



Professional Boxing Safety Act of 1996

NIOSH Report to Congress

STUDY ON HEALTH, SAFETY, AND EQUIPMENT STANDARDS FOR BOXING



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health



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Education and Information Division
Cincinnati, Ohio

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ABSTRACT

In accordance with the directive in the Professional Boxing Safety Act of 1996 (enacted by Congress on October 9, 1996), the National Institute for Occupational Safety and Health (NIOSH) reviewed the medical and related literature to develop recommendations for health, safety, and equipment standards for the sport of boxing and professional boxing matches.

Certain sports activities such as football and skiing are inherently dangerous and sometimes result in severe injuries and death. But boxing is a uniquely dangerous sport because it requires intentional blows to the head and other vital organs for the purpose of incapacitating the opponent. The following review indicated that such intentional and repeated blows to the head have resulted in irreversible acute and chronic brain damage, neurological impairments, serious eye damage, and premature death.

Although amateur boxing was intentionally excluded from the Professional Boxing Safety Act of 1996, the health and safety considerations of both forms of the sport must be compared to understand the basis for the new health, safety, and medical recommendations in the Act. Amateur boxing is fairly well supervised in the United States through several national organizations. Amateur boxing differs from professional boxing in that the fights are shorter (3 versus 4 to 12 rounds); the rules, regulatory policies, and medical evaluations are more stringent; and the use of protective devices is mandatory. Professional boxing is less well controlled in that the supervision of the sport is carried out worldwide through numerous uncoordinated national, State, and local boxing commissions that may have no reliable system of records. Therefore, determining the exact medical history or magnitude of injuries and deaths in professional boxers is difficult.

According to a review of the scientific literature, head injuries (including eye injuries) may account for up to 68 percent of all injuries in professional boxers. Although amateur boxing is less dangerous, significant trends in brain injury symptoms correlate with the number of bouts fought. This correlation is much stronger and more pronounced in professional boxers; 87 percent of those examined have symptoms of chronic brain damage. This chronic brain damage is directly related to the number of bouts; fighting more than 20 professional bouts appears to result in permanent damage. Ocular damage is also related to the number of bouts fought and affects as many as 66 percent of the boxers examined. Fighting more than 6 bouts is associated with a steep rise in retinal tears, and fighting more than 100 bouts results in retinal tears for nearly all boxers.

Numerous medical organizations have made official statements calling for significant boxing reforms or for a total ban on boxing. In 1984, the American Medical Association called for a ban on all boxing (amateur and professional) in the United States. The British, Canadian, and

Australian medical associations, as well as the World Medical Association, have recommended that boxing be banned. Sweden banned professional boxing in 1969; and in 1982, the Swedish government explored the possibility of forbidding amateur boxing. In 1984, the American Academy of Pediatrics opposed boxing in any sports programs for children and young adults [American Academy of Pediatrics 1984]. The American Neurological Association and the American Academy of Neurology have called for a ban on boxing. The *Journal of the American Medical Association* has printed several opinions calling for the banning of boxing. The U.S. Air Force Academy ended mandatory boxing in 1995.

Research reports on the efficacy of safety equipment are scarce. However, from those few studies in the literature, recommendations have been made to use safety equipment for reducing the risk of head and eye injury in the professional boxer. In one study, headgear reduced knockouts (KOs) from a 3 to 4 percent incidence to 0.8 percent and also protected boxers from eye injury, reducing the incidence from 8 to zero percent. However, other studies do not show the same injury reduction from using headgear. No reliable test exists to identify boxers at risk for sudden death or impending brain injury. To reduce this risk, many have recommended central administrative regulations and strict medical supervision for the sport of boxing.

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SUMMARY OF THE PROFESSIONAL BOXING SAFETY ACT OF 1996 (PUBLIC LAW 104-272)*

The Professional Boxing Safety Act of 1996 (Public Law 104-272) was enacted on October 9, 1996. Three sections apply to the health and safety study that the U.S. Department of Health and Human Services (DHSS) is to conduct:

Section 12 (b), Health, Safety, and Equipment. The Secretary of Health and Human Services shall conduct a study to develop recommendations for health, safety, and equipment standards for boxers and for professional boxing matches.

Section 12 (c), Health, Safety, and Equipment. Not later than 180 days after the date of enactment of this Act, the Secretary of Health and Human Services shall submit a report to the Congress on the findings of the study conducted pursuant to subsection (b).

Section 15, Effective Date. The provisions of this Act shall take effect January 1, 1997.

The House Report (104-833)

Section 12 (Studies). The second study shall develop recommendations for health, safety, and equipment standards for the sport of boxing and shall be performed by the Department of Health and Human Services, presumably within the National Institute for Occupational Safety and Health (NIOSH).

The Senate requires the Department of Labor to conduct a study on a pension system for professional boxers.

*See full text of law in Appendix I.

1 OVERVIEW OF BOXING

BACKGROUND

Boxing competition was first introduced in Olympia, Greece, about 700 B.C. and was followed 40 years later by *pankration*, a combination of boxing and wrestling. Although interest declined during the Middle Ages, a revival occurred during the 18th century in Great Britain and somewhat later in the United States [Unterharnscheidt 1970]. Periods in the history of boxing were dictated by the style of handgear utilized [Jordan 1993]. Fist fighting in ancient Greece and Rome became increasingly brutal as the type of handgear changed from soft (tanned oxhide) to sharp (untanned oxhide) thongs [Unterharnscheidt 1970]. The soft thongs were wound around the knuckles, wrist, and lower forearm with the fingers free to protect the hands (especially the knuckles) and to diminish the effect of the blows. About 400 B.C. in Greece, a prefabricated forerunner of the glove was introduced. The boxer could slip his hands into these gloves, which had a thickened and hard hump over the knuckles. The Greeks later introduced the hard thong version, which remained in use until the 2nd century A.D. This glove consisted of two parts—a padded glove and a hard leather ring encircling the knuckles. The Romans developed the *caestus*, which reinforced the humps over the knuckles with hard leather to protect the knuckles and increase the effectiveness of the blow. Both the Greek and Roman gloves extended the glove up the lower arm with a cuff of fleece padding or fur to protect the lower arm. Later, the Romans added lead or iron to the glove and metal spikes over the knuckles.

In 1839, new rules for the London prize-ring eliminated shoes with improper spikes and regarded as fouls holding, butting, gouging, kicking, biting, and blows below the belt [Stening 1992]. In 1887, the Marquis of Queensberry rules instituted gloves in all bouts, a 10-second count after a knockdown, and boxers matched by weight (i.e., light, middle, and heavy) [Lundberg 1985]. John L. Sullivan, champion in 1882, was the last bare-knuckle boxer [Stening 1992]. Boxing is the only sport in which the objective is for one competitor to render the other injured, defenseless, incapacitated, or unconscious [Lundberg 1983].

Numerous medical organizations have made official statements calling for significant boxing reforms or for a total ban on boxing. In 1984, the American Medical Association called for a ban on all boxing, amateur and professional, in the United States. The British, Canadian, and Australian medical associations as well as the World Medical Association have recommended that boxing be banned. Sweden banned professional boxing in 1969, and in 1982 the Swedish government explored the possibility of forbidding amateur boxing [Swedish government 1982]. In 1984, the American Academy of Pediatrics opposed boxing in any sports programs for

children and young adults [American Academy of Pediatrics 1984]. The American Neurological Association and the American Academy of Neurology have called for a ban on boxing [1983]. The *Journal of the American Medical Association* [Lundberg 1983, 1985] has printed several opinions calling for the banning of boxing. The U.S. Air Force Academy ended mandatory boxing in 1995 [Swartzberg 1995].

DEMOGRAPHICS AND SIZE OF THE POPULATIONS AT RISK: AMATEUR VERSUS PROFESSIONAL

In 1983, the American Medical Association Council on Scientific Affairs reported the following demographics for the United States on participation in this “collision sport.” In 1981, approximately 15,000 boxers between the ages of 10 and 15 were registered with the National Amateur Athletic Union Junior Olympic boxing program. Each boxer averaged between 10 and 30 bouts per year for a period of 5 to 6 years. The incidence of knockouts (KOs) was approximately 5% for the 14- to 15-year-old age group and was extremely rare among the younger age groups.

For the same year, an additional 12,500 amateur boxers participated in the Golden Gloves Association of America boxing program. Each boxer averaged approximately 20 bouts per year for 3 to 5 years. Fewer than 5% of these amateur boxers sustained a KO blow during their careers. Lubell [1989] reported that the U.S. Amateur Boxing Federation (ABF) presided over 16,500 amateur boxers nationwide as well as 6,000 coaches, officials, physicians, and administrators. O’Connor and Tucker [1991] reported that 16,000 amateur boxers were registered with the United States of America Amateur Boxing Federation (USAABF).

Boxing is not recognized as a varsity sport by the National Collegiate Athletic Association; however, in several colleges, boxing is a club sport and intramural boxing contests are held at most service academies under close supervision.

In 1983, the American Medical Association Council on Scientific Affairs reported that professional boxing was regulated by State or local boxing commissions established under law in 46 States, five territories, and the District of Columbia. At the time of the 1983 report, Georgia, Oklahoma, South Carolina, and Wyoming had no boxing statutes [American Medical Association Council 1983]. In 1995, a report to Congress noted that Colorado, Kansas, North Carolina, South Dakota, and Wyoming had no State boxing commissions and that Virginia had recently privatized their commission. The District of Columbia was considering privatization. The most recent data from the Nevada State Athletic Commission [1997] indicate that five States do not have Athletic Commissions: Alabama, Colorado, Kansas, South Dakota, and Wyoming.

In 1983, the number of licensed professional boxers in the United States was estimated to be 5,000. Licensed boxers frequently move between States for scheduled bouts, and some boxers perform under different names in several States. The 1995 report to Congress mentioned only

3,000 active boxers in the United States [American Medical Association Council 1983]. This figure of 3,000 professional boxers was confirmed by Otto [1997].

The various boxing commissions provide medical standards for the physical examination and licensing of boxers and medical supervision of boxing bouts. Sirb [1997] stated that since the early 1990s, the majority of professional boxing has been concentrated in seven States: California, Florida, Pennsylvania, New Jersey, Nevada, New York, and Texas. However, incomplete and fragmentary exchange of information appears to occur between many State boxing commissions regarding the routine identification and medical conditions of injured boxers.

The New York State Athletic Commission [1993] reported that 856 boxers with an average age of 22.3 years were licensed in New York between 1976 and 1981. These boxers participated in approximately 677 bouts per year, fighting an average 2,907 rounds of boxing.

The principal professional boxing governing bodies are the World Boxing Council (WBC) and the World Boxing Association (WBA). Each organization provides ratings for boxers under its control and sponsors championship matches in the various weight divisions. Neither organization routinely accepts the ratings of the other. Other active boxing associations include the United States Boxing Association (USBA), the North American Boxing Federation (NABF), the International Boxing Federation (IBF), the World Boxing Union (WBU), and the World Boxing Organization (WBO) [Lathan 1997]. Most State or local boxing commissions are voluntary members of one or more of the various boxing associations. Of the 3,000 professional boxers in the United States, only about 400 are sanctioned by the above governing bodies [Otto 1997]. A boxer may be sanctioned by more than one organization; however, this entails paying multiple fees for the sanctioning. Most professional boxers are not sanctioned by these organizations.

The Association of Boxing Commissions (ABC) represents the first active attempt by the boxing community in the United States to establish a national regulatory body for professional boxing [Jordan 1988] by establishing uniform rules for members. Membership in this nonprofit organization is voluntary and open to the boxing commissions of each U.S. State, Puerto Rico, the Virgin Islands, the provinces of Canada, and the States of Mexico. No authority exists over the participating boxing commissions, and the effectiveness of the ABC to regulate boxing depends on the cohesiveness and mutual cooperation of the participants.

