Viral Illnesses and Sports Performance

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Summary

Viruses are ubiquitous and cause numerous infections in humans. These may vary from asymptomatic infection to severe debilitating illness. Viruses enter the host cells to replicate, using host synthetic mechanisms, and, thus, are resistant to conventional antibiotics. The human body responds to viral infection by synthesising specific antibody which can be used to aid diagnosis. Infectious mononucleosis (glandular fever) commonly affects the 15 to 30 years age group. It may produce severe debility which may last a month or more. Coxsackie virus infection can produce symptoms of the common cold but may also invade heart muscle and produce myocarditis, a potentially serious disease. Other viruses also produce a wide spectrum of disease.

Recent evidence has shown that people undergoing severe mental or physical stress may have reduced immunity to viral infections. There are risks associated with strenuous physical activity during the acute phase of viral infection, and there are reports of sudden death and serious complications occurring in previously fit young adults who undertake vigorous exercise when in the acute phase of a viral illness. Abnormalities of skeletal muscle have been demonstrated in patients with viral infection and this may explain the loss of performance experienced by athletes after upper respiratory tract infection.

As a general rule, for all but mild common colds, it is advised that the athlete avoids hard training for the first month after infection.

Viruses are the most common infectious agents affecting humans. The average adult has between 1 and 6 upper respiratory tract viral infections per year (Beneson 1975). Not only are there innumerable viruses which infect man but also the effect of a single species of virus may vary enormously. Viral illnesses produce the entire spectrum of disease from fatal disease through mild colds to asymptomatic infections.

In this review I will discuss the more common viruses and the illnesses they produce, the effects of viruses on particular organ systems, e.g. muscle and heart, and make particular reference to sports performance. In sportsmen undergoing strenuous training and aiming for high performance standards, it is important that viral infections are recognised and correctly managed to avoid unnecessary complications. Often the desire of the athlete to train through an illness or minimise the lay-off time conflicts with the need to avoid stressful exercise during an acute viral illness. In addition there is evidence that athletes in training are more susceptible to viral illness than the normal population.

1. Mechanism of Viral Infection

Viruses are distinguished from bacteria by their dependence on host cells for replication. Viruses do not have the ability to reproduce their own gen-

etic material and therefore have to invade a host cell and take over its synthetic mechanisms to replicate their own genetic material and multiply. The majority of viruses enter the body via the respiratory tract, then individual cells by penetrating the cell membrane and displacing host control mechanisms. Usually the cell produces many viruses which are then released by either cell lysis or by budding from the cell. It is important to be aware that this method of reproduction renders the virus resistant to all the common antibiotics. Consequently, the routine prescription of antibiotics for viral upper respiratory tract infections is at best useless and may encourage resistance to antibiotics in potentially harmful bacteria present in the host.

The host responds to the viral infection by mobilising antibody and cellular defences and producing interferon, which inhibits viral reproduction. It is only if these defences are overwhelmed that severe illness occurs. Immunisation is effective against certain viral illnesses by mobilising host defences with a pseudo-infection. However there are innumerable viruses which can cause upper respiratory tract infections so immunisation is not practical. Table I shows the virus groups which are most commonly implicated in acute coryza (common cold) in man.

1.1 Immune Mechanisms

There are 3 main defences of the body to infection. One is the nonspecific humoral system, consisting of factors such as complement and interferon, and there are specific antibody and cell-mediated defences (fig. 1) which are stimulated by exposure to the infecting agent. The ability of a virus to infect the human host depends on the ability of the virus to survive in the environment and on its successful transmission to host cells. Viruses causing upper respiratory tract infections are inhaled into the nose and/or mouth. They are usually trapped by the surface mucus of the upper respiratory tract. Here the virus may encounter an antibody, secretory IgA, which is produced locally in the mucosa. The antibody recognises particular molecules on the cell surface, binds with them and initiates the destruction of the virus. If the subject

