A PRELIMINARY EVALUATION OF ALTITUDE TRAINING

PARTICULARLY AS CARRIED OUT BY SOME MEMBERS OF THE OLYMPIC TEAMS OF
GREAT BRITAIN AND OF OTHER EUROPEAN COUNTRIES IN 1972

J. RAYMOND OWEN, MA, MB, BChir

Honorary Medical Adviser, British Olympic Association

Although the physiological changes resulting from altitude have been known for years, both these and many of the apparent dangers relate to altitudes above 14,000 ft (4,270 m), and the comparatively low height of 7,000-8,000 ft (2,140-2,440 m) has received little attention. From the point of view of competitive sport there had been no appreciable interest in the effects of training at altitude until the selection of Mexico City for the 1968 Olympic Games, and no significant research into the problems had previously been carried out.

In 1965 the British Olympic Association, in conjunction with the Sports Council, sent a medical research team to Mexico City with the object of identifying the many problems that would affect an Olympic Team competing at an altitude of over 7,000 ft (2,140 m).

Although the primary objective concerned the problems of training and competition at altitude, some of us wondered whether the effects of training at altitude might result in an improvement in performance on return to sea level. We hoped, therefore, that after completion of the research programme in Mexico City it might be possible to carry out further trials at sea level. However, the only possible place where these might be carried out without prolonged travel or complete change of climate, was Acapulco; but the tropical conditions prevailing there in December soon showed this idea to be impracticable. Trials carried out on return to England would have been unlikely to have had any real value since, in addition to the effects of the journey and the time change, the weather would have been too different to have allowed a satisfactory comparison.

Three months after the end of the Games in Mexico City the British Olympic Association sent a questionnaire to each competitor asking, among other questions, whether he had taken part in any competition within four weeks of returning to sea level, and if so whether his performance had been improved, the same, or worse. Unfortunately this time coincided with the few weeks preceding Christmas, and most of the athletes had had no competition, partly because they were resting after the Olympic Games, and partly because there is normally little competition arranged at this time of the year. As a consequence insufficient replies were received to enable any conclusions to be reached.

Considerations responsible for altitude training being offered to continuous endurance event competitors

In September 1970 an international symposium on altitude training in relation to performance at sea level was held at St Moritz. This was attended by doctors from most European countries and from the USA. The most important paper was read by Professor Mellerovitz of Berlin and dealt with a controlled experiment involving two groups of Berlin policemen. The conditions for the two groups at altitude and sea level were as nearly as possible similar in all aspects, and the members of the groups were also similar both physically and in performance. The results showed a significant improvement in performance in those who had trained at altitude over those who had remained at sea level. This paper was agreed by experts in Great Britain as being acceptable research and the results as being valid. The results were also stated by three independent statisticians in Great Britain to be significant. At the conclusion of the symposium there was unanimous agreement that for some competitors altitude training could produce a significant improvement in performance on return to sea level. Nevertheless, it was also appreciated that the reasons for the improvement still required physiological demonstration, and that many other factors, such as the optimum time for competition after reaching sea level, and the length of time for which any improvement was retained, required further investigation. Thus, although the reasons were largely empirical and by no means fully understood, it seemed probable that there could be a significant improvement, at least for some competitors, in the continuous endurance events.

It was obvious that the answers to the many questions needing to be asked were most unlikely to be forthcoming before the 1972 Olympic Games. As a result it seemed necessary to offer altitude training to the continuous endurance event competitors of Great Britain's Olympic Team, who would otherwise feel at a great disadvantage to competitors from other countries whom they know would be undergoing altitude training before the Olympic Games in 1972.

The British Olympic Association therefore informed the governing bodies "that for certain categories of competitors there was likely to be an improvement on

return to sea level after training at altitude", and that it was proposed to offer altitude training at St Moritz for three weeks before the Olympic Games in Munich to all competitors in continuous endurance events.

This offer was accepted by the rowing team, the canoe team other than the slalom, the modern pentathlon team, and some, though not all, of those in the athletics team engaged in continuous endurance events. It was not accepted by the swimming team nor by the equestrian three day event team.