Professional boxing differs from amateur boxing in the duration of bouts (4 to 12 rounds versus 3 rounds), rules, regulatory policies, medical evaluation, and protective gear [Haglund and Eriksson 1993; Jordan 1995; Ley 1997] (see Appendix 5). In professional boxing, the 15-round rule was lowered in the mid-1980s to a maximum of 12 rounds [Sirb 1997]. In amateur boxing, shorter bouts, greater shock absorbency of gloves, and judging systems that favor technical superiority over raw strength are likely to lessen the risk of cerebral injury in amateur boxing [Porter and Fricker 1996]. Between 1984 and 1986, several additional measures were introduced

to amateur boxing to protect the athletes further. Headgear was required for competition, the padding of competition gloves was increased, additional categories were introduced to ensure that boxers competed only against opponents of similar skills, referees were encouraged to stop bouts earlier when one of the boxers was outclassed or unable to maintain adequate defense, and mandatory suspensions were imposed for boxers with observable cerebral injuries.

In amateur boxing, the “passbook” system was made compulsory in 1986 to record the outcome of each bout and to enforce the suspension rules. A more recent change in the amateur sport has been the introduction of a computer scoring system for all international competition to increase the objectivity of judging [Porter and Fricker 1996]. In professional boxing, headgear is not worn in official bouts but may be used in sparring. Raw strength and brute force are expected in professional boxing rather than technical skills. The State of New York was first to institute the passbook concept and has enforced stricter rules in the professional sport with mandatory physicals and other medical measures. According to Sirb [1997], additional States now use the passbook system (including Florida and Michigan) and the system was instituted in Pennsylvania in 1988.

The rules for the USAABF [1987] are very similar to Swedish amateur boxing rules. Following a KO or a bout lost by a “referee stopping contest (head)” (RSC[H]) decision, the boxer must rest for 1 month. No boxing or sparring is allowed until the boxer undergoes neurological examination. Following a second KO or RSC(H), the boxer must rest 3 months. The resting period after a third KO or RSC(H) is 1 year. All boxers must have one medical examination per year, and boxers who have fought more than 50 bouts must undergo a neurological examination including electroencephalography (EEG). Boxers continuing to fight at the age of 30 must receive a neurological examination including an EEG. Ley [1997] compared the differences between the amateur and professional versions of boxing (see Appendix 5).

“Tough man” and “tough women” boxing contests as well as “ultimate fighting” or “extreme fighting” have been promoted. These contests usually involve poorly conditioned, unlicensed amateurs and are not usually sanctioned by appropriate State boxing commissions. A recent New York Times article [Barry 1997] described extreme fighting matches. Although banned in California, Missouri, New York, and Illinois, they have been allowed in Oklahoma. Participants in these contests include boxers and practitioners of different martial arts (karate, sumo wrestling, judo, Tae Kwon Do, kickboxing, shootfighting, jujitsu, etc.). Very few rules exist, but eye gouging, biting, kicking the opponent’s throat, and kicking with shoes are prohibited. The contests have no rounds, and time is limited to 15 to 18 minutes [Acunto 1995]. The ring is an elevated octagonal or round ring surrounded by chain-link fence. Two ring physicians are required, and mouthpieces and groin protection are mandatory. The bout ends with a KO, when a boxer surrenders, or when a physician or referee stops the bout. The potential for serious injury is high in any such unlicensed and no-rules bouts. Acunto [1997] stated that ultimate fighting has been banned in New York by Governor Pataki, who signed the bill in March 1997. In 1995, Acunto stated that this type of barbaric activity has “no redeeming social value and need not be included in an already violent society.”

MAGNITUDE OF RISK: INJURIES IN BOXING AND COMPARISON WITH OTHER SPORTS

The overall rate of injury in boxing is lower than that of many other sports [Blonstein 1974; Lund and Espersen 1988]. Blonstein [1966] cited a report in which 6,057 consecutive injuries were recorded for various sports in Oslo, Norway. The incidence of injury was higher in skiing (29.4% of total), football (21.8%), gymnastics (10.3%), swimming (8.6%), handball (6.5%), skating (6.0%), tobogganing (4.6%), hockey (2.2%), and wrestling (1.9%) than in boxing (1.7%). Whether these figures were derived from professional participants or from a combination of professional, amateur, and recreational participants is unclear. Blonstein [1966] also cited injury rates per person from a 1961 study of sports injuries in Queensland University students. The rates were as follows: boxing, 0.17; rugby, (0.44); soccer, (0.3); gymnastics, (0.29); hockey, (0.25); judo, (0.21); and basketball, (0.15).

The most common boxing injuries are cuts to the face and simple nose bleeds [Blonstein 1966; Jensen et al. 1988]. In 4,350 bouts held by the London Amateur Boxing Association, 136 (3%) injuries were reported: 42 cuts in the region of the eyes, 15 other cuts, 3 fractured metacarpals, 2 fractured noses, 60 KOs, 9 cases of amnesia without KOs, and 5 sprains of the thumb or fingers [Blonstein 1966]. Fracture of the metacarpal bones is the most common skeletal injury [Noble 1987], and jaw fractures are rare. Serious eye injuries occur, but black eyes are most common [Blonstein 1969].

Enzenauer et al. [1989] reported on all boxing-related injuries serious enough to involve hospitalization in U.S. Army hospitals from 1980 through 1985. On the average, 67 hospitalizations occurred annually, with the injured spending an average of 5.1 days in bed and 8.9 days disabled or unfit for duty. One death occurred from serious head injury, and one instance of unilateral blindness occurred from ocular trauma requiring enucleation. Head injuries accounted for 68% (272/401) of all the injuries and were more common (81%) in the younger cadets and presumably less experienced boxers. Head injuries included intracranial injury, concussion and cerebral contusion, intracranial hemorrhage, skull fracture, fracture of facial bones, ocular injuries, head and neck contusion, and others. Upper-extremity trauma accounted for 17% of all hospitalizations and 9% of cadet injuries. Upper-extremity diagnoses included dislocation of the shoulder, elbow, wrist, or finger; fracture of the humerus, radius, ulna, or hand bones; sprain or strain of the upper-extremity; open wounds or infections; and others. Injuries to the trunk and torso accounted for 7% of total admissions and 6% of cadet admissions. Injuries included sprain or strain of the neck or back; contusion of chest, abdomen, or genitalia; injury to the kidney or intra-abdominal organs; fractured ribs; traumatic pneumothorax; and others. Lower-extremity injuries accounted for 6% of total admissions and 4% of cadet admissions. These included fracture of the femur, ankle, or metatarsals; tear of knee cartilage or meniscus; sprain or strain of hip, knee, or ankle; and others. Other miscellaneous injuries accounted for 2%

of all hospitalizations and included ill-defined sprains or strains, heat exhaustion, early complication of trauma, contusion of multiple sites, sinusitis or upper respiratory infection, and admission for observation.

Oelman et al. [1983] also reported the distribution of different types of injuries. The results were similar to those reported by Enzenauer et al.[1989]. The report included head injuries, 68% (fractures of the face bones, 83/296=28%; concussion, 115/296=39%); upper limb injuries, 14%, (including fractured metacarpal bones, 28/59=47.5%); lower limb injuries, 5%; trunk injuries, 5%; internal injuries, 3% (including four injuries to the kidneys and three to the pelvic organs); and other, 7%.

Jordan and Campbell [1988], reporting on a 2-year survey (August 1982 to July 1984), reviewed all acute boxing injuries that occurred in New York State during professional bouts. Of the 376 injuries reported, 70% were craniocerebral injuries, and the remaining injuries were mostly (17.6% of total) facial lacerations. Hand, eye, abdominal, and all other injuries each accounted for less than 2% of the total.

The most recent data from Jordan [1995] depict the type of medical injuries among professional boxers in New York State from 1988 to 1991. Sixty-two percent were cranialcerebral injuries, 23% were facial lacerations, and 5% were eye injuries. All other injuries accounted for less than 1.2% of the total. The annual injury rate per 100 boxers over the 4-year period ranged from 22% to 59% for craniocerebral, 8.7% to 13.6% for facial lacerations, and 0.6% to 4.9% for hand injuries. One death occurred in this 4-year period.

In Pennsylvania, statistics are kept on professional boxing events through mandated medical insurance records maintained by the Pennsylvania State Athletic Commission [Sirb 1997]. For the 288 bouts that occurred in the State during 1996, 15 claims (5% of the total 288 bouts) were made by boxers for various injuries. Of these 15 claims, 4 were more serious than facial cuts (the nature of the 4 claims was not mentioned). Sirb noted that many of the ringside physicians in Pennsylvania provide "stitch/sew" services (only for minor lacerations) to any and all boxers immediately after an event at no charge; thus these do not appear on the insurance claim report.

Acute and chronic brain injury are serious risks and account for 9% to 87% of all injuries in professional boxers [Jordan 1995; La Cava 1963; Lundberg 1985; Roberts 1969; Sercl and Jaros 1962]. However, these risks differ from the risk of brain injury in other sports because the boxer is exposed to repeated blows to the head, according to the rules of the international set of boxing laws. Repeated head trauma may also occur in sports such as soccer, wrestling, and diving [Haglund and Eriksson 1993; Smodlaka 1984; Tysvaer and Storli 1989]. Blonstein [1966] stated that far more cases (numbers were unspecified) of concussion were reported from skiing, football, wrestling, and gymnastics than from boxing.

Frequent blows to the head sustained over many bouts inflict cumulative damage to the brain in professional boxers. Martland [1928] was first to describe in clinical detail “punch drunkenness,” the best known of the neuropsychiatric sequelae. Punch drunkenness simulates alcohol intoxication; symptoms include ataxia (a broad-based gait), clumsiness, tremors, rigidity, spasticity, personality change, slurred speech, and impaired mental function (dementia). Critchley [1957] renamed the condition as “chronic progressive traumatic encephalopathy.” Sometimes the condition is referred to as “dementia pugilistica” [Millspaugh 1937; Ross et al. 1983]. The syndrome follows a three-stage clinical pattern: (1) affective disturbances and mild incoordination; (2) psychiatric symptoms with paranoid ideas, mild dysarthria (slurred speech), and resting tremor; and (3) a decrease in general cognitive functions, memory deficits, impaired hearing, hyperreflexia, dysarthria, intention tremor, and incoordination [Guterman and Smith 1987]. This syndrome may be progressive after a boxing career is over [Critchley 1957] and may occur 7 to 35 (mean 16) years after the start of the boxing career. Severe symptoms may appear later in life [Corsellis et al. 1973; Roberts 1969]. The neurological features are predominantly exhibited by extrapyramidal and cerebellar dysfunction. Furthermore, Haglund and Eriksson [1993] described dementia, personality change (immaturity, aggressiveness, suspiciousness), and social instabilities. Roberts et al. [1990] added signs and symptoms of Parkinsonism to the second stage.

2 KNOCKOUTS (CEREBRAL CONCUSSION)

A KO and—in many instances, a technical knockout (TKO)—indicates that the boxer has suffered a cerebral concussion. The Congress of Neurological Surgeons [1966] defined the wealth of terms related to concussions. In his review of head injury in sports, Jordan [1990b] stated that no uniform definition exists for cerebral concussion in the medical literature. He added that the term has been loosely used to describe all types of nonfocal brain injury secondary to head trauma that results in neurological dysfunction. The Centers for Disease Control and Prevention [1997] recently published a summary of recommendations from the American Academy of Neurology [1997] for management of concussion in sports (see Appendix 5).

Jordan further discussed the division of cerebral concussion into two major categories: the mild cerebral concussion and the classic cerebral concussion. The first syndrome is characterized by no loss of consciousness [Fisher 1966], but a transient disturbance of neurological function occurs. The classic cerebral concussion is characterized by loss of consciousness and some degrees of retrograde and posttraumatic amnesia. Ommaya and Gennarelli [1974] described concussion as “traumatic unconsciousness.” Jordan commented that the duration of unconsciousness usually correlates directly with the severity of the cerebral concussion. Unconsciousness occurs at the moment of impact and by definition should not exceed 6 hours. Those experiencing unconsciousness longer than 6 hours may have sustained “diffuse axonal injuries.” (Jordan described three distinct categories of diffuse axonal injury, which are beyond the scope of this review.) Ommaya and Gennarelli [1974] implied that concussion was produced in experimental studies only when the moving head was allowed to angulate or rotate. When rotation was prevented and the head was allowed to translate (move in a straight line) only, cerebral concussion did not occur. However, they also added that focal primary brain damage could be produced under conditions of pure translational energy.

