Symposium: Nutrition and Physical Performance: A Century of Progress and Tribute to the Modern Olympic Movement

Sports Medicine: A Century of Progress[1]

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ABSTRACT According to the International Olympic Committee, it is the responsibility of the sports medicine profession to care for the health and welfare of Olympic athletes, treat and prevent injuries, conduct medical examinations, evaluate performance capacity, provide nutritional advice, prescribe and supervise training programs, and to monitor substance use. Implicit in these functions is to assist Olympic athletes in achieving the objectives of the Olympic Motto (*Citius, Altius, Fortius*), which is to become faster, higher, and stronger. During the past Olympiads, athletic performance has increased, as indicated by times for the men's marathon (−28%) or by the distance covered in the women's javelin throw (+80%). However, the fulfillment of these responsibilities was a slow and protracted process, as demonstrated by the facts that medical examinations were not required until 1920, that 28 years elapsed before an official team physician was appointed, and that women had to wait until 1984 before sanction was given to compete in the marathon race. Doping was not defined until 1964, and monitoring of substance abuse did not materialize until after 1972. Although individuals have prepared for athletic competition since the ancient Olympics, the scientific foundations for various training prescriptions were not firmly established until the 1960s and 1970s. It was speculated that performance records will continue to improve in the next century because more scientific sports medicine information would be available and because such information would be better disseminated to athletes. J. Nutr. 127: 878S–885S, 1997

KEY WORDS: • *doping* • *performance* • *training principles* • *women and competition*

In 1996, the United States will proudly acknowledge its heritage of 100 years of participation in the Olympic Games. However, we should not forget the foundations, traditions and achievements of more than a thousand years of athletic competition that existed until 393 A.D., when the Olympic Games were banned by Theodosius I because of their pagan nature (Finley and Pleket 1976). Olympic competition remained dormant for more than 1500 years before Baron Pierre de Coubertin and the International Olympic Committee (IOC) (which was established in 1894) convinced Greece and 12 other countries to resume what has since been labeled as the "modern" Olympic Games (Holmes 1984, USOC 1993, Vialar 1962, Wels 1995).

The athletic traditions of ancient Greece and the spirit of the modern Olympic Games have been symbolized in the Olympic creed, flame, motto, oath, rings and torch and in Olympic literature (USOC 1993). However, the nationalistic and political impact of Olympic competition is best found in the Latin Olympic motto of *Citius, Altius, Fortius*, which means "Swifter, Higher, Stronger" (USOC 1993). In essence, the nationalistic driving force for Olympic competition has been athletic performance, and because of this relationship, sports medicine has become an integral component of the Olympic movement.

In the last 96 years, Olympic performance records have changed significantly, and selected results from male and female competitors dramatize this fact (**Fig. 1, Table 1**). Factors associated with these changes include increased number of participants (**Table 2**), improvements in coaching, advances in nutrition, perfection of athletic facilities, refinement of athletic equipment and contributions from sports medicine. Sports medicine, according to the IOC, "is as old as medicine itself" and has the responsibility for the care of athletes, the treatment and prevention of athletic injuries, supervision of medical examinations and diagnostic services that include testing of drug use, evaluation of athletic performance, nutritional advice, and the prescription of training programs that will enhance athletic performance (Hollmann 1988). The only area not included within these medical responsibilities that would affect athletic performance is the design, testing and evaluation of equipment and facilities (Kearney 1996, Wels 1995).

SPORTS MEDICINE BEFORE ESTABLISHMENT OF THE UNITED STATES OLYMPIC COMMITTEE

In the United States, the United States Olympic Committee (USOC) is the only organization authorized by the IOC to sponsor, supervise and underwrite an Olympic team (Ryan 1989). Before 1978, the Amateur Athletic Union (AAU) had the responsibility for the selection and supervision of the Olympic team (Ryan 1989). Since that date, the USOC has