Recommended principles of altitude training

On the recommendations of the Medical Advisory Committee of the British Olympic Association the following principles were agreed:

- a) That altitude training be offered only to Olympic competitors entered in continuous endurance events.
- b) That altitude training should be carried out with competitors living at a height of about 2,000 m (6,560 ft), with facilities for going higher. (St Moritz was suitable.)
- c) That the required period in St Moritz should be not less than three weeks.
- d) The minimum period before competition on coming down from altitude, should be four to five days in the Munich Olympic Village.
- e) The maximum period in the Munich Olympic Village before competition should be 10 to 14 days.
- f) Training in St Moritz:
 - i) Should start on arrival
 - ii) Hard training should continue until about the 12th day, stopping short of fatigue and if necessary increasing rest periods.
 - iii) Full training to start on or about the 12th day, provided the individual concerned felt capable of it.
 - iv) There should be two training sessions daily:
 - A. Technical training in St Moritz on track, in pool, etc.
 - B. Conditioning training at a higher altitude, e.g. Corviglia (2,620m – 8,600 ft)
 These training sessions should be separated by several hour's rest.

These principles were explained to the relevant officials and coaches in the United Kingdom, and in printed medical booklets sent to each governing body for distribution to their Olympic "possibles".

However, whether due to a lack of communications, failure of appreciation of what was involved, or possibly

disagreement with what was suggested, not all of these principles – in particular the training at a higher altitude – were carried out by all those at St Moritz. To what extent the altitude training might have produced different results if these principles had been more fully observed is anybody's guess.

Opinions on altitude training in St Moritz

After the Olympic Games in Munich, an attempt was made to assess the results of altitude training on performance at the Games. An analysis showed that only five of those in the athletics team who had trained at altitude improved their previous best performance while in Munich, but the individual factors causing variations were too great and the numbers too small for this to prove anything of significance. At the same time a questionnaire was sent to all those who had taken part in altitude training to find out their opinions. Of those who replied, eight considered there was no value in altitude training, eight were doubtful, while 33 thought there was definite value. A further six agreed there was value, but did not consider that altitude was the cause.

There were many different views of how the training at altitude might be changed with advantage, but no unanimity of opinion, some being diametrically opposed to others. Generally, the majority felt they would have been better with a longer time in Munich before competition, and that they would have welcomed measures to relieve boredom. It is, however, only fair to quote a minority who felt the time in Munich was too long, and at least as many who did not suffer from boredom. It is also interesting to note that the number who thought the three weeks spent in St Moritz was too long was exactly balanced by the number who thought it was too short. In answer to the question of whether they would wish to carry out altitude training on a future occasion, those who said "yes" were: canoe team, 28%; athletics team, 62%; rowing team, 91%; and modern pentathlon team, 100%. Those who felt their performance was improved on return to sea level were: canoe team, nil; athletics team, 32%; rowing team, 71%; and modern pentathlon team, 100%.

To summarize, it would seem that the canoe team felt they had obtained no benefit and would not wish a repeat; two thirds of the athletics team would wish a repeat, but half of these would want to change their methods; three quarters of the rowing team felt they obtained benefit and would wish to train at altitude again, but would want some changes in methods; all the modern pentathlon team would want a repeat, and would make no changes. Apart from this it was obvious that opinions were very much affected by individual likes and dislikes, by adverse weather conditions that might just as easily have been the opposite, and by various other extraneous and unpredictable details not subject to control by anyone, and none of which were

related to the altitude itself.

At this stage the natural reaction was to attempt to draw conclusions about the advantages or otherwise of altitude training, and I did in fact, begin to do so. On further consideration, however, I realized that the data available to me applied only to the comparatively small number of the British team who had trained at St Moritz, and was based on these competitors' personal opinions and on the observations of myself and the other team doctors in Munich. In other words, any conclusions reached at this stage would be too circumscribed to be generally applicable.

Views expressed abroad on altitude training

Consequently I felt that I must talk with as many team doctors from other countries as I could to find out, first, whether they had carried out altitude training in the same way as ourselves or whether it had differed appreciably; secondly, to learn their results and hear their personal opinions, and thirdly, to find out whether they would wish to train at altitude again, and if so what changes, if any, would they propose to make. These questions covered a large field, and there was naturally some doubt as to whether all countries would be prepared to answer all my questions. In the event, I can only say that in every country I visited the team doctors were only too willing to discuss all aspects of their training methods, to tell me their results, and to give me their personal opinions on the value of altitude training.