Kelly and Rosenberg [1997] authored a document on the diagnosis and management of concussion in sports because of their perception of the disagreement about the terminology of mild traumatic brain injury and concerns about the proper management of sports-related concussions. They noted that frequently the loss of objectivity on the part of the athlete, coaches, sports media, and spectators is an unfortunate and potentially harmful bias that does not always ensure participant safety. The authors urge the adoption of a single-concussion grading scale [American Academy of Neurology 1997] (NOTE: the AAN called for a ban on boxing in 1983). They deem such a scale essential to the advancement of clinical research into the incidence of concussion, patterns of recovery, risks of neurosurgical emergencies, and the development of permanent neurologic dysfunction. Of particular concern is the prevention of catastrophic outcome and cumulative neurobehavioral deficits from repeated concussions. Kelly and Rosenberg noted that repeated concussions have been shown to cause cumulative neuropsychological and neuroanatomical damage, even when the incidents are separated in time by months or years. This “second impact syndrome” is thought to be a result of a second concussion occurring while the individual is still symptomatic from an earlier concussion. With

this syndrome, the athlete suffers cerebrovascular congestion, or a loss of cerebrovascular auto-regulation, leading to malignant brain swelling and marked increase in intracranial pressure which, could lead to permanent disability or death. CDC [1997] also noted that repeated mild brain injuries occurring over an extended period (months or years) can result in cumulative neurologic and cognitive deficits [Jordan and Zimmerman 1990; Gronwall and Wrightson 1975]; but repeated mild brain injuries occurring within a short period (i.e., hours, days, or weeks) can be catastrophic or fatal [Saunders and Harbaugh 1984; Kelly et al. 1991; Cantu and Voy 1995]. It must be noted that not all concussions result from direct trauma to the head; for example, they may result from whiplash mechanism injury [Kelly and Rosenberg 1997].

A cerebral concussion may be associated with other focal brain injuries, such as a subdural (dural venous sinus rupture), epidural (meningeal artery rupture), or intracerebral (hemorrhagic areas within the brain parenchyma) hematomas and cerebral contusion (heterogeneous areas of necrosis, infarction, hemorrhage, or edema within the brain parenchyma). Amnesia may result with no loss of consciousness. Memory loss, dizziness, and nausea may follow a KO and the cumulative effects may result in disabling headache, classic migraine, and delayed recovery of brain function [Haglund and Eriksson 1993]. As mentioned above, a second minor impact following a preexisting cerebral contusion may be lethal. Povlishock and Kontos [1985] attributed the sensitivity of secondary insult to be associated with a continuum of regenerative responses in axons leading to vascular abnormalities and the generation of oxygen radicals through acceleration of arachidonate metabolism and subsequent increased prostaglandin production. Ommaya and Gennarelli [1974] described a paradigm for head injury mechanics which detailed a flow chart to help understand the critical factors involved in the mechanism of head injury.

Saunders and Harbaugh [1984] recommended a computed tomography (CT) scan as an adjunct to the clinical examination for athletes exposed to the risk of sequential-impact head injuries. Patterson [1993] stated that intracranial hematomas can be demonstrated in boxers, particularly with magnetic resonance imaging (MRI), which is more sensitive than CT for imaging the consequences of brain trauma. Zimmerman and Jordan [1993] noted that MRI is a much more sensitive test than CT in demonstrating hemorrhagic shear injuries. They added that other acute sequelae of head trauma (i.e., acute subdural hematomas and contusions) are better detected by MRI than CT with one exception—subarachnoid hemorrhage. (A detailed description of the sensitivity and specificity of diagnostic tests as well as clinical management of the boxer is clearly beyond the scope of this review.)

The incidence of KOs in professional bouts in New York State was 6.4% (43 in 677 bouts) during the 5-year period 1976–81 [American Medical Association Council 1983]. More than 90% of these KOs occurred during the first three rounds. McCunney and Russo [1984] noted that KOs occur in 1% to 4% of all matches. Blonstein and Clarke [1957] reported on boxing injuries encountered in 3,000 London Amateur Boxing Association contests during 1955–56. Boxers suffered severe concussions or were knocked out more than once in only 29 (0.58%) of these matches. However, since accurate records have not been maintained, the range of KOs over the

years is unknown. Patterson [1993] stated that most brain injuries in boxing occur as a result of fatigue.

Jordan [1995] reviewed the experiences of professional boxers in New York State for 1988 and found that 4-round bouts accounted for 38% of scheduled competitions. Ten-round bouts were the second highest (30%) in total competition. Six- and 8-round bouts each made up 15% of the total competition, and 12- to 15-round bouts accounted for 2%. Among the 189 bouts, 65% resulted in a TKO or KO. The frequency of TKOs or KOs was lowest for 4-round bouts and all of the 12- to 15-round bouts resulted in TKOs or KOs. Bouts scheduled for 6 to 10 rounds had a TKO or KO frequency of 70% to 75%. Of all the TKOs or KOs, 80% occurred within the first 3 rounds and were most frequent in the first round. Only one occurred after the ninth round.

Sirb [1997] submitted the following data from Pennsylvania on the 288 bouts fought in 1996. The frequency of KOs was 21% and the TKO incidence was 32%. The total of 53% frequency of TKOs or KOs is similar to that reported by Jordan [1995]. Of the 151 bouts ending in a TKO or KO, 56% ended in rounds 1 or 2; 24% ended in rounds 3 or 4; 12% ended in rounds 5 or 6; and 7% ended after round 6.

3 FATALITIES

The exact number of fatalities among amateur and professional boxers in the world is unknown. However, a number of estimates have been proposed. Ryan [1987] estimated that from 1918 to 1983, 645 fatalities occurred in boxing worldwide; 190, or approximately one-third, were among amateurs. Moore [1980] stated that 335 deaths occurred among amateur and professional boxers worldwide during the 35-year period between 1945 and 1979, and Friedman [1989] reported that 370 deaths occurred between 1945 and 1985. Since the exact number of amateur and professional boxers in the world was unknown during these time periods, calculating specific mortality rates is not possible; however, McCunney and Russo [1984] estimated the mortality rate to be 0.13 per 1,000 participants per year from 1945 to 1979 on the basis of 335 amateur and professional boxing fatalities during that period. McCunney and Russo stated that the mortality rates were imprecise, since the exact number of boxers could not be determined. Table 1 illustrates the fatality rates of high-risk sports estimated by the authors.

Table 1. The fatality rates of high-risk sports

Sport	Deaths per year/ number of participants	Rate per 1,000 participants
Horse racing	23/1,800	12.8
Sports parachuting	370/30,000	12.3
Hang gliding	169/30,000	5.6
Mountaineering	308/60,000	5.1
Scuba diving	1,100/1,000,000	1.1
Motorcycle racing	77/115,000	0.7
College football	11/40,000	0.3
Boxing	10/78,000	0.13

According to these estimates, the mortality rates for American football, horse racing, sports parachuting, hang gliding, mountaineering, scuba diving, or motorcycle racing are higher than that for boxing. However, as a result of the peer review of this current congressional report, Cantu [1997] commented that the figures may be inaccurate according to information he obtained as medical director for the National Center for Catastrophic Sports Injury Research. He stated that the number of participants in college football each year is not 40,000 but approximately 75,000. The National Center death rates for college football are less than 1/100,000, whereas, the death rates in Table 1 are 30/100,000. Whether the amount of participation in college football increased from 40,000 to 75,000 between 1979 and 1997 is unclear.

Murphy [1987] reported that 174 deaths in American football occurred between 1976 and 1986 in sandlot, high school, college, semiprofessional, and professional football games. This total roughly matches the above estimate of yearly deaths [McCunney and Russo 1984]. Refshauge [1963] used press reports from Australia during the period 1922–62 to estimate a mortality rate of 1 in 10,000 boxing contests— an estimate similar to that of McCunney and Russo [1984].

Gonzales [1951] reported fatalities from participation in various sports in New York City over a 32-year period from 1918 to 1950. The numbers and associated sports are shown in Table 2; however, the number of participants in each sport was not provided.

Table 2. Sports fatalities in New York City for the years 1918–50

Sport	Number of cases
Baseball	43
Basketball	7
Boxing	21
Cricket	1
Football	22
Golf	1
Handball	3
Polo	1
Relay races	1
Soccer	2
Wrestling	2
Total	104

Lindsay et al. [1980] stated that of the 84,000 head injuries reported to emergency departments in Scotland in 1974, 11% were due to sports. They further reported the details of 52 head injury admissions to their hospital between 1974 and 1978. The breakdown for each sport is given in Table 3; however, the number of participants in each sport was not provided.

The authors commented that the number of patients sustaining head injury from different sports varies with locality depending on the risk factor of that particular sport and on the number of participants. They also added that some figures, such as those for climbing, do not reflect the actual death rate, since death often occurs before transfer to a hospital is possible.

The mortality rate of 0.13/1,000 for boxing is lower than the rates of traumatic injury deaths reported for mining (0.265/1000), agriculture (0.195/1000), transportation (0.162/1,000) and construction (0.144/1000) for the years 1980 to 1989 [NIOSH 1993]. The preceding four industries are the most dangerous industries when fatality rates are considered.

Table 3. Head injury admissions in Scotland for the years 1974–78

Sport	% total cases
Golf	27
Horse-riding	15
Football	13
Shooting	10
Climbing	8
Rugby	6
Boxing	4
Skating	4
Other (swimming, karate, hang-gliding, squash, hockey, cricket, and athletics)	13
Total	100

In his review of the literature, Ryan [1987] stated that a substantial number of fatalities in boxers are due to intracranial injuries at both the amateur and professional levels. The number of such fatalities has decreased steadily in recent years, according to Ryan, because of measures taken by boxing authorities to decrease the physical hazards in the ring and to improve monitoring of boxers during bouts by referees and physicians.

Payne [1968] indicated that the usual cause of boxing fatalities is subdural hemorrhage and its complications. The mechanism of the fatal injury is related to rotational acceleration of the head from a forceful blow with rupture of bridging or connecting veins. Such hemorrhage may result from the direct effects of the blow or from the subsequent impact of the head against the floor or ringposts.

4 AMATEUR BOXING INJURIES

Details of the following studies appear in Appendix 2 of this document.

The focus of this report is on professional boxers but the following information compares amateur and professional boxing injury outcomes. Numerous studies have been conducted on amateur boxers to prove that nonprofessional boxing is safer and should not be subject to the call for banning that professional boxing has. Since the major injury in professional boxers is brain injury, most of the studies on amateur boxers have focused on this aspect.

Numerous studies have compared the safety levels and medical controls in amateur boxing with those in professional boxing, or they have ascertained the level of injury and its progressive nature in amateurs. Thomassen et al. [1979] found only minor neuropsychological disturbances in amateur boxers compared with football players matched for age, education, and vocabulary. The most pronounced effect was impaired motor function of the left hand in the boxers. Brooks et al. [1987] found no significant impaired performance in neuropsychological examinations of amateur boxers and a comparison group of similar age, ethnicity, and education. In contrast, McLatchie et al. [1987] reported abnormal results from clinical neurological examinations (35%), abnormal EEG (40%), and abnormal neuropsychometry (60%) in the 20 amateurs studied; these findings were correlated with an increasing number of bouts. Heilbronner et al. [1991] used a range of cognitive measures that indicated impairments in verbal and memory skills in postbout measurements compared with prebout measurements. Stewart et al. [1994] studied boxers from six cities over a 2-year interval for changes in central nervous system function and found changes in memory, motor function and visuoconstruction ability associated with past bouts, but not more recent bouts. This finding may indicate a long latency period before the neurological effects are manifested. Butler [1994] reviewed 10 studies in which neuropsychological examinations were performed and concluded that some trends emerged that suggested a long career in amateur boxing might reduce fine motor reactions. In a comparison of active amateur boxers with nonboxing sportsmen, Kemp et al. [1995] found that boxers who had fought fewer bouts performed better at psychometric tests than boxers who had fought more bouts. Boxers had more aberrations in brain perfusion scanning than nonboxers. In a prospective study using a battery of eight tests, Porter and Fricker [1996] found only finger-tapping deterioration in boxers compared with a group matched for age and socioeconomic status.