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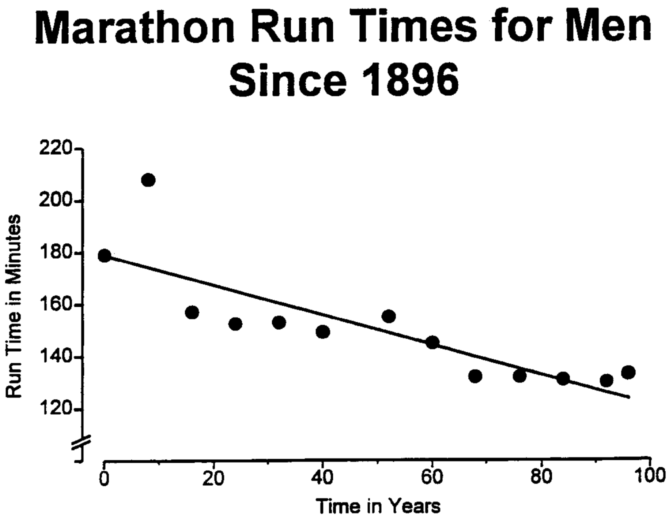

FIGURE 1 Select performance times of the men's Olympic marathon race. Line represents the results from a linear regression calculation of all times since 1896. $R^2 = 0.778$.

TABLE 2

The participation of women in Olympic events[1]

Year	Number of women	Percentage
1896	0	0.0
1904	6	0.9
1912	57	2.2
1920	77	2.9
1928	290	9.6
1936	328	8.1
1948	385	9.4
1956	384	11.5
1964	683	13.3
1972	781	14.1
1980	1247	20.1
1988	2186	23.2
1992	2708	25.6

[1] Data calculated by author from information provided in 1996 by USOC Library (Colorado Springs, Co).

been organized into several divisions that include sports medicine, drug control and Olympic training centers. To fulfill their 1996 Olympic obligations to several thousand participants, information received from the USOC indicates they will send to Atlanta, Georgia, a sports medicine team that includes at least 11 physicians, one chiropractor and 33 certified athletic trainers. Moreover, they will have access to the services, facilities and staff of a major hospital in Atlanta throughout the games. Unfortunately, the sports medicine coverage of the athletes representing the United States has not always been this extensive.

In 1896, the United States Olympic team consisted of 14 men (two were American Embassy employees in Greece; one was a tourist), and 11 participated in track and field events (Giller 1980, Wels 1995). The American delegation had no team physician. In fact, the first year that the United States Olympic team had assigned physicians was 1924 (Ryan 1974). Physicians assigned have been volunteers, and this relationship has continued today, with the majority having previous experience and training as team physicians (Stone 1992). In addition, the appointment process of physicians is competitive, selective and possibly "political" (Stone 1992). Before 1924, medical care and supervision was provided by the trainer, who accompanied the athlete, or by physicians or nurses who attended the games as spectators. At the 1924 Games, the sports medicine staff included two physicians and a nurse, plus an athletic trainer (Ryan 1974).

Unlike other disciplines, sports medicine has not been approved by the American Board of Medical Specialties of the American Medical Association (AMA) to be a medical specialty with a detailed curriculum and well-defined specialty training (Ryan 1989). Although an extensive body of knowledge has evolved in sports medicine (American College of Sports Medicine 1994), this literature overlaps other disciplines in medicine and the biological sciences (Ryan 1989). Moreover, it was not until the 1970s that postgraduate courses in sports medicine were available in the United States to physicians (Ryan 1989). In essence, the sports medicine expertise of the United States Team Physicians before several decades ago was obtained more from their professional experi-

TABLE 1

Select Olympic performance records and their changes since 1896 or later[1]

Event	Unit	Sex	First year scheduled	First record	Percent change
100-m race	Seconds	Males	1896	12.00	−17.3
100-m race	Seconds	Females	1928	12.20	−13.6
800-m race	Minutes and seconds	Males	1896	2:11.0	−20.6
800-m race	Minutes and seconds	Females	1928	2:16.8	−14.6
Marathon race	Hours and minutes	Females	1984	2:24.52	+0.6
Discus throw	Meters	Males	1896	29.15	+136.0
Discus throw	Meters	Females	1928	39.62	+82.5
Javelin throw	Meters	Males	1908	54.82	+63.5
Javelin throw	Meters	Females	1932	43.68	+80.0
400-m freestyle swim	Minutes and seconds	Males	1896	8:12.6	−55.4
400-m freestyle swim	Minutes and seconds	Females	1920	4:34.0	−9.8
800m freestyle swim	Minutes and seconds	Females	1968	9:24.0	−10.5
1500-m freestyle swim	Minutes and seconds	Males	1896	18:22.2	−19.8
60.0-kg weight lifting class	Kilograms	Males	1920	245.0	+71.6
82.5-kg weight lifting class	Kilograms	Males	1920	290.0	+75.0

[1] Initial result compared with best record since that date. Table prepared by author from data obtained from U.S. Olympic Committee (USOC) records published in USOC (1993).

ences with athletic teams than from didactic instruction and specialized clinical training. Although athletic trainers were organized as a specialty in 1938, they disbanded during the Second World War and were re-established as the National Athletic Trainers Association (NATA) in 1950 (Berryman 1995). However, their curriculum and specialized clinical training program were not approved by the AMA until 1969 (Ryan 1989). Therefore, the sports medicine expertise of the athletic trainer before the 1970s was also dependent upon professional experience rather than clinical instruction.