The countries I visited were Holland (Amsterdam), Switzerland (Magglingen), Italy (Rome), France (Paris), West Germany (Freiburg), East Germany (Berlin), Rumania (Bucharest), and USSR (Moscow). In each country I met and held discussions with the chief medical officers of the Olympic Team, in addition to general secretaries, assistant doctors, trainers, etc. All the doctors were members of the International Association of Olympic Medical Officers. Since then I have received a communication from the Chairman of the USA Olympic Committee and have also recently had discussions in Athens with Professor Demeter of Bucharest and Professor Jokl of Kentucky.

All these countries, with the exception of Italy, carried out altitude training to a greater or lesser extent before the Munich Games. All trained at altitude for three to four weeks, the average being three weeks. The competitors sent were, in the majority, those engaged in continuous endurance events. The height varied from 1,600 – 2,000m (5,250 – 6,560 ft), with an average of about 1,800m (5,900 ft). All except the USSR made only one stay at altitude. The time of first competition in Munich varied from three to 12 days after leaving altitude, with the majority at five to seven days. In other words, almost all these countries carried out their altitude training in virtually the same way as ourselves –

though this is not to imply that they would not now wish to make some changes on a future occasion, in the light of experience in 1972. France differed in that in addition to continuous endurance competitors, they included those in the jumps and fencing teams; West Germany included swimming, handball, and volleyball; Rumania included boxing, fencing, and volleyball.

All teams made the trip to altitude for 21 days, except for the Rumanians who were there for 28 days, and some individuals from West Germany and the USA who were there for up to four weeks. The USSR was different in that the whole of their team regularly goes to a training camp in the Urals for two weeks in the spring and a further two weeks in the autumn. This is a normal part of their routine training which has been carried out for several years, and no particular change was made because it happened to be an Olympic year. In Rumania all the explosive event competitors trained at 1,000m (3,280 ft) for four weeks, while the boxing, fencing, long distance athletes, volleyball, basketball, and handball competitors trained at 2,000m (6,560 ft), also for four weeks. In Rumania the rowing team did no altitude training, but the Rumanian officials felt it would have been to their advantage had they done so.

The French trained at a height of 2,000m (6,560 ft), except for the rowing team who trained at 1,000m (3,280 ft). This was because the rowing course at Font Romeu is very exposed and subject to wind, making the water too rough to row for much of the year.

I was also interested to know whether any countries had carried out scientific tests during the training at altitude. The answers I received are shown in Table I.

TABLE I

Country	Test
<i>Scientific tests carried out during training at altitude</i>	
France	Haemoglobin Electrocardiogram every Muscular excitability 5 – 7 days
Rumania	Pulse Blood pressure daily Vital capacity – weekly (Haemoglobin not estimated)
Great Britain	Haemoglobin on arrival General examination
Holland Switzerland West Germany East Germany USSR	No specific tests

Those countries which did not carry out specific tests at altitude said that it was impossible to carry out real tests or research on an Olympic team because the competitors will not tolerate having needles stuck into them at this time, nor will they agree to undergo any test which they feel, rightly or wrongly, might affect their performance or interfere in any way with their training schedule — and as an ex-team manager, I am in complete agreement with this.

Negative Phase

I was interested to obtain opinions about the so-called negative phase which is often said to occur on return to sea level from altitude. There was considerable variation of opinion about this, both as regards the time when it occurred, and whether it did in fact occur at all. (Table II). But everyone agreed that if such a thing exists, its cause is unknown. On the whole they seemed more willing to accept that time must be allowed, on reaching sea level, for re-adaptation, and that since the time required for this varies from person to person, it is possible only to recommend an arbitrary time to cover a whole team. Re-adaptation would seem a more reasonable term than "negative phase", though scientific evidence is equally lacking on both.

TABLE II

Timing of the negative phase

Country	Timing
Holland	5th — 10th day after reaching sea level
Switzerland	2nd — 4th day after reaching sea level
France	Possibly sometime during first five days, but unsure
West Germany	Do not accept existence of negative phase, but feel it wiser not to compete until after 3rd day at sea level
East Germany	Possibly up to 10th day
Rumania	2nd and 3rd days
USA	? 10 days

Other points of interest

Two countries felt that daily vitamin supplements were important. This was strongly supported by a biochemist whom I know in Paris, though his view was not apparently shared by the French Olympic authorities.