Haglund and others performed a series of studies comparing amateur boxers with other athletes [Haglund and Eriksson 1993; Haglund and Persson 1990; Haglund et al. 1990]. In 1990, they compared the medical outcome (using career length as a variable) of amateur boxers with equal numbers of age-matched soccer players and track and field athletes and found some EEG differences that may indicate brain dysfunction in some of the boxers [Haglund and Persson 1990; Haglund et al. 1990]. Using standard neuropsychological tests, they found differences in finger-tapping performance in boxers compared with other athletes. In 1993, Haglund and

Eriksson again found a higher difference in EEG deviations in boxers and decreased finger-tapping performance when compared with other athletes. Whether the latter studies were studies of independent groups or followup studies of the same groups is unclear.

Jordan et al. [1990] reported boxing injuries that occurred at the U.S. Olympic Training Center from January 1977 to August 1987 to determine the types of acute and chronic injuries sustained by amateur boxers during training, sparring, and competition. The total number of boxers was not available. Of the 447 injuries reported, most occurred to the upper extremity (32.9% of total; 92/147 were of the hand and wrist), followed by the lower extremity (23.9% of total; 63/107 were of the knee and ankle), head and face (20.5% of total; 70/92 were of the nose, eyes, and mouth/throat), back (6.9% of the total), and brain (6.5% of the total). The authors remarked that the low percentage of cerebral injuries was probably related to the noncompetitive nature of the boxing at the training center, where fewer blows to the head occur during sparring and training than during competition. Welch et al. [1986] reported that the injury rate increased by a factor of 5 during competition; they concluded that more injuries occurred during competition than during practice per unit time of exposure.

Kemp [1995] published a critique of amateur boxing studies published after 1979 and attempted to point out methodological deficiencies that may explain the lack of a consensus in these studies. Potential deficiencies in these studies included the following:

1. Selection bias in the recruitment of boxers (i.e., self-selection of volunteers leading to reluctance to participate for impaired boxers, more representation from successful boxers, and presenile dementia that may impair volunteering)
2. Extraneous head injuries incurred outside the boxing ring
3. Comparing the results of the boxers' investigations with established norms without comparing age, education, social class, etc.
4. Selection of inappropriate controls
5. Statistical analysis and chance findings from multiple comparisons
6. Selection of inappropriate neuroinvestigatory techniques
7. Recruiting ex-amateur boxers who have turned professional

Wedrich et al. [1993] evaluated the nature and incidence of ocular pathological conditions and found that 76% of the amateur boxers has lesions attributable contusion trauma compared with 4% in the comparison group. Porter and O'Brien [1996] determined the incidence, pattern, and severity of injuries that occurred in amateur boxers over a 5-month period of competition and training. They found an injury incidence of about 0.7 injuries per boxer per year, whether the boxers were competing or in training. Cerebral concussions occurred in 11.8%, hand/wrist injuries in 4.6%, and facial injuries 4.6% of the boxers.

5 PROFESSIONAL BOXING INJURIES

Details of the following studies appear in Appendix 3 of this document.

NEUROLOGICAL AND PSYCHOLOGICAL EFFECTS

Traumatic encephalopathy has been recognized to be more common in professional boxers than in amateurs for more than 40 years [Blonstein and Clarke 1954; 1957]. This condition is thought to be more prevalent in those of poor boxing ability, in those who have fought mainly in poorly supervised arenas, and in boxers of small stature. The total number of bouts and KOs is significantly linked to the degree of deterioration [Hazards of boxing 1969]. Lundberg [1985] reported that chronic brain damage caused by repetitive subconcussive blows to the head is present in 70% to 87% of boxers who had many bouts (unspecified number). Defenders of the sport claim that chronic encephalopathy occurs only occasionally in poorly skilled boxers and they argue that minimal education, lack of modern medical controls, and drug and alcohol abuse are the explanations of the few cases of chronic encephalopathy [American Medical Association Council 1983].

To explain the risk of neurological damage in various sports, Corsellis [1989] requested 162 British neurologists in 1976 to estimate the number of patients at risk of neurological damage ("punch-drunk" syndrome) in sports. The survey respondents listed 5 soccer players, 12 steeplechasers, 2 amateur rugby players, 2 wrestlers, and a parachute jumper. Boxers were mentioned 290 times, although the same boxers may have been mentioned more than once.

Johnson [1969] noted two main types of psychological changes. The first, directly attributable to brain damage, includes impaired memory, dementia, and impotence. The second type of change included those that appear to be exaggerations of preexisting personality traits or the precipitational psychotic states in predisposed persons. The most common disorder appears to be a variable degree of impaired short-term memory and retention, which is linked to damage to the mamillo-thalamic-fornico-hippocampal system. Dementia, which affected about 25% of boxers in this study, was attributed to atrophy of the frontal and temporal cortex. Lesions of the limbic system were linked to impotence, and the condition identified as "morbid jealousy" occurred in the same men. Rage reactions and unpredictable outbursts, especially after alcohol consumption, resulted in some admissions to acute psychiatric hospitals.

In studies by Roberts [1969] and an unknown author [Medical aspects of boxing 1969], 17% of a large random sample of professional boxers' fighting matches between 1929 and 1955 showed

evidence of brain damage, and a third of these had severe chronic traumatic encephalopathy. The study demonstrated that the length of a boxer's career and the total number of bouts fought were closely linked to the severity of the ultimate neurological damage. Ross et al. [1987] commented that in the years before World War II, many professional boxers fought more than 200 matches during a career, whereas in more recent times, it is unusual for a boxer to fight more than 40 or 50 bouts during a professional career. Since Ross et al. [1987] demonstrated that the amount of brain injury is highly correlated with the number of professional bouts. Thus the decreasing total number of bouts may have caused the shift in disease patterns from the full-blown punch-drunk syndrome to the subclinical and mild clinical patterns because of reduced accumulation of brain damage. They generalized that boxers with fewer than 20 to 30 professional bouts usually do not have clinical or subclinical evidence of brain injury. Those with 25 to 50 bouts often demonstrate CT scan and neuropsychological test abnormalities without obvious clinical dysfunction. Boxers with more than 50 professional bouts often exhibit clinical signs and symptoms along with CT scan and neuropsychologic test abnormalities.

Kaplan and Browder [1954] performed 1,400 EEGs on 1,043 professional boxers but found no significant correlations between EEG measurements and number of bouts, weight division, win-loss record, type of boxer, or occurrence of KOs. In contrast, Casson et al. [1982] performed detailed neurological examinations, EEGs, and CT scans on a limited number of professional boxers who had just been knocked out. All of the boxers had mild head injuries by clinical criteria. CT scans revealed cerebral atrophy in 50% of the boxers, predominantly in the boxers with the most bouts. Of the boxers with 20 or more bouts, 80% had cerebral atrophy; of the boxers with fewer than 12 bouts, only 20% had cerebral atrophy.

Using CT scan results, Kaste et al. [1982] reported pathological findings attributable to brain injury in 66% of professional boxers and 12.5% of amateur boxers examined. The occurrence of EEG abnormalities in 46% of the boxers in this study is similar to rates of 37% to 60% in other studies and is clearly higher than the rate of 10% to 15% found in the general population. Seventy-five percent of the boxers had psychological test results that suggested brain injury. Ross et al. [1983] demonstrated a significant relationship between the number of bouts fought and CT scan changes indicating cerebral atrophy and EEG abnormalities.

Casson et al. [1984] found that 87% of professional boxers examined had definite evidence of brain damage on at least two of the four tests. Seventy-five percent of boxers with more than 20 professional bouts had abnormal CT scans, whereas only 20% with fewer than 20 professional bouts had abnormal CT scans. Every subject with an abnormal CT scan or an abnormal EEG had an impairment index that correlated significantly with the number of professional bouts and with age; however, the impairment index did not correlate significantly with the number of KOs or episodes of amnesia. The authors suggested that the longer boxing careers result in a greater likelihood of brain damage and the cumulative effect of multiple subconcussive blows to the head may be a cause.

Drew et al. [1986] found a pattern of neuropsychological deficits in young, active, licensed professional boxers consistent with the more severe punch-drunk syndrome, and these deficits resulted in significantly lower test performance than that of the comparison group of athletes. Seventy-nine percent of boxers scored in the impaired range of one of the tests compared with 20% of the comparison groups. Although the number of bouts was not related to the impairments, the extent of brain damage was primarily a function of the amount of “punishment received” as measured by number of losses.

In a prospective investigation [Levin et al. 1987] of neurobehavioral functioning, mostly young professional boxers paired with comparison group subjects underwent tests of attention, information-processing rate, memory, and visuomotor coordination and speed. More proficient verbal learning was found in the comparison group subjects, and reaction time was faster in the boxers. Some subjects of both groups were retested 6 months later and exhibited improvement in their neuropsychological performance compared with baseline measurements. Magnetic resonance imaging (MRI) disclosed normal findings.

Jordan and Zimmerman [1990] compared the efficacy of CT scans and MRI in identifying traumatic brain injuries in a population of amateur and professional boxers. The authors concluded that the MRI scan appears to be the neuroradiodiagnostic test of choice for evaluating traumatic anatomic lesions of the central nervous system in boxing, but it does not assess brain function and should not serve as a substitute for EEGs, neurological examination, and neuropsychological testing. The authors added that a CT scan remains the procedure of choice for evaluating acute (lasting less than 24 hours), severe head trauma. MRI examinations take longer and would make the maintenance of unstable patients more difficult; in addition, some diagnoses (such as intraventricular hemorrhage) are not manifested during the first 24 hours.

Breton et al. [1991] investigated boxers' attention and orienting mechanisms using event-related brain potential recordings (not described as EEGs) before and after a bout. This very small study did not reveal any abnormalities of attention or detection processes. However, a slight deficit was observed in the orienting reaction toward stimuli delivered in the right ear. This deficit was related to a greater number of blows delivered on the left side of the head.

Jordan et al. [1992] found that 7% of a large number of active professional boxers had abnormal CT scans. The most common abnormality was brain atrophy. Boxers with abnormal CT scans were similar to those with borderline or normal CT scans in age, win-loss record, number of bouts, or history of abnormal EEGs. Forty-nine percent of the boxers with borderline CT scans and 68% with abnormal CT scans reported a previous TKO or KO compared with only 37% of the boxers with normal CT scans. Brain atrophy was noted more frequently in boxers with a large cavum septum pellucidum (CSP) than in those with a small or no CSP. Boxers with abnormal or borderline CT scans who had experienced a TKO or KO were slightly older than those with normal CT scans and a history of a TKO or KO. Five percent of the boxers who received an EEG showed abnormal results. Boxers with abnormal and borderline EEGs tended

to have had more bouts than did boxers with normal EEGs, but the difference was not statistically significant. Ninety-two percent of the boxers with abnormal CT scans had normal EEGs.

Jordan et al. [1996] found in a group of professional boxers who volunteered for the study that performance on neuropsychological tests was not associated with age, amateur or professional boxing record (wins, losses, or total number of bouts), length of career, or history of KOs or TKOs. The amount of sparring was inversely associated with the performance of the boxers on several tests of attention, concentration, and memory. The authors concluded from the results of this cross-sectional study that sparring, not competition, is associated with poorer performance on neuropsychological tests. They found that the tests most consistently emerging as sensitive measures of cerebral trauma from sparring were the Rey complex figure, the Stroop color and word test, and the verbal memory and visual reproduction subtests of the Wechsler memory scale.