During the early years of Olympic competition and until the beginning of World War II, it was Germany that provided the leadership in sports medicine (Berryman 1995). Germans were the first to use the term "sports physicians" in 1904, and a sports physician Congress was held in Germany in 1912. A German association for sport physicians was formed in 1924, and in 1933 the German professor and physician Herxheimer published his influential text entitled *Grundriss der Sportsmedizin für Arzte und Studierende*, later translated in 1936 and re-titled *The Principles of Medicine in Sports for Physicians and Students* (Herxheimer 1933). Thus, it was German leadership that stimulated the meeting in 1927 that attracted 33 physicians from 11 countries to discuss issues associated with the clinical care of Olympic participants and the research needed in the area of athletic performance. Their discussions led to the formation of an international sports medicine organization to promote clinical and scientific research, interactions with sport federations, and congresses at Olympic sites (Ryan 1974). Subsequently, this organization became the Federation International Medico-Sportive (FIMS) (Ryan 1974). By 1936, FIMS attracted 1500 physicians representing 40 countries to their congress in Berlin. Because FIMS has representatives from sports medicine organizations throughout the world as well as from the Medical Commission of the IOC, it has become an important voice for sports medicine interests. Unfortunately, very few American physicians or Olympic representatives were active in FIMS during its formative years.

The American College of Sports Medicine (ACSM) was established in 1954 with 11 members, with the objective of representing and linking the interests and expertise of medicine, physiology and physical education into a single organization (Berryman 1995). Although the ACSM publishes a professional journal (established 1969), takes positions on scientific and clinical issues (first one published in 1976), sponsors annual conventions attracting several thousand participants, provides workshops, schedules professional courses, certifies qualified team physicians, and has a current membership of approximately 16,000, the scientific and clinical impact of ACSM on Olympic administration, athletes, policies, practices or research was minimal until the last three decades. Since the American Orthopedic Society for Sports Medicine was established for physicians in 1975, sports medicine contributions from the United States to the modern Olympics have been primarily made by individual efforts of athletic trainers, basic scientists, biomechanists, clinicians, engineers and physical educators rather than by the directed activities of formal sports medicine associations.

SPORTS MEDICINE CONTRIBUTIONS

Care of athletes and the treatment and prevention of injuries. Since ancient times Olympic athletes have had the services of trainers (*paidotribes*), and in many circumstances athlete relationships with physicians interested in sports (*gymnastes*), for example Galen, lacked mutual respect (Sarton 1954). Fortunately, this situation did not exist when the Olympic games were resumed centuries later.

As noted earlier, the United States had no official team physician until 1924; thus the medical care and treatment of the athlete was left to the trainer, spectator physician or nurse, or to chance. Because experience and availability were important pre-requisites for an appointment as a team physician, the care of the athlete and treatment of injuries by USOC-appointed specialists in cardiology, emergency medicine, family practice, obstetrics and gynecology, orthopedic surgery, and surgery are of recent vintage (Stone 1992). The same conclusion apples to the Certified Athletic Trainer; hence the United States Olympic athlete in 1996 will have the services of an experienced and better prepared medical staff than was possible 100 years ago.

Although a complete medical examination is considered routine before participation in athletic competition, and especially before strenuous events, this has not always been the situation (Allman 1989). For example, because of the heat and humidity encountered at the 1904 and 1908 Olympic Games, the marathon had a high "drop-out" rate (~45%). When a death occurred in the marathon at the 1912 Games, medical examinations became required for these long distance runners in 1920 (Ryan 1974). Subsequently, medical examinations became required for all contestants. However, medical examinations assumed a new meaning after 1946 when two "women" medal winners were discovered to be men. Visual examination for sex determination had an unpopular and short period before genotyping of sexual differences by buccal mucosa smear was initiated in 1968 (Ryan 1974). This procedure is no longer used, but genotyping continues based upon hair sample analysis (Ryan, personal communication).