To the best of my knowledge there is no scientific proof that vitamins serve any real purpose at altitude.

A story was circulating around Europe that three members of the West German rowing team had died from coronary infarcts while training at altitude, and it was suggested, to my surprise, that there might be a relationship between altitude and coronary thrombosis. I did, however, obtain the true facts from Professor Keul and Professor Reindell in Freiburg. These were that none of their competitors had died, and that two, not three, of the rowing team had suffered from myocarditis, not infarction, as a result of training at altitude while incubating an infection; both were completely restored to health, and able to row normally again.

In France it was suggested that a study of blood cells and bilirubin might give some indication of the length of time any benefit from altitude training might be retained, though there appeared to be no clinical foundation for this.

The importance of enzyme studies and changes in the muscle fibres were considered in many countries to be of importance in altitude training, and certainly electron-microscope photographs, which I was shown in Magglingen, were very convincing. However, both these studies, although of considerable interest, obviously require much more investigation before their practical relationship to altitude can be evaluated.

The question of the optimum height at which altitude training should be carried out was also discussed. It was generally agreed that above 2,800m, (9,180 ft) the actual exercise has to be curtailed too much for it to be effective. Some considered that a further limiting factor at high altitude was an increased viscosity of the blood, though this was not accepted by all countries. However, while this may, indeed, be true, it only applies to altitudes in excess of 4,270m (14,000 ft) where altitude training would not, in any case, be practicable.

There was general agreement that there was no advantage in repeated visits to altitude, as had been suggested by Balke.

The use of pressure chambers — although possibly of some value in research — was generally agreed to have no place in altitude training, because one could only remain in them for a limited time, and because of the impossibility of carrying out adequate training in the limited space available.

The Rumanian canoe team did not compete in Munich until three weeks after leaving altitude, because the doctor in charge felt that it was of supreme importance to have enough time to acclimatize to the peculiarities of the Munich climate, in particular the

much publicised and controversial “Föhn”. He felt that this was of more importance than the possibility of losing any advantage from their stay at altitude, and while their gold medal certainly appeared to justify him, there would seem to be no proof that this was the cause of their success.

Lastly, some countries believed that altitude can produce an improvement in reaction times, as claimed by Demeter of Bucharest in his paper in 1971, and again more recently when I talked to him. Certainly some countries sent fencing, boxing and jumping competitors to train at altitude, though I have no knowledge of whether the results supported their belief.

All countries, without exception, agreed that there was great individual variation in the response to altitude training. This in itself made the evaluation of results extremely difficult and in some cases impossible to prove, at least in the present state of our knowledge.

Most countries agreed that for altitude training to have any real effect it was necessary to do some daily training at 2,500 – 2,800m (8,200 – 9,180 ft). The competitors should sleep at 2,000m (6,560 ft), and work at 2,500m (8,200 ft), with a maximum height of 2,800m (9,180 ft).

Several countries felt that it was important to do more work at altitude, especially distance work – the Swiss rowing team complained of being very tired in the second week, but were not allowed to slacken off, and by the third week had completely lost their tiredness and were training normally.

It seemed to be generally agreed that the best time for competition after reaching sea level was 10 to 12 days. There was also general agreement that the length of stay at altitude should be three weeks.

Is any benefit physiological or psychological?

Finally I asked whether they considered the benefit, if any, of altitude training was physiological or psychological.

Nine countries felt that there were certainly some beneficial results, and one (the USA) that there were none. However, of the nine who felt there was benefit, six considered this to be physiological, two (West Germany and France) considered it to be psychological, and one was not sure. However, it is interesting to note that those who considered the benefits to be purely psychological would be prepared to train at altitude again, because they feel the reason for any improvement in performance is less important than the fact that there is an improvement.

Two countries made the point that there is no real physiological proof that altitude training is beneficial, and another country remarked, perhaps realistically, that “performance is the only real proof”.

It is therefore clear that almost all the countries I visited would wish to do altitude training again, though on a more selective basis, and not always for the same reasons.

Conclusions

Before drawing my own conclusions I feel it is essential to point out that altitude training in order to perform well at altitude (as in Mexico) is different from altitude training in order to obtain better performance at sea level (as in Munich). In the first case one is endeavouring to produce physical adaptations which will assist the body to continue to work and compete at altitude. In the second case the adaptations produced by altitude training are intended to enable the body to use its energy more economically and so perform better than previously at sea level.