Generally, the EEG is considered a less reliable indicator of boxers' encephalopathy than neurological and psychopathological examinations, and its value, according to Unterharnscheidt [1970], is recognized only in the context of a neurological-psychopathological evaluation. According to this author, a normal EEG finding does not exclude the possible existence of a traumatic encephalopathy.

PARKINSON'S DISEASE

According to Friedman [1989], posttraumatic Parkinsonism (one form of boxer's encephalopathy) is an uncommon diagnosis, even in the large Parkinson's disease treatment centers. Although the disease is well recognized, the course of the boxer's form of the disease is not well described, and the literature contains no reports about its responsiveness to typical anti-Parkinsonian drugs. Two points of interest in this syndrome are relevant to the understanding of other degenerative brain disorders: (1) the presence of neurofibrillary tangles in the cortices of former boxers, and (2) the delayed onset of symptoms, often decades after the last cerebral insult. Friedman [1989] hypothesized that the development and progression of Parkinsonism in boxers result from a few massive insults to the substantia nigra followed by normal aging which leads to idiopathic Parkinson's disease.

OTHER NEUROLOGICAL OUTCOMES

Friedman [1989] proposed that frontal lobe tumors and multiple sclerosis occur more frequently in boxers than in the general population. Guterman and Smith [1987] stated that of the primary intracranial tumors, the meningioma is the only type for which trauma is "felt" to be a risk factor for development. In their review of the literature that associated central nervous system tumors with brain trauma, they pointed to a study by Prestin-Martin et al. [1983] that used a case control

protocol. In this study, a history of boxing (amateur or professional) was a significant risk factor for the development of meningiomas. Other potential long-term neurological sequelae from boxing—posttraumatic epilepsy and traumatic cranial nerve palsies, for example—have not been adequately documented.

BRAIN PATHOLOGY

Neurological lesions include rupture of the septum pellucidum, dilation of the ventricles, and damage in the region of the upper brain stem and hippocampal and fornical systems [Hazards of boxing 1969; Corsellis et al. 1973]. Corsellis et al. [1973] described the main pathological sites of change in boxers. The most obvious abnormality was centered on the deep midline structures where the septa were wide apart, torn, and fenestrated. The ventricles were enlarged and the fornices atrophied. The tissue in this area, including the thalamus and hypothalamus, showed severe gliosis. In the cerebellum, atrophy and glial fibrosis affected folia that were encircled by the foramen magnum. In addition, a pronounced loss of Purkinje cells occurred in the undersurface of the cerebellum. In the substantia nigra, large pigmented neurones were absent; this condition is the classical neuropathological feature of a Parkinsonian state. Many neurones, mainly in the deep temporal grey matter, tended to develop abnormal neurofibrils (the so-called Alzheimer tangle) without neuritic (senile) plaques.

Roberts et al. [1990] reinvestigated the cases in the Corsellis report using immunocytochemical methods and an antibody to the beta-protein in Alzheimer's disease plaques. All cases with substantial neurofibrillary tangle formation showed evidence of extensive beta-protein immunoreactive deposits (plaques). The data indicated that the present neuropathological description of chronic progressive traumatic encephalopathy (tangles but no plaques) should be altered to acknowledge the presence of substantial beta-protein deposition (plaques). According to the authors, the molecular markers in the plaques and tangles in the boxer's syndrome are the same as those in Alzheimer's disease. They speculated that similarities in clinical symptoms, anatomy, distribution of pathology, and neurochemical deficits make it probable that both syndromes share common pathogenic mechanisms that lead to tangle and plaque formation. The authors noted that in large studies of brain-damaged patients, an insidious dementia occurred some years after the initial trauma in 11% [Lewin et al. 1979] and 25% [Saija et al. 1988] of the patients, a rate more than double the rate of the "normal" aging population.

Tokuda et al. [1991] performed a histopathological study on the brains of ex-boxers using conventional histological staining methods and immunocytochemistry with antibodies to amyloid beta-protein and the PHF-related tau protein. All ex-boxers studied showed a large number of tau-immunoreactive neurofibrillary tangles and beta-protein immunoreactive senile plaques in the cortex. In the areas with many neurofibrillary tangles, neuropil threads with tau-immunoreactivity were also observed, and some of the senile plaque lesions were surrounded by abnormal neurites with tau-immunoreactivity. Thirty-eight percent of the boxers revealed beta-protein-type cerebrovascular amyloid deposits on both leptomeningeal and cortical blood vessels. According to the authors, the observations indicated that the cerebral pathology of

dementia pugilistica is very similar to that of Alzheimer's disease. They suggest that these two disorders share some common etiological and pathogenic mechanisms.

Jordan et al. [1997] further evaluated the relationship between chronic traumatic brain injury in 30 professional boxers (approximately equal numbers of whites, blacks, and Hispanics) and the genotypic expression of the polymorphic apolipoprotein E (APOE). The APOE genotype has been identified as a susceptibility gene for late-onset familial and sporadic Alzheimer's disease and is produced in the human liver and brain. The three common allelic forms, which give rise to six possible genotype combinations, are designated as epsilon 2, 3, and 4. Possession of the epsilon 4 allele is associated with increased risk of Alzheimer's disease in a dose-dependent fashion and shifts the age of onset distribution to earlier ages. APOE epsilon 2 is underrepresented in Alzheimer's disease populations and may protect against the disease. Jordan et al. devised a 10-point clinical chronic brain injury (CBI) scale to assess the severity of traumatic encephalopathy associated with boxing. They further classified boxers with abnormal scores according to their boxing exposure (number of professional bouts) and APOE genotype. Eleven boxers (37%) had a normal CBI score (0), and the remaining 63% exhibited abnormalities. Of those rated as abnormal, 12 showed mild deficits (CBI=1–2), 4 were moderately impaired (CBI=3–4), and 3 were severely impaired (CBI>4). High-exposure boxers (those with ≥ 12 professional bouts) had significantly higher ($P<0.001$) CBI scores (mean 2.6, standard deviation [SD] 1.9) than low-exposure boxers (mean 0.3, SD 0.7). The APOE genotype frequencies of the boxers were approximately the same as those in the general population. Boxers with low exposure had mean CBI scores of 0.33, irrespective of the APOE genotype. High-exposure boxers with the APOE epsilon 4 allele had significantly greater ($P<0.001$) CBI scores (mean 3.9, SD 2.3) than those highly exposed without the epsilon 4 allele (mean 1.8, SD 1.2). All boxers reported to have severe impairment had at least one copy of the APOE epsilon 4 allele. According to the authors, these preliminary findings suggest that possession of an APOE epsilon 4 allele is associated with increased severity of chronic neurologic deficits in high-exposure boxers. The authors further commented that this hypothesis (i.e., that APOE epsilon 4 carries a genetic predisposition to chronic traumatic brain injury) has ramifications for the regulation of health and safety in boxing and other high-risk sports, including American football, soccer, and ice hockey. They added that boxers who are a high risk could undergo more detailed neurological evaluations and therefore be better advised regarding future participation in the sport.

MECHANISMS OF BRAIN DAMAGE

Adams and Bruton [1989] histologically examined the brains of ex-boxers to determine the frequency of recent or old hemorrhage. Eighteen percent of the boxers had died of acute intracerebral bleeding, usually soon after a boxing bout, and 39% of the remaining subjects showed evidence of previous perivascular hemorrhage. A similar number showed minor degrees of meningeal or subpial siderosis consistent with previous meningeal bleeding. Cerebellar siderosis was present in 27% of the boxers. Seventy-seven percent of the boxers showed

evidence of recent or past hemorrhage. Control material showed an incidence of 11% for perivascular iron deposition and only 4% for minor degrees of meningeal siderosis.

Most boxing blows are rotational (the type most likely to cause brain injury). According to some authors [Lampert and Hardman 1984; Unterharnscheidt and Higgins 1969], translational acceleration is caused by an impact directed at the center of gravity of a freely movable mass (a straight blow to the head), whereas rotational acceleration is directed at a point that is not the center of gravity (an uppercut punch). When a blow strikes the cranium, pressure increases in the part of the brain closest to the point of impact and decreases in the opposing region. These pressure waves are reflected back and forth inside the skull until dampened. With rotational acceleration, an angular momentum component is added to the translational acceleration. Rotational acceleration of the head leads to a swirling motion of the brain [Patterson 1993]. The different layers of the brain are likely to slide and shear over each other, especially when the layers have different physical properties. The shearing can tear axons, causing diffuse brain injury.

When the head is struck, it pivots at the junction of the cervical spine and skull and in the lower cervical spine. Although the skull may not fracture, it may deform with a change in intracranial capacity and result in both positive and negative pressures. Although nerve tissue can withstand high positive pressures, the negative pressure causes rupture of small blood vessels (i.e., cavitation). Some degree of rebound (*contre-coup*) may also occur. This process adds to the damage by applying torsion within the brain to stretch and rupture the association of nerve tracts. The pressure may even be low enough to allow some bubbling out of gases such as nitrogen and oxygen dissolved in tissue; the bubbling gases can cause brain injury [Patterson 1993].

No explanation exists as to why certain areas of the brain are consistently affected in boxers. But Friedman [1989] states that some areas may be more susceptible to repeated shock waves, and vascular compromise with resulting edema may also be involved. When Atha et al. [1985] measured an experimental punch delivered by a professional boxer, it represented a transient blow of 0.63 ton to the head. This experimental punch is equivalent to a blow being delivered by a mass of 6 kg (13 lb) swung at 20 miles per hour.

Unterharnscheidt [1970] commented on the significance of successive blows in experiments with cats and rabbits. After application of only five blows of subconcussive intensity, the animals developed parapareses of the forelegs that lasted several hours without the loss of consciousness. With 10 similar blows, the parapareses of the forelegs persisted for at least several days and were more often irreversible. After 15 blows, the animals developed tetrapareses; their hindlegs showed only residual weakness after several days, but their forelegs remained paretic or clearly weakened. The muscular hypotony or atony of the affected limbs was attributed to the distribution and quality of histologic brain lesions seen in hypoxic lesions. No morphological alterations were observed after a single impact of concussive strength; however, if the same impact was repeated at 1- or 2-day intervals, the result was severe, permanent brain damage.

Creatine kinase isoenzyme BB (CK-BB) is found in high concentrations in the brain. Normally, concentrations in blood are undetectable or low. Brayne et al. [1982] measured blood concentrations of CK-BB in amateur boxers before and after a bout (three 3-minute rounds = 9 minutes) and in track cyclists before and after a 40-mile race. Blood CK-BB rose to significantly higher concentrations in the boxers than in the cyclists. The number of blows received to the head was estimated in half the boxers and correlated significantly with the rise in CK-BB. This increase in blood CK-BB may indicate disruption of the blood-brain barrier. The increased level is similar to levels found with mild head injuries and may be one of the mechanisms accounting for brain damage in boxers.

OTHER NON-NEUROLOGICAL EFFECTS

Schmid [1970] addressed lesions of the kidneys, which are seldom caused by legal punches. He concluded that post-fight proteinuria, microscopic hematuria, and cylindruria in healthy boxers are not the consequences of injury but of physiological phenomena similar to those found in other sports after muscular effort. Hoppes et al. [1991] confirmed these observations in a study of amateur boxers.