In the past several decades, the most universal method to prevent pre-season and post-season athletic injuries is strength and power training. Although these programs are emphasized to increase muscle mass and to enhance performance, they can help reduce the magnitude of an injury and its duration (Kraemer and Baechle 1989). Requiring boxers and cyclists to wear helmets and having clinics for coaches on how to reduce athlete injuries are two additional examples of the progress made through the years.

The most dramatic changes in the care, treatment and prevention of athletic injuries during the past 100 years, however, have been in methods used for examination and diagnostic purposes. Although auscultation, inspection, mensuration, palpitation, percussion and succussion (Flint 1866) are diagnostic techniques still practiced today in determining the physical status of an athlete, the use of technological procedures associated with arthroscopy, arthrography, computed tomography (CT), magnetic resonance imaging (MRI), radiography, radionuclide scintigraphy and ultrasonography have provided a dimension and direction for the care of athletes that was inconceivable a century ago (Irrgang et al. 1996). Not only have the developments in technology facilitated the correctness of diagnosis, they have improved the surgical treatment of the injury and markedly reduced the duration and scope of the recovery period. A case in point is the use of the arthroscope for diagnosis as well as for select surgical treatments for injuries to the ankle, elbow, knee and shoulder (Irrgang et al. 1996). Even though endoscopes were used in the 1920s to examine the human knee, and arthroscopic techniques were introduced in 1959, their acceptance for widespread use with athletic injuries did not materialize until the 1970s (Stanish et al. 1989). Because the clinical use of CT and MRI scans did not exist three decades ago, one may conclude that the progress in diagnosis has been a recent development. Furthermore, changes in technology have enhanced the use of muscle testing for diagnostic as well as for therapeutic and training purposes (Heyward 1988).

In the ancient Olympic Games, sprained ankles were treated by bleeding and application of dressing that contained ointments (Ryan 1974). Fortunately, this approach was abolished before the first modern Olympic Games. Because the treatment of athletic injuries is a complex subject—with a scope beyond the purpose of this symposium—I will mention only a few examples of changes.

A century ago, the application of heat and cold to acute athletic injuries was extensively practiced. However, the use of heat is no longer advocated for such purposes, and cryotherapy has become the modality for use in the initial treatment and for rehabilitation of musculo-skeletal injuries (Loane 1988). For many decades, injured and repaired tissues were immobilized for extended periods of time before it was recognized that immobilized joints and limbs resulted in deleterious anatomical and physiological changes to bone, ligament, muscle and tendon. Consequently, the frequency and duration of immobilization for athletic injuries and their surgical repair have been dramatically reduced in recent decades (Tipton and Vailas 1990).

Prolonged inactivity is no longer prescribed for athletes recovering from severe trauma or surgical interventions, and passive motion is advocated to assist the healing process (Tipton and Vailas 1990). On the other hand, the medical awareness that overtraining can lead to injuries, decreased performance scores, "staleness," undesirable psychological changes, and longer recovery periods is a relatively recent development in sports medicine (Morgan and O'Connor 1989, Wenger et al. 1996).

While it is evident that the care, treatment and management of athletic injuries have vastly improved during the past 100 years, development in recent years has created a different type of problem for the "modern" Olympic physician than existed 100 years ago. Specifically, athletes who intend to "use" their Olympic performances to become recognized professionals are inclined to minimize the seriousness of an injury and to ignore medical advise concerning their "fitness" for competition (Ryan, personal communication).

Nutritional consultation and advice. Although this topic is discussed in greater detail by other symposium speakers, it is noteworthy that in 1900 few American scientists had conducted detailed dietary analyses of athletic or working populations, and none had studied Olympic competitors. Before the turn of the century, the Department of Agriculture commissioned Atwater and Bryant to obtain nutritional data from men performing "severe muscular work." They selected seven members of the crew teams from Harvard and Yale Universities to carefully study their dietary practices. Data that they published revealed that the athletes consumed a diet that consisted of 15.6% protein, 40.7% fat and 44.2% carbohydrates, with an energy intake of 4085 kcal (Atwater and Bryant 1900). Although Olympic performers were studied at the 1928 games, no dietary investigations were performed. In 1952, Olympic athletes were evaluated on their dietary requirements, and the collective result was a daily consumption of 4500 kcal, with 20% from protein, 40% from fat and 40% from carbohydrate (Jokl 1964). Dietary characteristics of female and male Olympians (endurance competitors) of recent years have revealed patterns of 14.8% protein, 32.8% fat and 50.5% carbohydrates (Grandjean and Ruud 1994). Other researchers studied the dietary habits of 419 elite athletes (including Olympians) and reported average fat consumption lower than 35% of energy; ingested carbohydrate intakes ranged from 40 to 63%, whereas recommended values were between 60 and 70% (van Erp-Baart et al. 1989).