Table I. Common respiratory viruses and their clinical features

Virus group	No. of serotypes	Clinical features
Rhinovirus	> 110	Common cold
Coxsackie A	23	Upper respiratory tract infection
Coxsackie B	6	Infection, especially common cold
Echovirus	31	Common cold
Adenovirus	33	Upper and lower respiratory tract infection
Coronavirus	?	Common cold
Respiratory syncitial virus	1	Upper respiratory tract infection bronchiolitis, pneumonia
Influenza (ABC)$_3$	3	Influenza: upper respiratory tract infection
Parainfluenza	1	Upper respiratory tract infection
Herpesvirus: Epstein-Barr virus	1	Infectious mononucleosis

is not immune to the virus, i.e. has no previous exposure, the antibodies present will not recognise the virus. The virus is then able to bind to the cell surface on the underlying mucosa. Once the cell is entered, the viruses multiply, are released and spread to adjacent cells and via the blood to distant cells. Here the second arm of the body's immunity, cell-mediated immunity, is important. When the body encounters a foreign organism, in addition to the production of antibody, lymphocytes and macrophages are activated which infiltrate the virus-infected tissues, producing an intense inflammatory reaction, killing cells containing any viral antigens.

Acquired immunity consists of an immunological 'memory'. This allows rapid production of specific antibody and rapid proliferation of killer T lymphocytes and macrophages. Immunity to viruses may last for life, or only for a few weeks. Prolonged immunity is characteristic of infections where the virus has entered the blood stream, such
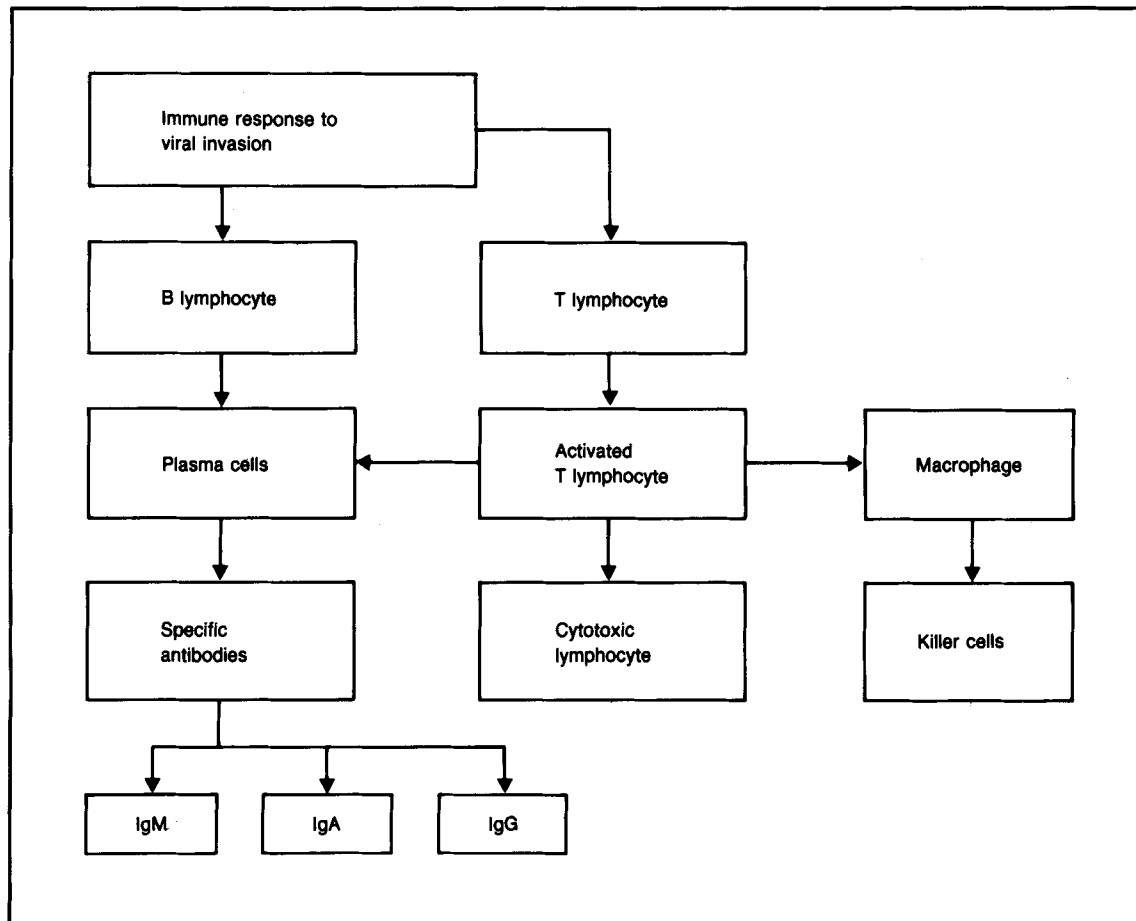
Fig. 1. Schematic representation of the interactions in the specific immune system.