Birrer [1993] reported that there is little information available on truncal injuries (chest and abdomen) in boxing which comprise approximately 5 to 7% of the reported injuries, although some prevalence rates may double this figure [Enzenauer et al, 1989]. Soft tissue injury, i.e., sprains, strains, contusions, abrasions, lacerations, make up 80 to 90% of truncal injuries. Bone (fractures, for example of the rib causing pneumothorax, and dislocations/subluxations) and nerve injuries account for 5 to 10%. Visceral organ injury (heart, spleen, kidney, etc.) constitutes the remaining 10 to 15%. This author stated that renal injury is the most common visceral injury. He also noted that there have been a number of fatal injuries in boxing related to direct blows to the pericordium and upper abdominal quadrants and the pathology has been attributed to hemorrhage, myocardial infarction/contusion, ventricular aneurysm, and rupture.

Schmid et al. [1968] reported on a 19-year-old boxer who, after receiving several chest and neck blows, lost his breath and suffered complete cardiac arrest. Blunt flat blows to the thorax or abdomen cause a marked stimulation of the vagal nerve; this condition reduces cardiac action (vaso-vagal reflex). Blows to the solar plexus result in similar effects on the circulatory system. Also, a slowdown and even arrest of cardiac actions may occur when the eye and surrounding areas are hit (Aschner-Dagnini reflex). Unterharnscheidt [1970] commented that the compression of the blood vessels leading to the brain, especially the carotid arteries, leads to mechanical irritation of the carotid sinus. This condition may provoke a syndrome with decreased cardiac beat, cardiac arrest, abrupt fall of blood pressure, and unconsciousness. Brown and King [1993] reviewed the cardiovascular evaluation of the boxer and cited the role of the physician to identify those boxers who have cardiac abnormalities, particularly those that place the athlete at high risk for sudden death.

Whiteson [1981] noted that cauliflower ear, the trademark of the professional boxer before World War II, has virtually disappeared because of the vigilant actions of referees; however, a boxer occasionally receives a direct blow to the ear and sustains a traumatic perforation of the ear drum. Seltzer [1967] stated that more than 25% of professional boxers sustain perforated eardrums and eventual loss of hearing.

Williams [1981] called attention to special medical considerations that ringside physicians need to give to boxers of African heritage. These include the following:

- Keloid tumor formation, especially as a result of cuts and lacerations about the eyes
- Incarceration, strangulation, or rupture of an umbilical hernia after blunt abdominal trauma
- Sickle cell trait, which involves about 8% of the African-American population and may lead to hypoxia, acidosis, cramping, pain, and damage to tissues and organs—especially at high altitudes
- Hypertension, which is present in more than 27% of this population and can lead to increased risk of cerebral hemorrhage, coronary occlusion, renal failure, and decreased survival rate in serious injury

FRACTURES

Fracture of the first metacarpal bone is the most frequent skeletal injury [Noble 1987], but jaw fractures are rare. Strano and Marais [1983] presented a case report of an adult boxer with an isolated vertical fracture of the anterior arch of the atlas. The authors stated that cervical vertebral injuries are rare in boxing. In their review of the literature, Guterman and Smith [1987] also concluded that cervical spine injuries were rare in boxing. They added that this type of injury was more likely to occur when the boxer was in a “groggy” state and less able to maintain the normal extension of the neck muscles.

Nasal injury of the cartilage is relatively common; however, fractured nasal bones are rare. Fractures of the skull are rare, but those of the jaw occur at the rate of about two per season [Blonstein 1966].

Sixty-nine percent of boxers who had been Finnish, Scandinavian, or European champions had hand fractures, and 43% had nose fractures [Kaste et al. 1982].

OCULAR INJURY

Smith [1988] found that 21% of the boxers examined had pronounced ocular damage and 4% had multiple problems. Cataracts accounted for almost half of the damage. Nineteen percent of boxers examined with dilation had vitreoretinal pathology, which included holes, retinal tears, lattice, and old vitreous hemorrhage. The average age of the group was 24; the average age of those who had pathological findings was 27. The mean number of professional bouts was 15 (range 0–79), but the mean was 17 for those with pathological findings. The author commented that many of the boxers had fought hundreds of amateur bouts, and all of the boxers had sparred innumerable rounds; so total exposure time was impossible to quantify. Smith [1988] also reported that in a large unpublished study of professional boxers between 1982 and 1986, 20% had ocular problems—most common cataract formation.

Enzenauer and Mauldin [1989] studied ocular injuries attributable to military boxing as a subset of a larger study of boxing-related injuries. Ocular injuries occurred in 5% of soldiers hospitalized for boxing-related trauma between 1980 and 1985. Of those soldiers, 68% were admitted with ocular injury as the primary cause. Ocular injuries resulted in a longer hospitalization and disability than all other boxing injuries. One soldier was blind in one eye after complications from a ruptured globe.

Palmer et al. [1976] documented contusion angle deformity in 8% of 55 former boxers; the authors described cataracts and retinal detachments among several of those examined. Whiteson [1981] stated that retinal detachments were uncommon in boxing. However, Maguire and Benson [1986] described traumatic retinal injuries, including 8 (89%) retinal detachments in a group of 9 boxers over a 2-year period. Vitreous hemorrhage, retinal detachment, and various other ocular injuries can result in serious visual impairment; and unless the macula is disturbed, most boxers are unaware of having the most common ocular injuries associated with boxing.

Reasons for such variable results may stem from the problems in the selection of a representative series of boxers. In a study of visually asymptomatic boxers, vision-threatening injuries were defined as significant damage to the angle, lens, macula, or peripheral retina; they occurred in 58% of boxers [Giovinazzo et al. 1987]. This study was performed in cooperation with the New York State Athletic Commission and examined 74 boxers ranging from age 16 to 42 (mean age, 25) applying for a new or yearly renewal license over a 2-year period. Sixty-six percent of boxers had at least one ocular injury. Nineteen percent of boxers had pathological cataracts, more than 70% of which were posterior subcapsular. Eight percent had macular lesions. Twenty-four percent had retinal tears. The presence of retinal tears was significantly correlated with the total number of bouts, and the total number of losses and rose steeply after six bouts. After 100 bouts, nearly all of the study boxers had suffered retinal tears. The relationship between retinal tears and losses was almost linear. Significant differences were found between boxers and college varsity athletes (who served as a comparison group) in the total number of injuries, total vision-threatening injuries, and the number of retinal tears.

A 1989 study reported by Sills of ocular exams on 286 boxers, he found 10% to have cataracts and this figure is identical to that reported by Smith [1988].

BLOODBORNE DISEASE: ACQUIRED IMMUNODEFICIENCY SYNDROME

A Bulgarian boxing referee proposed to the international boxing community [Punching AIDS 1988] that all boxers be tested for acquired immunodeficiency syndrome (AIDS) before they enter the ring. He also requested that boxing gloves be disinfected between rounds and that bouts be ended as soon as one of the boxers was cut and bleeding. Nevada's Athletic Commission requires periodic AIDS antibody testing of anyone who boxes in that State, and New Jersey fight officials require persons assisting a boxer in the boxer's corner between rounds to wear plastic gloves to prevent human immunodeficiency virus (HIV) transfer from an infected person (e.g., while attempting to stop a boxer's bleeding before the next round) [AIDS antibody testing required for boxers in Nevada 1988]. Jordan [1993] stated that there was no documentation that the AIDS virus could be transferred from an infected boxer to another boxer, ring official, or spectator. He also added that although the possibility of transmission of AIDS virus is extremely remote, the boxer who tests positive should probably not be allowed to spar or box competitively. Drotman [1996] specifically recommended against AIDS testing in boxers and instead recommended the adherence to guidelines that virtually all major athletic organizations have adopted, including those at scholastic, collegiate, professional, and international levels. When a bleeding injury occurs, the guidelines recommend that the game or match be stopped, that all bleeding athletes receive care as soon as practical, and that the injured players not resume participation until the bleeding is halted and the wound is dressed. The risk of HIV transmission has been judged to be low in all sports [Drotman 1996].

6 MODIFIERS OF INJURY RISKS

Three factors appear to be essential in helping to reduce the risk of injury in professional boxers. These main categories originated from various organizations and individuals offering recommendations to improve the sport and lessen the risk of serious injury and death. The recommendations can be found in Appendices 4 and 5 of this report.

EDUCATION AND TRAINING OF RING PERSONNEL

The only literature found that addresses training stems from the New York State Athletic Commission recommendations [Novich and Amboy 1988]. The commission called for a National or Local Boxing Commission to provide training courses, medical seminars, and boxing safety conferences and require mandatory attendance for license approval and renewal. McCunney and Russo [1984] recommended a national council to sponsor seminars for physicians and other ringside personnel.

EQUIPMENT (HEADGEAR, MOUTH PROTECTION, GLOVES, RING SURFACE, AND TURNBUCKLES)

Headgear

Johnson et al. [1975] measured the acceleration forces in a typical translational (linear) blow and compared the forces with a severity index used by the automotive industry for testing crash safety of vehicles. They found that the linear acceleration forces encountered in unprotected boxing exceeded the safety limit for vehicles by a factor of four.

In 1966 new rules were published in Czechoslovakia that allowed boxing only with headgear and 10-ounce gloves [Schmid et al. 1968]. The headgear weighs 400 grams, does not have padding, and does not hinder head motion. The investigators tested the efficiency of the headgear in decreasing skull acceleration using three different types of blows: frontal, side, and on the jaw. The headgear reduced short-time acceleration of the skull bone from 250 to 175 meters per second squared (m/sec^2), a 70% reduction from a frontal blow. Acceleration fell from 180 to 110 m/sec^2 , a 60% reduction with headgear for a side blow. For jaw blows, the change in acceleration was hardly perceptible. However, measurements taken when headgear was used showed that the protective effects depended on the boxer's ability to catch the blow. On the average, according to the authors, the decrease in acceleration due to the headgear is about 15% to 25%. Schmid et al. [1968] also compared the incidence of KOs before and after the introduction of headgear in amateur matches. Following 605 contests, the incidence of KOs with headgear was 0.8% compared with 3% to 4% before the mandatory use of headgear. However, this reduction may have been confounded by the introduction of 10-ounce gloves and better

work by the referee. Another positive outcome of the introduction of headgear was the reduction of eyebrow (“cut eye”) injury from 8.8% of all boxing injuries to 0%.

Ryan [1983] estimated that protective headgear could drop the force of a punch from 1,000 to 500 pounds. Jordan [1987] hypothesized that to design headgear that provides protection from acute brain injury in boxing would be difficult because the mechanism of damage usually involves acceleration and deceleration [Moore 1980]. Guterman and Smith [1987] cited the requirement of protective headgear in Olympic competition, but they questioned its effectiveness because of its current design. They raised the issue of using any headgear “short of a really efficient crash helmet which effectively absorbs these forces without transmitting through the skull” because it does not protect the boxer from head trauma. Smith [1988] recommended the use of a protective helmet and eye guard (similar to a hockey shield) in sparring sessions to reduce the risk of injury.

Schmidt-Olsen et al. [1990] demonstrated that the introduction of “safety measures” in amateur boxing had no effect on the number of bouts stopped because of cerebral injury. Of 5,272 matches fought, 3,240 were senior matches (participants were over age 19) and 2,032 were junior matches (participants were aged 17 to 19). Prophylactic intervention consisted of unlimited length of hand bandages, voluntary use of boxing helmets (about 60% usage), and heavier gloves (10-ounce) for boxers who weigh more than 149 pounds. The authors suggested that the headgear is not effective in decreasing the risk of traumatic encephalopathy. However, these results were from amateur boxing contests where the point scoring system does not favor KOs. Some investigators argue that headgear may increase the risk [Porter and Fricker 1996]. Jordan [1990a] disagreed with the conclusion that headgear does not provide safety to the brain since it has not been substantiated in long-term studies. He further commented on the relatively low frequency of bouts stopped following KOs or blows to the head in amateur boxing. Only about 10% of bouts were terminated for these reasons; this rate is comparable to a reported 8.7% at the U.S.A. National Amateur Boxing Championships [Estwanik et al. 1984].