In essence, these fragmentary data suggest that the last 100 years have seen a reduction in dietary fat, coupled with a modest increase in carbohydrate consumption. Moreover, it appears that the dietary knowledge concerning benefits of carbohydrate consumption for endurance performance has not been effectively utilized by Olympic athletes. It is interesting to note that the McDonald Corporation, one official food-server at the 1996 Olympic Games in Atlanta, established an upper limit for athlete food consumption of 10,000 kcal/d (McDonald Corporation, personal communication). Because this value markedly exceeds the daily dietary requirements for the Tour de France, it is unclear what specific Olympic performers the McDonald Corporation used as the reference population.

Principles of training and assessment of performance. Olympic performances have markedly improved since 1986 (Fig. 1, Table 1), and one plausible explanation is the change in training methods. Principles advocated by trainers and followed by athletes during the early years were a composite of Galen's concepts, personal observations, experiences of the trainers and various word-of-mouth theories (Park 1992). In 1885, after the New York Athletic Club defeated the London Athletic Club in 12 events, the British press credited the stunning defeat to the weather, availability of a training table, and to paid coaches (Park 1992). It is interesting that very little was mentioned about differences in training methods, because the fundamental principles had yet to be verified or confirmed by experimental investigation. In addition, the majority of textbooks available to coaches or athletes contained information that lacked scientific credibility (Park 1992).

Examination of selected training manuals, exercise physiology reviews or textbooks published before 1950 (Dawson 1935, Maclaren 1866, Reidman 1945, Schneider 1933, Schneider and Karpovich 1948, Steinhaus 1933) reveals that scientific investigations on the validity of training methods are surprisingly absent. Maclaren (1866) used crew training as representative for all sports and advised two repetitions at "a speed increasing with the strength of the crew" in a 3-h practice session. Reidman (1945) mentioned that training used the principles of continuous use, intensity of use, drive, persistence, and alternation of rest and exertion. Unfortunately, she provided no quantitative examples or evidence that substantiated her statements.

A time-honored method for prescribing a training program is to have the athlete perform repeat activities, and/or compete against others in an event. Although there is intrinsic value in such an approach, it is incomplete in assessing and maximizing the potential of a performer, prescribing an individualized training program, or evaluating athletic progress. To the sports medicine specialist, performance-related tests are needed for these purposes, and two examples are tests that measure aerobic capacity ($\dot{V}O_2$ max) and maximal muscle power.

Although oxygen consumption under maximal conditions was measured and the method perfected before World War II (Hill and Lupton 1923, Robinson 1938), it was not until Cureton and associates pioneered the use of physical fitness and $\dot{V}O_2$ max testing (Cureton 1951) that these measures were used to evaluate and prescribe training programs for Olympic athletes. In the 1970s and thereafter, these activities and approaches were assumed by the governing bodies of the various Olympic sports, and much testing and evaluation were conducted at the USOC Olympic Headquarters in Colorado Springs, Colorado (Kearney 1996).

Because the training prescription is dependent upon a maxi-

TABLE 3

The application of training principles for a 10-km race[1]

	Day and emphasis of training						
	1 (Aerobic adaptations)	2 (Aerobic and anaerobic adaptations)	3 (Aerobic adaptations)	4 (Rest)	5 (Aerobic adaptations)	6 (Aerobic and anaerobic adaptations)	7 (Rest)
Total distance covered (*km*)	12.8	6.4	10.0	NA	10.0	6.0	NA
10-km intensity reference time (*min and s*)	40.0	40.0	40.0	NA	40.0	40.0	NA
Repetitions	0	8.0	NA	NA	NA	4.0	NA
Interval distance (*m*)	0	80.0	NA	NA	NA	1500	NA
Rest between intervals (*s*)	0	60–120	NA	NA	NA	60–120	NA
Interval pace (*min and s*)	0	3.20	NA	NA	NA	6.00	NA

[1] Table modified from information presented by Costill (1986) for wk 7 of training program designed for an individual to compete in a 10-km race. NA = not appropriate.

mal response, the development, verification and perfection of training principles followed standardization of the VO_2 max testing procedures (Taylor et al. 1955). The concept of training specificity was formulated by Henry in 1954 (Scheuer and Tipton 1977), whereas aspects related to intensity, duration, frequency and rest were extensively investigated and defined during subsequent decades (Fox 1979).