as mononucleosis. Common cold viruses which produce only local effects may produce only a short-lived immunity. Other nonspecific factors, such as white cell phagocytosis, interferon and complement, also help the body fight infection.

2. Common Viral Illnesses

2.1 Epstein-Barr Virus

Epstein-Barr virus is the causative agent of the disease infectious mononucleosis, also known as glandular fever, common in adolescents and young adults (Henle et al. 1974; Neiderman et al. 1968). It is estimated that it affects between 2 and 6 per 10,000 of the population in any one year (Edmond 1975). Once infected, an individual carries the virus in his or her lymphocytoid cells in a latent form for life, but, despite this, clinically identifiable reactivation of Epstein-Barr virus is rare.

Most patients with infectious mononucleosis recall a 3 to 5 day prodromal period of malaise, fatigue, anorexia and mild headache. The patient then develops pharyngitis, with fever, and enlarged cervical lymph nodes. By the second week, 50 to 70% have an enlarged spleen and occasionally the liver is enlarged. The acute phase of the illness lasts 5 to 15 days (Hoagland 1967) and is followed by a period of gradual improvement. Occasionally a prolonged symptomatic illness can occur (Chretien et al. 1977).

It has been suggested that infectious mononucleosis is a less severe disease in athletes (Dalrymple 1965) and I have seen 2 athletes with deterioration of athletic performance as their only symptom both of whom had evidence of recent infectious mononucleosis (Roberts 1985). Further evidence in support of this suggestion comes from a survey of physically active army cadets in whom 75% of Epstein-Barr virus infections were asymptomatic (Lehane 1970). However, fatigue and lassitude in normal subjects could be equivalent to poor performance or loss of form in trained athletes. Most patients have recovered within 2 months after the onset of illness, although athletes may take longer to attain full fitness.

Complications of infectious mononucleosis include splenic rupture which has been reported as occurring in 0.1 to 0.2% of all cases (Hoagland 1967) but Rutkow (1978) on analysis of world literature found spontaneous splenic rupture to be very rare. Splenic rupture occurs when the spleen is enlarged, although this may not be clinically detectable (Maki & Reich 1982). Splenic ruptures occur predominantly (90%) in males and there appears to be no relationship between severity of illness and likelihood of splenic rupture (Maki et al. 1982). If ampicillin is given during an acute attack of infectious mononucleosis, a maculopapular rash develops, regardless of previous exposure to the antibiotic in 90% of cases (McKenzie et al. 1986).

The condition is diagnosed by examining the blood film for atypical lymphocytes (Downey et al. 1923) and by serological testing. There are no specific treatments for the condition. Ampicillin should be avoided. A recent report of a pilot study using cephalexin in infectious mononucleosis seemed to shorten the course of the disease (Lakic 1983), but a properly controlled trial would be required to confirm this observation. Corticosteroids have also been used to accelerate the resolution of symptoms (Bolden 1972) but there is no evidence that they reduce the complication rate.