There is no doubt, of course, that training at altitude does produce certain physiological changes, and that these changes are, in greater or lesser degrees, retained for an unknown length of time after return to sea level. It is also accepted that in some cases, though by no means all, there is an improvement in performance as compared with that when previously at sea level. Whether, however, the physiological changes resulting from the training at altitude are the direct cause of any improvement in performance, or whether, indeed, there is any relation between the two, is impossible to prove.

On the one hand it is obvious that there must be few competitors who, given three weeks away from work, in pleasant surroundings, with good food and accommodation, additional personal coaching, and unlimited time for training whether at altitude or sea level, will not be better, both physically and psychologically, at the end of it. On the other hand the controlled experiment of Mellerowicz, albeit with policemen, and the uncontrolled experiment of Balke and Jackson with world class 1,500 metre runners, cannot be written off as of no significance. In addition there are examples of individuals in whom altitude training produced an unexpected personal best performance which it is difficult to explain except by a relationship with altitude.

Again one can quote the Finns, who won gold medals in the 5,000, 10,000, and 1,500 metres, who did not train at altitude, and the New Zealand rowing team who won a gold medal in the eights and a silver in the coxwainless fours and also did not train at altitude. This of course proves nothing because one can argue that

these medal winners who did not do altitude training might have performed even better had they done so. Against this one must, of necessity, put those others, the majority, who won medals and did train at altitude. It is therefore obvious that actual performance is neither proof, nor disproof of the effectiveness of altitude training, because there are so many factors involved, both mental and physical, in the training of an Olympic competitor, of which altitude is only one. To what extent altitude is a predominant factor depends on the individual concerned, because just as reaction to altitude varies from person to person, so does reaction to the many other factors, including environment, boredom, adverse articles in the press, loneliness, likes and dislikes of food, disappointment in performance.

One can summarize the present position on altitude training by saying that certain individuals do improve their performance at sea level by having trained at altitude. There are no means by which these particular individuals can be picked out except by sending them to altitude, but it does appear that if any individual has once trained at altitude and has received no benefit, he is unlikely to benefit on a future occasion unless he makes some radical alteration in his training which was at fault previously. Conversely, if an individual has trained at altitude and produced an improved performance on return to sea level, it would seem reasonable for him to repeat this, but only if he is quite convinced that the altitude played an important part, and only if he himself wishes to do it again. For someone who has never been to altitude the position is much more difficult and, indeed, is impossible to advise in many cases. The answer must depend upon how anxious he is to train at altitude, and to what extent he really believes he will benefit. Although I may appear to be suggesting that any result is only psychological, this is not, in fact, the case — I am simply saying that if he really believes he will benefit, then this may prove to be the case; but whether this is psychological or physical is of no real importance. However, if he does not really feel that altitude training is going to help him, then it is fairly certain that it will not do so, and it would be a great mistake to try to persuade him.

I think that if one is going to train at altitude at all one should sleep and do technical training for half a day at a height of about 2,000m (6,560 ft) and the other half of the day should be spent in physical training (weights, circuits, running) at about 2,500m (8,200 ft). Less than this is not really true altitude training, and one cannot expect to benefit from it, while to try to train at much over 2,500m (8,200 ft) is impracticable and serves no purpose.

Having completed 21 days of altitude training the best time for competition seems to me to be between seven and 10 days after reaching sea level, and up to 14 days in events spread over a longer time.

The choice of individuals to train at altitude should be made on a selective basis, depending on the previous experience and personal wishes and beliefs. There should certainly be no question of a whole team being sent to altitude without consideration of the individuals who compose it. Where a team, such as a rowing eight, is concerned, the position is difficult — some of the members may have experience, and believe in it or not as a result, and others without experience may have difficulty deciding what they want to do. There is no easy solution; the question can only be settled by discussion with all the individuals composing that crew and by the advice of the coaches concerned — whatever is decided must be by real agreement between all concerned, and if the decision is to go to altitude then all must want to go and believe that they will derive some benefit.