Despite the legendary feats of strength by the ancient Greek wrestler Milo and his reported daily training routine of lifting a calf that subsequently developed into a bull (Finley and Pleket 1976, Karpovich 1959), the concept of overload as a means to increase strength and power is attributed to Roux in 1895 (Karvinen and Komi 1974). However, this concept was not officially defined and scientifically investigated until the 1950s (Hellenbrandt and Houtz 1956). This fact, coupled with publication of the principles for progressive resistive training for muscles, i.e., load, repetition, sets (Delorme and Watkins 1948), means that the essential training principles currently being advocated for improving either aerobic capacity or muscle power are of recent vintage.

It was not until 1979 that sport physiology was applied to sports training, and training principles were incorporated into various methods currently used by both recreational and elite athletes. Specifically, acceleration sprints, circuit training, continuous fast running, continuous slow running, Farlek training, interval training, jogging and repetition running (Fox 1979). **Table 3** provides an example of a prescription for aerobic training for a runner training for a 10-km race (Costill 1986).

In recent years, another time-practiced method used by athletes has been verified and quantified as a training principle for select swimmers, namely, tapering. Swimming performance before a competitive meet can be maintained or increased by reducing the amount of work performed while increasing the power output over a 7- to 21-d tapering period (Costill et al. 1985, Houmard and Johns 1994).

It has been suggested that Loues, winner of the 1896 marathon at the Athens Olympic Games, followed the principle of interval training although unaware of the concept (Messinesi 1973). During the past 100 years, Olympic athletes and their coaches have used training methods that "worked" for them or for other performers without knowing whether they had any scientific justification. In many situations, their innate ability, experience, intuition and judgment were more than adequate for their specific event. On the other hand, the scientific knowledge and understanding gained during the past several decades on training principles, the assessment of athletic potential, and the evaluation of performance should enable athletes to establish new records in the next century.

Participation of women in "strenuous" Olympic events. In ancient Greece, women were forbidden to attend or to participate in athletic events at Olympia, even though they were allowed to drive chariots in the opening day races (Finley and Pleket 1976). However, women at Sparta did compete at the same games as men, and they were permitted to run a 160-m race in "special" games to honor the goddess Hera, the consort of Zeus (Finley and Pleket 1976, Swaddling 1980).

When the Olympic Games were resumed in 1896, women were not included because of a variety of factors that included the practices of ancient Greece, unpopularity of women's sports, and the influence of Baron Pierre de Coubertin in convincing the organizing countries of his beliefs that athletics made women appear indecent, improper and ugly, while risking their "delicate" constitutions and nerves to injury (Borish 1996, Lekarska 1973). These beliefs and practices did not prevent the woman runner Melpomene from requesting permission to participate in the 1896 Olympic marathon. When her request was denied, she ran and completed the event some 4.5 h later. The Greek press vigorously chastised the IOC for not allowing Melpomene to compete, but the objections had no impact on the committee (Messinesi 1973).