2.1.1 Prolonged Illness after Infectious Mononucleosis

Primary infection with Epstein-Barr virus usu-ally produces a short term infection without long term effects. Infections in children are nearly always symptomless, but in young adolescents, the ratio of overt to symptomless infection increases to between one-third and two-thirds. Occasionally patients do not fully recover for months or years and there is increasing evidence that this prolonged illness is related to a latent infection of the B lymphocytes which is subject to reactivation. Tobi et al. (1982) and Straus et al. (1985) have reported abnormalities of immune function in patients with apparent persisting infection, but Jones et al. (1985) found no consistent difference in lymphocyte function. Whether this abnormality is cause or effect could only be determined by a prospective study of a large population of young adults.

2.2 Coxsackie Group

Coxsackie viruses are part of the enterovirus group. Coxsackie virus infection may be asymptomatic or cause mild common cold symptoms. However, Coxsackie infections have also been associated with myocarditis and aseptic meningitis (Grist et al. 1978). There is naturally a bias towards investigation of patients with symptoms, so the true incidence of subclinical infection is unknown, but 2 out of 12 athletes that I have seen (Roberts 1985) with loss of form and no other symptoms of viral infection have evidence of recent Coxsackie B group infection shown by rising antibody titres. There is a high prevalence of immunity to Coxsackie viruses (Lau 1983) which makes assessment of current disease difficult. The development of reliable antiviral IgM antibody assays, high levels of which are evidence of recent infection, should help clarify the situation (Dories & Ter Meulen 1983).

Lau (1983) surveyed cardiac and non-cardiac patients and also a normal population for evidence of recent Coxsackie virus infection. Between 30 and 60% of normal subjects had evidence of previous Coxsackie B1-5 infection; 8.6% of non-cardiac patients had evidence of recent Coxsackie infection and 8.9% of non-cardiac patients had evidence of recent Coxsackie infection. Thus, Coxsackie virus infection is a common condition.

Postviral fatigue syndrome (or epidemic myalgic encephalomyelitis) is an increasingly recognised condition. It usually occurs after Coxsackie virus infection (Behan & Behan 1980), although it has also been diagnosed after influenza and varicella virus infections. The patient complains of persisting malaise, fatigue, lassitude and aching muscles. Recent work has demonstrated subtle abnormalities of skeletal muscle metabolism (Arnold et al. 1984) confirming that the condition has a physical basis. Unfortunately, symptoms may persist for months or years and there is no treatment. Obviously, this condition would have a devastating effect on sports performance.

2.3 Other Viruses

Rhinoviruses are in the same family as the Coxsackie group. There are more than 100 different viruses in this group that produce the common cold symptoms in man. Adenovirus produce mainly eye disease and pharyngitis, but a few serotypes (types 3,4,14,21) produce upper respiratory symptoms. Influenza A produces an upper respiratory tract infection with an associated malaise which is usually quite severe. It tends to occur in pandemics. Influenza B and C have a more sporadic pattern to outbreaks and produce less severe symptoms (see table I). Most of the viruses listed in table I have been associated with nonspecific debilitating illnesses.