Summary

These conclusions are based on my own experience in Mexico with the medical research team in 1965, and again at the Olympic Games in 1968; at Font Romeu in 1967; at St Moritz on four occasions between 1971 and 1973; at the Games in Munich in 1972; and on the discussions I have had with team doctors in various countries. I appreciate that they are limited, but perhaps future research will resolve the many questions still unanswered.

My conclusions may be summarised as follows:

1. In certain cases altitude training appears to result in an improved performance on return to sea level, whatever the reason may be.
2. No one should train at altitude unless he both wishes to do so, and feels that he will benefit from it. Conversely, if anyone has trained at altitude and obtained no benefit, it is unlikely that he will do so on a future occasion.
3. Once at altitude he should sleep and carry out his technical training at about 2,000m (6,560 ft) for half the day, and do physical training at about 2,500 – 2,800m (8,200 – 9,180 ft) for the other half.
4. It seems likely that the optimum time to start competition is seven to 10 days after reaching sea level.
5. While at altitude the work should not be allowed to slack off, though the rest intervals will need to be increased, and it should not be reduced too much on arrival at sea level. It appears that the faster the work is reduced at sea level, the faster will any benefits from altitude training be lost.
6. The response to altitude training is subject to very wide individual variation, and it is essential that this is

appreciated, and altitude training organized on an individual rather than a team basis.

I do not attempt to offer physiological proof for these conclusions, because it seems that although altitude produces certain physiological changes which are retained for some time after return to sea level, there is no proof that any alterations in performance are the results of these changes. It appears certain that a number

of individuals do produce improved performances on return to sea level from altitude, and although we do not know to what extent this is the result of the altitude, the fact that there is an improvement seems to be the factor of over-riding importance. Therefore in the light of our present knowledge I feel that altitude training should be offered again on a future occasion, but with much greater selectivity, and with a full appreciation of the individual variations in response.

DISCUSSION

CHAIRMAN: I should like to thank Dr Owen for that most thoughtful analysis of what are necessarily incomplete data, but data to which no one else has access. His caution and critical approach are extremely important.

The end-point of measurement of whether altitude was of benefit or not is the Olympic performance of the subject concerned. You said that only five of those who had trained at altitude improved on their previous best performance at Munich. Can you tell us how many were at St Moritz for altitude training? In other words, the five who improved were out of a group of how many athletes?

MR DENIS WATTS (Principal National Coach, British Amateur Athletic Board): Five out of 22.

CHAIRMAN: Can you tell me how large was the group of middle distance runners, within the range offered altitude training, who refused it?

MR ARTHUR GOLD (Honorary Secretary, British Amateur Athletic Board): A maximum of 30 were offered altitude training, and 22 went.

CHAIRMAN: Usually we expect athletes to improve their performances at the Olympic Games with the extra stimulus these provide. If only five out of 22 improved, that seems rather weak evidence for a benefit.

Would it be possible, through the medical advisers of the other Olympic associations, to produce more data along these lines? I think these facts are far more important than the subjective views of teams about whether they felt good afterwards, or would train at altitude again. They are the only objective sources that might give us a basis for judgment. As I said, I attach far more weight to the Olympic outcome under maximal stress than I do to studies of fit policemen, who cannot be motivated in the same way in any experiment.

MR HARRY WILSON (Athletics Coach): As far as Great Britain is concerned, it is a fallacy that our middle- and long-distance athletes improve their performances at the Olympics. I analysed the results of the last three Olympic Games. In two, I found that four people had improved their performances and in the other, nobody improved their performance — that was in Mexico. The fact that five improved at Munich is quite significant because there are so many other factors involved in Olympic Games performances.

In the 800m hardly anybody in the whole final ran up to their personal best, but that does not matter when it is winning that counts. These factors have to be borne in mind.

DR MALCOLM READ (British Olympic Association): I should like to support this comment about analysis by performance being the criterion. I stand ready to be corrected, but hardly any of the swimming team — who did not go to St Moritz — reached their previous best performance. We really must not take performance as being the criterion on which the benefit of altitude is to be judged.

DR OWEN: It may be imperfect, but the other criteria may be even more imperfect.

MRS MARIA GOLDBERGER (Women's Ski Team Manager): I have been manager of the Olympic ladies ski team for seven years, and we always train at altitude. I should like to make the following comments because I have a lot of experience with this problem.

There seems to be a conflict between the physiological and psychological aspects of altitude training. At very high