Women were allowed to participate in the 1900 Olympics, but only in tennis. Four years later, they were permitted to compete in archery, and in 1912, only after much debate, the IOC scheduled a 100-m swim for females (Messinesi 1973, Wels 1995). After World War I, participation of women in the Olympics was pursued with much vigor by various interest groups, and a limited track and swimming competition was scheduled for women at the Olympics of 1920 and 1924 (Wels 1995). The issue of women participation in the Olympics was referred to an Olympic Medical Subcommission in 1925 that concluded the "special functions" and "special organizations" of women required events that were different from those for men (Borish 1996). Because the pressure for more female participation intensified, the IOC scheduled, on a trial basis, competition for women in six events: discus throw, high jump, 100-m race, 400-m relay, 800-m race and gymnastics (Messinesi 1973, Wels 1995). The 800-m race, however, was a disaster for advocates of distance running for women because several of the slower and poorly conditioned contestants collapsed at the finish line. This ending to the 800-m race reinforced the beliefs of the IOC members that running events that lasted longer than 2 min were too strenuous for women. It was not until 32 years later that women were allowed to participate in an Olympic 800-m run, and it was in 1972, 44 years after the famous "collapse," that women were scheduled to compete in a 1500-m race that required slightly more than 4 min of maximum effort to finish (Wels 1995). These changes occurred because of several factors; namely, World War II had demonstrated that women had the ability to perform many muscular tasks performed by men, and that Russian and East German women were successful in post-war Olympics. Other factors were social and political forces responsible for implementation of Title IX of the Educational Assistance Act of 1972 in the United States, and the fact that sports medicine research demonstrated that women had the physiological capacity to perform athletic events that previously had been considered suitable only for men.

Despite this progress in scheduling longer-distance running events in the Olympics, the IOC and its medical advisors continued to ignore the 1896 marathon result of Melpomene, the 1920 accomplishments of women who ran a 54-mile marathon in South Africa (Comrades Marathon), and the 83 women who completed the Boston Marathon (unofficially) between 1966 and 1976 (Kusick 1977). However, when it became apparent to medical and nonmedical authorities that women were anatomically, biochemically and physiologically able to successfully complete long-distance running events without peril or injury, the IOC scheduled a 3000-m and marathon race for women at the 1984 Olympic Games in Los Angeles (Wels 1995).

Although sports medicine officials can "claim" credit for allowing women to participate in strenuous Olympic running events 88 years after granting the same privilege to men, it was an achievement that occurred more by default than by design. Moreover, as documented in Table 2, only recently have representatives from IOC and sports medicine been vigorous in promoting participation of women in Olympic competition (Borish 1995).

Regulation and monitoring of ergogenic aids. An intrinsic component of both ancient and modern Olympic Games is to provide fair and equal opportunities for all participants, and since the modern revival it has been the responsibility of the IOC to safeguard this legacy. The IOC is also obligated to protect the health of all participants and to defend the ethics of medical practices at the games. Further, it is the duty of the Medical Commission of the IOC to provide the leadership, regulation and supervision necessary to fulfill these responsibilities (DeMerode 1988).

An ergogenic or performance aid is defined as any substance or method used to enhance athletic performance. Because the substance could be hormonal (epinephrine), medicative (antibiotic), nutritional (glucose), pharmaceutical (amphetamine) or therapeutic (aspirin), and because the method could be as diverse as either training or infusion of red blood cells, it is essential that the IOC have rigorous definitions and strict guidelines regarding what constitutes legal or illegal ergogenic aids. Unfortunately, such definitions and guidelines have not always been available, monitored or upheld by the IOC during the past 100 years.

As early as the 3rd century B.C., Greek athletes drank wine or brandy or ingested mushrooms before competition because they believed that these products enhanced their performance (Voy 1988). Moreover, Roman gladiators used alkaloids such as strychnine to improve their chances for survival in the arena (Voy 1991). A wide range of ergogenic substances has been documented since 1865, including alcohol, amphetamines, anabolic steroids, caffeine, cocaine, ethyl ether, erythropoietin, growth hormone, heroine, nitroglycerin and strychnine (Voy 1988, Williams 1989). During the 1900 Olympic Games in St. Louis, Missouri, the marathon winner received brandy and several strychnine tablets during the race, administered by physicians who followed him throughout (Giller 1980).

Although it generally has been known throughout the athletic community that certain athletes who died during endurance events used amphetamines to enhance their performance, it took the death of a cyclist from an overdose of amphetamines at the 1960 Olympics in Rome for the IOC to take action, and the IOC finally define doping[2] in 1964: "The administration of or use by a competing athlete of any substance foreign to the body or of any physiological substance taken in abnormal quantity or taken by an abnormal route of entry into the body with the sole intention of increasing in an artificial and unfair manner his/her performance in competition" (Voy 1988).

Consequently, the IOC began drug testing at the Olympic Games in Mexico City in 1968. Unfortunately, the process was not very effective, and athletes were able to avoid detection (Williams 1989). By the 1984 Olympics in Los Angeles, the methodology had been vastly improved, and detection will be even better at the 1996 Games in Atlanta (USOC Drug Education and Doping Program, personal communication). Although the original IOC statements concerning doping have been modified twice since 1964, the definition and intent remain the same (Voy 1991, Williams 1989).