Wedrich et al. [1993] described two styles of headgear used in amateur boxing. One is typically used in sparring and is made of hard leather pads from 1 to 2 centimeters thick. This headgear protects the forehead and ears and surrounds the orbit superiorly, temporally, and inferiorly; together with the bridge of the nose, padding creates an artificial enophthalmos. This design protects the globe of the eye from blows delivered inferotemporally. In contrast, the pads of the headgear used for bouts, which are thinner, do not cover the cheekbone and leave the inferior orbital rim of the eye unprotected.

Mouth Protection

Schwartz and Novich [1980] addressed several needs in the design of athletes’ mouthpieces. The mouthguard is a very important piece of protective equipment. It prevents the premature loss of teeth, which could lead to changes in vasculature and nervous structures of the nasal sinus and

affect the filtration system. These authors believe that jaw position can be changed by loss of teeth, which could alter the size of the airway, performance of musculature, and aerobics of the athlete under conditions of extreme exertion. The well-fitted mouthguard should cover the upper teeth on the lips and biting surfaces. The double mouthguards that cover the upper and lower teeth may not provide adequate airway space for breathing if a boxer is experiencing nasal obstruction secondary to a recent or remote nasal injury. Williams and Jordan [1993] mentioned that in addition to protecting the oral cavity, mouthguards may also dissipate forces that are transmitted through the intracranial cavity, particularly when a blow is delivered to the lower jaw. However, they add that since most knockouts are a result of rotational acceleration, it is unlikely that the mouthguard will prevent most knockouts. These authors described three types, which include the stock, mouth-formed, and custom-formed. The stock type, usually made of latex rubber and held in place by constant occlusal pressure, is not recommended in boxing because the design does not provide a personal fit. Mouth-formed protectors consist of a firm outer shell and soft inner substance that is thermally or chemically molded over the individual's teeth. Custom-formed mouthpieces require a dentist for fabrication and usually provide cover for the maxillary teeth. The latter two were recommended by the authors for boxers.

Gloves

The mechanical processes during the transfer of energy of the blow were tested in gloves, typically with leather and padding of equal weight [Unterharnscheidt 1970]. Gloves of 6 to 16 ounces were tested mechanically for their characteristics and effectiveness by measuring acceleration of the boxer's head and tolerance curves. The velocity achieved by a 6-ounce glove was 2.7 times greater than that of a 16-ounce glove. During repeated blow measurements, higher accelerations were registered from the last blow. This finding indicates that the material retained some deformation.

According to Jordan [1987], the weight of the boxing glove influences the force of a blow delivered to the head. Ten-ounce gloves are used in amateur matches, and 8-ounce gloves are used by professionals. Jordan stated that the larger glove has the greater cushioning effect, but this may be counterbalanced by the sweat the glove absorbs during a bout, which further increases its weight. Moore [1980] also mentioned that the heavier gloves used in professional bouts may not provide the extra cushioning intended with the design because the gloves absorb sweat over a period of 10 to 15 rounds and create a pendulum effect. Ryan [1983] stated that eliminating the boxing glove would eliminate some forms of KO punches (such as hooks and roundhouse punches) because the lack of gloves would more readily lead to hand fractures than the less forceful straight punch.

Smith [1988] recommended the use of thumbless gloves to reduce eye injuries. Sills [1993] commented that to be fully effective, thumbless gloves would have to be worn for all bouts and during all sparring sessions. The Everlast Company has designed a thumbless glove with 50% additional padding and no additional weight; however, boxers are reluctant to use these gloves

because of the difficulty of making a fist in them. Smith further stated that thumbless gloves might prevent corneal abrasions but would not prevent the concussive blows that are responsible for serious intraocular problems.

Strano and Marais [1983] recommended the use of brightly colored gloves (e.g., orange, so that they would be more noticeable and provide the defender with more time to prepare for oncoming blows).

Schwartz et al. [1986] demonstrated the effectiveness of heavier gloves in attenuating impact forces. Porter and Fricker [1996] theorized that because heavier gloves are larger, the blocking of punches is easier.

Sirb [1997] stated that many, if not all, States now require the use of “thumbless” gloves. He also stated that no State has allowed the use of anything smaller than an 8-ounce glove since the late 1980s, and he added that the 6-ounce glove was abolished. Sirb reported that boxers weighing less than 147 pounds use 8-ounce gloves and boxers weighing more use 10-ounce gloves.

Ring Surface

As part of the knockdown, boxers hit the ropes or mat. Falls on the back of the head produce rapid deceleration of the brain, which typically results in contrecoup contusions of the orbital surfaces of the frontal lobes of the brain and the tips of the temporal lobes. The crests of the convolutions are torn apart, resulting in possible parenchymal and subarachnoid hemorrhages. Gliding contusions as well as subdural hematomas may result from impact deceleration [Lundberg 1985]. Questions have been raised about the amount and type of padding that is sufficient (i.e., felt versus foam [open or closed]), but no references were found in the literature. McCunney and Russo [1984] cited the New York Athletic Commission as recommending changes in the padding under the canvas of the ring from felt to “ensolite” fiberboard. The fiberboard would reduce mortality by preventing back-and-forth rocking of the head on impact.

Turnbuckles

We have located no references in the literature on turnbuckles.

MEDICAL SUPERVISION

Blonstein and Clarke [1957] demonstrated that careful control of boxing reduces morbidity. Close medical supervision is clearly important [Hazards of boxing 1969]. Various authors and boxing authorities recommend improvements in the medical supervision of professional boxers. These authorities consider their recommendations essential for reducing neuropsychiatric consequences. They include strict physical and psychological examinations before and after

bouts, limitation of the number of bouts fought each year, and compulsory retirement if brain injury becomes evident. These measures are very similar to current medical controls for amateur boxers.

The American Medical Association Council on Scientific Affairs [1983] commented that in recent years, medical supervision of boxing has improved in some boxing jurisdictions and that such precautions minimize and may even prevent acute intracranial hemorrhage and death. Improvements were noted in the following areas: (1) basic standards and requirements for the medical examination of boxers, (2) adequate medical supervision and equipment for the boxer at ringside, and (3) periodic examination and evaluation of boxers who are at an increased risk of injury.

The activities of the New York State Athletic Commission provide one example of improved medical supervision of professional boxers. Following the death of a boxer in 1979, the Commission made a series of changes in its boxing rules and practices. A boxer must have a passport to box in New York, and all medical and previous boxing data are checked by computer before he receives clearance for a bout. The State assigns two physicians at ringside before the start of any boxing match; each physician can enter the ring at any time and stop the bout for medical reasons. A boxing match is never started until an ambulance and emergency equipment are on the premises. The State also authorizes suspensions for medical reasons. If lacerations of the face occur, a boxer may be suspended for 60 days; a TKO, with minor injuries entails a suspension of 30 days, and a boxer with head injuries receives a 45-day suspension. A boxer with immediate response to a KO receives a 60-day suspension, and a boxer with a slow response receives a 90-day suspension plus a CT scan. However, no reports have analyzed the outcomes of the rule changes.

According to Sirb [1997], “safety” features are now in place in many States because of the dialogue and meetings that have occurred through the Association of Boxing Commissions. Since the early 1990s, professional boxing has been concentrated in seven States: California, Florida, Pennsylvania, New Jersey, Nevada, New York, and Texas. In each of these States, KOs or TKOs carry mandatory medical suspensions. These cases are reported to the central Suspension Report, which is currently kept by Florida and sent to all State Commissions. Some laws (States were unspecified) mandate that at least one physician be at ringside at all times along with an ambulance having appropriate resuscitation equipment. In Pennsylvania, a five-member medical advisory board reviews all medical problems and situations. Pennsylvania is one of the few States that require a physician (doctor of medicine or osteopathy) to be a “voting” member of the commission. Sirb [1997] also noted that many of the boxing States (an unspecified number) hold annual medical seminars for their ring personnel; and in Pennsylvania, the law requires such seminars. In addition, many States (also an unspecified number) give the ringside physician the authority to stop a bout at any time. In Pennsylvania, this authority is the law, and Sirb [1997] recommended that it be the law in all States. Sirb added that, in his opinion, the medical prefight and postfight examinations are only part of the solution to preventing boxing injuries. He stated that injuries occur more often through mismatches than through the

lack of adequate physical examinations. He noted that any State can demand medical examinations for their boxers; but if a boxer's style is poorly understood or if a boxer's previous record is not examined or is unknown, the boxer is more likely to be mismatched and thus suffer more traumatic injuries.

Ludwig [1986] described the Swedish model for amateur boxing, which consists of the following:

- No boxing is allowed before the age of 15; from age 10 to 15, only technical training is permitted. In competition, points are counted for different technical details, and a boxer earns a diploma for good technique.
- Boxers younger than age 19 are scored on points. If knocked out, the boxer is forced to rest for at least 1 month. A second KO requires 3 months of rest, and each period of rest requires a neurological examination before fighting can resume. A ring physician can order rest after an extremely hard bout in which a boxer has received many blows to the head.
- Every boxer must have a "startbook" from the boxer's first bout. This book contains a photograph, name, address, and club. Initial medical examination findings and a record of every match are entered; included are the opponent's name, result of the bout, record of any KO, and the physician's notes.
- A committee checks the startbooks each year before the boxer is allowed to continue fighting. The boxer has one major medical examination each year that includes tests of fitness, vision, hearing, and a neurological examination. Every boxer who has had more than 100 matches is seen by a neurologist for examination and electroencephalography. This same examination applies to all boxers over age 30.
- Before every match, the ring physician examines the boxer for heart rate and temperature; inspects the eyes, throat, and hands; and auscultates the heart and lungs. If the boxer has more than one bout in a tournament, the boxer is examined between bouts for pupil reaction, finger-nose and finger-finger coordination, diadochokinesis, and strength of the hands; he is also given the Romberg test with the eyes shut. The ring physician examines the boxer after each bout.

Jordan [1988] explained that when an amateur boxer is medically suspended in the United States, the national office is notified, the boxer is prohibited from fighting, and the boxer's passport is taken away. The passport documents the outcome of previous bouts and provides an updated account of the boxer's activities. Presentation of this passport is mandatory before any amateur boxer can participate in competition.

7 CONCLUSIONS AND RECOMMENDATIONS

In response to provisions of the Professional Boxing Safety Act of 1996 (enacted by Congress on October 9, 1996), NIOSH reviewed the medical and related literature to develop recommendations for health, safety, and equipment standards for the sport of boxing and professional boxing matches. This literature review has documented that professional boxing is a uniquely dangerous sport because it involves repeated, intentional blows to the head and other vital organs for the purpose of incapacitating the opponent. The review indicated that such intentional and repeated blows to the head result in very high rates of irreversible acute and chronic brain damage, neurological impairments (cognitive, perceptual, visual, auditory, and emotional), serious eye damage, and premature death compared with other occupations.

Amateur boxing is fairly well supervised in the United States through several national organizations, and it differs from professional boxing in scoring, the shorter duration of bouts, more stringent rules, better regulatory policies, strict medical evaluations, and mandatory use of protective devices. This review clearly shows that amateur boxing is much less risk-prone than professional boxing because of these tighter controls. Many studies lack adequate numbers of subjects, and the bases for making exact calculations of injury and death rates do not exist; however, the literature review demonstrates that many measures can be adopted from the amateur sport to reduce the risk of major injuries experienced by professionals.

Professional boxing is not well controlled nationally, but exceptions can be found in some local or State jurisdictions. Overall, the causes for the elevated risks in the professional sport are many: the supervision of the sport is carried out worldwide through numerous uncoordinated national, State, and local boxing commissions; currently, no credible or reliable central system of records exists; adequate training of ringside personnel is lacking; no minimum standardized medical examinations are enforced for licensing; the sport lacks a mechanism for certifying and standardizing equipment; and no minimum system of suspensions is enforced. With some exceptions, ringside physicians across the United States are not independent of the boxing industry promoters and may not have the independent authority to deny or reissue licenses, grant suspensions or stop bouts for medical reasons, or declare mismatches because of the opponent's lack of ability.