3. Are Athletes at Increased Risk of Infection?

The fact that most athletes are gregarious in their training habits will expose them to an increased risk of cross-infection from their fellows. However, there may also be more subtle reasons for increased susceptibility to infection. Various forms of stress have been shown to alter immune function. Jemmott et al. (1983) showed in a group of dental students, that levels of secretory IgA in saliva fell during the stress of major examinations. They suggested that the increased adrenaline levels associated with stress may inhibit both humoral and cell-mediated immunity. A direct action of the central nervous system on thymus (Bullock & Moore 1980) or spleen (Williams et al. 1981) may modulate the immune system and corticosteroids which are elevated by stress may also be important. Dorian et al. (1981) have shown that lymphocyte response to mitogens is impaired when under stress. Strenuous exercise in mice has been shown to increase susceptibility to Coxsackie B3 infection (Reyes & Lerner 1976) and Douglas & Hanson (1978) have reported an increased incidence of upper respiratory tract infection in training athletes. Thomasi et al. (1982) examined secretory IgA levels in Nordic cross-country skiers before and after national cross-country races. They found a significant fall in mucus IgA, one of the main defences of the upper respiratory tract to infection. Thus, either exercise itself, or the emotional stress attached to athletic competition may render the athlete more susceptible to various infectious diseases of the respiratory tract, although this is by no means proven (Simon 1984).

4. Physical Exercise and Viral Infections

If upper respiratory tract infections are subclinical, do they matter? Sudden death occurs in young people associated with vigorous exercise. In a survey of 78 sudden deaths during, or immediately after, exercise, Jokl and McLellan (1971) found a history of recent upper respiratory tract infection in 5 out of 78, cardiovascular problems accounting for most of the remainder. It is difficult to prove that intercurrent viral illness increases the risk of death during exercise, but there are numerous anecdotal reports of death in young healthy people who undertake vigorous exercise during an acute viral illness. The predilection of Coxsackie virus for the heart muscle to produce myocarditis or pericarditis (Smith 1966) could explain, by increasing the risk of acute arrhythmias, sudden death in young fit people. Burch (1979) advised that young people who stress themselves with vigorous, prolonged physical exercise during upper respiratory tract infections have an increased risk of developing viral cardiomyopathy, causing irreversible

damage to the heart muscle. This illness may have a fatal outcome. Burch (1979) stated that strenuous physical exercise should be avoided for 2 weeks after the infection has resolved.

Sutton et al. (1967) described a case of a previously fit 42-year-old patient who undertook a vigorous swimming session while recovering from an upper respiratory tract infection. He subsequently died of heart failure. At postmortem examination, Coxsackie B4 virus was isolated from the myocardium. Pether (1982) described 2 patients who exercised while convalescing from influenza B upper respiratory tract infections. Both contracted bacterial meningitis and one died. Pether suggested that heavy exercise might have been a contributory factor to the increased susceptibility to infection and advised against strenuous exercise for 1 week after a flu-like illness. Jodselson et al. (1980) described a 26-year-old runner who developed acute rhabdomyolysis (acute muscle destruction) following a training run. He required emergency treatment to prevent renal failure developing. He had no symptoms suggestive of recent viral illness, but investigation revealed evidence of acute echovirus 9 infection.

In people with overt asthma, or who have an asthmatic tendency, it is well-recognised that upper respiratory tract viral infections may worsen asthmatic symptoms (Empey et al. 1976). Exercise induces an asthmatic attack in 70% of susceptible individuals (McNeill et al. 1966) which, in turn, may lead to an influx of inflammatory cells, termed the 'late response' (Durham & Kay 1985), thereby increasing the asthmatic state. The late, or inflammatory, response may be prevented by appropriate treatment so it is important to ensure athletes with asthmatic tendencies are carefully monitored during upper respiratory tract infections, avoid strenuous exercise and have optimum anti-asthma treatment.

5. Athlete's Performance

Why should viral illness affect an athlete's performance? Despite the occurrence of either local upper respiratory symptoms or even none at all,