In addition to amphetamine use, it generally was known in the late 1950s and middle 1960s that some athletes used anabolic steroids as ergogenic aids before Olympic and non-Olympic competitions. However, it was not until 1975 that their use was banned by the IOC (Voy 1991). Related stories may be detailed about use of blood doping, erythropoietin or growth hormone. In essence, sports medicine recommendations and actions taken since 1896 have been notoriously slow and cautious in addressing and monitoring use of substances or methods that transgress the spirit of the modern Olympics and violate the ethics of medical practice and athletic competition.

Summarized in **Table 4** are the 1996 listings by the USOC Drug Education and Doping Program of the prohibited classes of substances, prohibited methods and drug classes that contain specified restrictions. This 14-page document can be obtained by writing the United States Olympic Committee, Colorado Springs, CO (telephone 1-800-233-0393).

EQUIPMENT AND FACILITY MODIFICATIONS

Although it is tempting to credit sports medicine as being responsible for the increases in performance that have occurred since 1896 (Fig. 1, Table 1), such a conclusion ignores the impressive advances that have been made in recent decades in the design and construction of clothing (jumping shoes, running shoes, swim suits), event equipment (improvements in bicycles, skis, tennis rackets and vaulting poles) and protective equipment (helmets), as well as improvement in facilities (track surfaces) and the advances made by biomechanists and engineers (Kearney 1996, Komi and Knuttgen 1996, Wels 1995). Such a conclusion also would ignore the use of computers and software programs, as well as video equipment, that record and analyze performance data so that coaches and sport

[2] The term doping was adopted after the South Africa Kaffirs term, *dop,* applied to a liquor used for many centuries in religious ceremonies. *Dop* subsequently was incorporated into Afrikaans to define brandy, and the term was later extended and redefined in English as a narcotic mixture of opium administered to racehorses (Voy 1989 and 1991, Williams 1989).

TABLE 4

Select USOC listing of substances and methods that are prohibited for Olympic competition[1]

Category	Class	Select examples
Prohibited subtances	Stimulants	Amphetamine, caffeine, cocaine, ephedrine, isoproterenol, strychnine
	Narcotics	Morphine, opium
	Anabolic agents	Metandienone (Dianabol), testosterone
	Diuretics	Amiloride, mannitol, spironolactone
	Peptides, Glycoprotein hormones and analogs	Chorionic gonadotrophin, growth hormone, erythropoietin
Drugs subjected to certain restrictions	Alcohol	
	Marijuana	
	Local anesthetics	Lidocaine
	Corticosteroids	Cortisone, prednisone
	Beta blockers	
	Select beta-2 agonist	Salbutamol, terbutaline
Doping methods	Blood doping	Administration of blood, red blood cells, blood products

[1] Table prepared by author from 1996 information received from USOC Drug Education and Doping Control Program (Colorado Springs, CO).

scientists can advise athletes how to correct biomechanical "errors" and improve performances.

CONCLUSION

Throughout my presentation I have emphasized that individual and group athletic performance in a competitive environment has been a primary reason for the acceptance, promotion and continuance of the Olympic Games since 1896. While this concept requires acceptance of ancient Greek traditions, the embodiment and preservation of the Olympic creed, flag, flame, oath and spirit, it recognizes the "driving force" of the Olympic motto, which is to perform faster, higher and stronger.

Atlanta, Georgia, will be the site of the XXIV Olympiad of the modern era and will likely witness the establishment of new Olympic and world performance records, a characteristic of previous games. These improvements in athletic performance can be explained, in part by the contributions from sports medicine, and the focus of my presentation has been to identify those contributions. However, the presence and influence of sports medicine in the organization and conduct of the Olympic Games, or in establishing athletic performance records, could be described as being limited, cautious or ineffective for many decades because of the collective effects of a lack of the necessary critical mass in scientific information, a dearth of qualified and dedicated personnel, absence of professional organizations, reluctance to change social and cultural customs, and minimal public and financial support.

Because improvements in athletic performance have variable subjective and objective components, it is difficult to assign a date that convincingly validates the influences of sport medicine. But for reasons identified in this presentation, by the 1960s and 1970s the influences of sports medicine were noticeable and important. Moreover, when the next 100 years of progress are evaluated, this fact will become even more important.

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