mass (for a recent review, see Shetty), and hence an indication of metabolic adaptation. With continued energy restriction, however, any further decrease in BMR is accounted for by the loss of active tissue (i.e. protein). The latter seems very unlikely considering the quality and quantity of training required at the elite athlete level. This is supported by several studies showing that $\dot{V}O_{2\text{max}}$ and maximal aerobic power were reduced in undernourished compared with well-nourished young adults. Marginally undernourished adolescents in Brazil working on a cycle-ergometer showed uncompromised gross mechanical efficiency. However, this was achieved at the expense of a higher percentage of their maximum work capacity, i.e. higher heart rates for the same level of oxygen consumption. The blood lactate levels were also higher during exercise. The same compromising
physiological response could not be seen when adolescent and adult elite male Kenyan runners were compared with Scandinavian elite male runners in Kenya (altitude) and Denmark (sea level) during treadmill tests in the laboratory. Furthermore, the study on Kalenjin runners’ dietary intake carried out by our group showed that the runners were in energy balance based on measurement of energy intake and an estimate on energy output over a two-week period. Based on the above, this author therefore suggests that Kenyan elite runners are in energy balance at least during times of heavy training and competition, and at worst temporarily undernourished.

Conclusions

Distance runners from Kenya consume a diet based on a small range of food items primarily of vegetable origin that has been shown to provide sufficient carbohydrate and total protein intake for endurance athletes. Only essential amino acid intake may be in the low to borderline range, at least for limited periods of time. Based on the two studies published so far on the dietary intake of Kenyan runners there is controversy concerning their energy balance. However, this author suggests that the diet provides for energy balance, and at worst temporary undernourishment, otherwise training and competing at the elite level would not be possible. It is important to keep in mind that sophisticated dietary studies (for example, using tracer methodology) carried out in the laboratory have not been done so far for Kenyan runners. The discussions in this paper concerning the physical performance of Kenyan runners have therefore been based on extrapolations of results from other studies done in laboratory environments. It is hoped that, in the near future, Kenyan runners as well as athletes from other developing countries will be participating in well-controlled laboratory-based studies on dietary intake and performance. This way we will acquire a better understanding of the quality of local diets in the developing world, and add to our knowledge of potential physiological adaptation mechanisms in general among athletes with a high habitual daily energy turnover.

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References

Nutrition of Kenyan runners