the virus may be disseminated via the blood stream to many organs. Furthermore, I have already described evidence that infections may run a protracted course. One way in which viruses could affect performance is by a direct effect on skeletal muscle. Friman (1977) tested a group of subjects who had recent viral infections. He assessed isometric strength in the recently infected subjects and in a matched control group. There was a significant reduction (up to 15%) in isometric strength in the infected subjects which had not fully recovered to reference values one month after illness. Astrom et al. (1976), in a controlled test, examined muscle tissue obtained from patients recovering from recent viral or mycoplasma illnesses. They found significantly reduced muscle enzyme activity (glyceraldehyde phosphate, lactate dehydrogenase, cytochrome oxidase and citrate synthetase) in infected patients. Furthermore, electron microscopy showed focal abnormalities in muscle ultrastructure. These changes had almost completely resolved when muscle biopsy was repeated 3 months after illness. The muscle enzyme changes described were similar to those found in certain muscle diseases with muscle weakness as a main symptom. Electron microscopic appearances were nonspecific, as occurs in most muscle diseases. Excess glycogen stored in abnormal muscle would suggest that muscle energy utilisation had been altered.

A recent case report (Arnold et al. 1984) described a patient with postviral (herpes zoster) fatigue syndrome. Using nuclear magnetic resonance they demonstrated early excessive intracellular acidosis during muscular exercise. They suggested that the defect might involve the interaction between glycolytic and oxidative metabolism within the muscle cell. In contrast, a study by Friman et al. (1985) using inoculated virus (sandfly fever virus) to produce pyrexia found that isometric strength was reduced during the pyrexial phase but recovered when the body temperature returned to normal. However, this is an unusual viral infection and may not be representative of viral illnesses in man.

There is a well-known phenomenon in horse-racing circles called 'the poor performance syn-

drome' (Mumford & Rossdale 1980). It is associated with upper respiratory tract infections in horses. A prospective study of British horse racing stables was organised by the Horse Betting Levy board with 600 horses being sampled annually for 8 years. They found evidence of frequent subclinical infections, some of which were associated with the 'poor performance syndrome' (Powell et al. 1978). There are obvious parallels with athletes in training and horse-racing training, although definite conclusions cannot be drawn.

6. Resumption of Training

When should an athlete resume activity? The best studied of viral infections affecting sportsmen is infectious mononucleosis. The main complication of this infection is splenic rupture which may be spontaneous and occurs in the first 21 days of the illness (Hoagland 1967) or later (Rutkow 1978). Most physicians therefore arbitrarily recommend that strenuous activity be avoided for 1 month after onset of illness (Shields 1983; Yan et al. 1978), although Rutkow (1978) recommends a 6 month rest after resolution of the illness before full athletic activity is resumed. An alternative approach is to monitor the size of the spleen by x-ray of the abdomen (Riemenschneider & Whelan 1965) or ultrasonography (Kardel et al. 1971) and to delay the return to activity until the spleen has returned to normal size.

With other viral infections there are no hard and fast rules. The article by Friman (1977) demonstrated that muscle abnormalities had not fully resolved 1 month after the onset of symptoms due to a variety of viral infections. I suggest that if the athlete has symptoms of a common cold with no constitutional upset then training may be safely resumed a few days after the resolution of symptoms. However, if there are symptoms or signs of systemic involvement, e.g. extreme tiredness, muscle aches or swollen lymph glands, then a full month should be allowed before resumption of full training.

7. Conclusions

Viral infections are common. They can be asymptomatic or debilitating. Viruses enter the cell and take over cellular mechanisms to reproduce. As a result, they are not affected by conventional antibiotics. There are various humoral and cell-mediated mechanisms which aid recovery from viral infections. Various viruses produce well-recognised acute effects but may also be followed by more subtle changes. There are risks of serious complications including death, if strenuous exercise is undertaken during an acute viral infection. Viral infections may present with loss of performance as the only symptom. There are many possible explanations of this loss of form, but there is evidence from several approaches that skeletal muscle function may be altered.

Exercise per se may alter the immune response such that the individual is more susceptible to viral infection. Some surveys have confirmed that athletes in training have an increased incidence of upper respiratory tract infections.

Athletes should not undertake strenuous training routines when they have any symptoms of infection. Furthermore, it is worth arranging a medical check-up to exclude a viral cause if an athlete develops unexplained loss of form.

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