This literature review also reveals that more research is needed to (1) understand the short- and long-term risks of injury, disease, and death through better surveillance records; (2) develop better safety equipment for use by professional boxers during matches, sparring, and training; and (3) improve the training of ringside personnel.

The literature reports many recommendations by various medical authorities, individual physicians, boxing commissions, etc. These recommendations can be used to formulate a national strategy for professional boxing. The detailed recommendations appear in Appendices 4 and 5 of this document.

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APPENDIX 1

PROFESSIONAL BOXING ACT OF 1996

Public Law 104-272
104th Congress

An Act

Oct. 9, 1996—[H.R. 4167] To provide for the safety of
journeymen boxers, and for other purposes.

Be it enacted by the Senate and House of Representatives of the
United States of America in Congress assembled, Professional
Boxing Safety Act of 1996

15 USC 6301, note SEC. 1. SHORT TITLE.

This Act may be cited as the “Professional Boxing Safety Act of
1996.”

SEC. 2. DEFINITIONS.

For purposes of this Act:

(1) Boxer.—The term “boxer” means an individual who
fights in a professional boxing match.

(2) Boxing commission.—(A) The term “boxing commission”
means an entity authorized under State law to regulate
professional boxing matches.

(3) Boxer registry.—The term “boxer registry” means any
entity certified by the Association of Boxing Commissions for
the purposes of maintaining records and identification of
boxers.

(4) **Licensee.**—The term “licensee” means an individual who serves as a trainer, second, or cut man for a boxer.

(5) **Manager.**—The term “manager” means a person who receives compensation for service as an agent or representative of a boxer.

(6) **Matchmaker.**—The term “matchmaker” means a person that proposes, selects, and arranges the boxers to participate in a professional boxing match.

(7) **Physician.**—The term “physician” means a doctor of medicine legally authorized to practice medicine by the State in which the physician performs such function or action.

(8) **Professional boxing match.**—The term “professional boxing match” means a boxing contest held in the United States between individuals for financial compensation. Such term does not include a boxing contest that is regulated by an amateur sports organization.

(9) **Promoter.**—The term “promoter” means the person primarily responsible for organizing, promoting, and producing a professional boxing match.

(10) **State.**—The term “State” means each of the 50 States, Puerto Rico, the District of Columbia, and any territory or possession of the United States.

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15 USC 6302. SEC. 3. PURPOSES.

The purposes of this Act are—

(1) to improve and expand the system of safety precautions that protects the welfare of professional boxers; and

(2) to assist State boxing commissions to provide proper oversight for the professional boxing industry in the United States.

15 USC 6303. SEC. 4. BOXING MATCHES IN STATES WITHOUT BOXING COMMISSIONS.

No person may arrange, promote, organize, produce, or fight in a professional boxing match held in a State that does not have a boxing commission unless the match is supervised by a boxing commission from another State and subject to the most recent version of the recommended regulatory guidelines certified and published by the Association of Boxing Commissions as well as any additional relevant professional boxing regulations and requirements of such other State.

15 USC 6304. SEC. 5. SAFETY STANDARDS.

No person may arrange, promote, organize, produce, or fight in a professional boxing match without meeting each of the following requirements or an alternative requirement in effect under regulations of a boxing commission that provides equivalent protection of the health and safety of boxers:

- (1) A physical examination of each boxer by a physician certifying whether or not the boxer is physically fit to safely compete, copies of which must be provided to the boxing commission.
- (2) Except as otherwise expressly provided under regulation of a boxing commission promulgated subsequent to the enactment of this Act, an ambulance or medical personnel with appropriate resuscitation equipment continuously present on site.
- (3) A physician continuously present at ringside.
- (4) Health insurance for each boxer to provide medical coverage for any injuries sustained in the match.

15 USC 6305. SEC. 6. REGISTRATION.

(a) Requirements.—Each boxer shall register with—

- (1) the boxing commission of the State in which such boxer resides; or
- (2) in the case of a boxer who is a resident of a foreign country, or a State in which there is no boxing commission, the boxing commission of any State that has such a commission.

(b) Identification Card.—

(1) Issuance.—A boxing commission shall issue to each professional boxer who registers in accordance with subsection

(a), an identification card that contains each of the following:

(A) A recent photograph of the boxer.

(B) The social security number of the boxer (or, in the case of a foreign boxer, any similar citizen identification number or professional boxer number from the country of residence of the boxer).

(C) A personal identification number assigned to the boxer by a boxing registry.

(2) Renewal.—Each professional boxer shall renew his or her identification card at least once every 2 years.

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(3) Presentation.—Each professional boxer shall present his or her identification card to the appropriate boxing commission not later than the time of the weigh-in for a professional boxing match.

NOTE: 15 USC 6306. SEC. 7. REVIEW.

(a) Procedures.—Each boxing commission shall establish each of the following procedures:

(1) Procedures to evaluate the professional records and physician's certification of each boxer participating in a professional boxing match in the State, and to deny authorization for a boxer to fight where appropriate.

(2) Procedures to ensure that, except as provided in subsection (b), no boxer is permitted to box while under suspension from any boxing commission due to--

(A) a recent KO or series of consecutive losses;

(B) an injury, requirement for a medical procedure, or physician denial of certification;

(C) failure of a drug test; or

(D) the use of false aliases, or falsifying, or attempting to falsify, official identification cards or documents.

(3) Procedures to review a suspension where appealed by a boxer, including an opportunity for a boxer to present contradictory evidence.

- (4) Procedures to revoke a suspension where a boxer--
- (A) was suspended under subparagraph (A) or (B) of paragraph (2) of this subsection, and has furnished further proof of a sufficiently improved medical or physical condition; or
 - (B) furnishes proof under subparagraph (C) or (D) of paragraph (2) that a suspension was not, or is no longer, merited by the facts.

(b) Suspension in Another State.—A boxing commission may allow a boxer who is under suspension in any State to participate in a professional boxing match—

- (1) for any reason other than those listed in subsection (a) if such commission notifies in writing and consults with the designated official of the suspending State's boxing commission prior to the grant of approval for such individual to participate in that professional boxing match; or
- (2) if the boxer appeals to the Association of Boxing Commissions, and the Association of Boxing Commissions determines that the suspension of such boxer was without sufficient grounds, for an improper purpose, or not related to the health and safety of the boxer or the purposes of this Act.

NOTE: 15 USC 6307. SEC. 8. REPORTING.

Not later than 48 business hours after the conclusion of a professional boxing match, the supervising boxing commission shall report the results of such boxing match and any related suspensions to each boxer registry.

NOTE: 15 USC 6308. SEC. 9. CONFLICTS OF INTEREST.

No member or employee of a boxing commission, no person who administers or enforces State boxing laws, and no member of the Association of Boxing Commissions may belong to, contract with, or receive any compensation from, any person who sanctions, arranges, or promotes professional boxing matches or who otherwise has a financial interest in an active boxer currently registered with a boxer registry. For purposes of this section, the term “compensation” does not include funds held in escrow for payment to another person in connection with a professional boxing match. The prohibition set forth in this section shall not apply to any contract entered into, or any

reasonable compensation received, by a boxing commission to supervise a professional boxing match in another State as described in Section 4.

NOTE: 15 USC 6309. SEC. 10. ENFORCEMENT.

(a) Injunctions.—Whenever the Attorney General of the United States has reasonable cause to believe that a person is engaged in a violation of this Act, the Attorney General may bring a civil action in the appropriate district court of the United States requesting such relief, including a permanent or temporary injunction, restraining order, or other order, against the person, as the Attorney General determines to be necessary to restrain the person from continuing to engage in, sanction, promote, or otherwise participate in a professional boxing match in violation of this Act.

(b) Criminal Penalties.—

(1) Managers, promoters, matchmakers, and licensees.—Any manager, promoter, matchmaker, and licensee who knowingly violates, or coerces or causes any other person to violate, any provision of this Act shall, upon conviction, be imprisoned for not more than 1 year or fined not more than \$20,000, or both.

(2) Conflict of interest.—Any member or employee of a boxing commission, any person who administers or enforces State boxing laws, and any member of the Association of Boxing Commissions who knowingly violates Section 9 of this Act shall, upon conviction, be imprisoned for not more than 1 year or fined not more than \$20,000, or both.

(3) Boxers.—Any boxer who knowingly violates any provision of this Act shall, upon conviction, be fined not more than \$1,000.

NOTE: 15 USC 6310. SEC. 11. NOTIFICATION OF SUPERVISING BOXING COMMISSION.

Each promoter who intends to hold a professional boxing match in a State that does not have a boxing commission shall, not later than 14 days before the intended date of that match, provide written notification to the supervising boxing commission designated under Section 4. Such notification shall contain each of the following:

(1) Assurances that, with respect to that professional boxing match, all applicable requirements of this Act will be met.

(2) The name of any person who, at the time of the submission of the notification—

(A) is under suspension from a boxing commission; and

(B) will be involved in organizing or participating in the event.

(3) For any individual listed under paragraph (2), the identity of the boxing commission that issued the suspension described in paragraph (2)(A).

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NOTE: 15 USC 6311. SEC. 12. STUDIES.

(a) Pension.—The Secretary of Labor shall conduct a study on the feasibility and cost of a national pension system for boxers, including potential funding sources.

(b) Health, Safety and Equipment.—The Secretary of Health and Human Services shall conduct a study to develop recommendations for health, safety, and equipment standards for boxers and for professional boxing matches.

(c) Reports.—Not later than one year after the date of enactment of this Act, the Secretary of Labor shall submit a report to the Congress on the findings of the study conducted pursuant to subSection (a). Not later than 180 days after the date of enactment of this Act, the Secretary of Health and Human Services shall submit a report to the Congress on the findings of the study conducted pursuant to subSection (b).

NOTE: 15 USC 6312. SEC. 13. PROFESSIONAL BOXING MATCHES CONDUCTED ON INDIAN RESERVATIONS.

(a) Definitions.—For purposes of this Section, the following definitions shall apply:

(1) Indian tribe.—The term “Indian tribe” has the same meaning as in Section 4(e) of the Indian Self-Determination and Education Assistance Act (25 U.S.C. 450b(e)).

(2) Reservation.—The term “reservation” means the geographically defined area over which a tribal organization exercises governmental jurisdiction.

(3) Tribal organization.—The term “tribal organization” has the same meaning as in Section 4(l) of the Indian Self-Determination and Education Assistance Act (25 U.S.C. 450b(l)).

(b) Requirements.—

(1) In general.—Notwithstanding any other provision of law, a tribal organization of an Indian tribe may, upon the initiative of the tribal organization—

(A) regulate professional boxing matches held within the reservation under the jurisdiction of that tribal organization; and

(B) carry out that regulation or enter into a contract with a boxing commission to carry out that regulation.

(2) Standards and licensing.—If a tribal organization regulates professional boxing matches pursuant to paragraph (1), the tribal organization shall, by tribal ordinance or resolution, establish and provide for the implementation of health and safety standards, licensing requirements, and other requirements relating to the conduct of professional boxing matches that are at least as restrictive as—

(A) the otherwise applicable standards and requirements of a State in which the reservation is located; or

(B) the most recently published version of the recommended regulatory guidelines certified and published by the Association of Boxing Commissions.

NOTE: 15 USC 6313. SEC. 14. RELATIONSHIP WITH STATE LAW.

Nothing in this Act shall prohibit a State from adopting or enforcing supplemental or more stringent laws or regulations not inconsistent with this Act, or criminal, civil, or administrative fines for violations of such laws or regulations.

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NOTE: 15 USC 6301 note. SEC. 15. EFFECTIVE DATE.

The provisions of this Act shall take effect on January 1, 1997, except as follows:

(1) Section 9 shall not apply to an otherwise authorized boxing commission in the Commonwealth of Virginia until July 1, 1998.

(2) Sections 5 through 9 shall take effect on July 1, 1997.

Approved October 9, 1996.

LEGISLATIVE HISTORY—H.R. 4167 (H.R. 1186) (S. 187):

HOUSE REPORTS: No. 104-833, Pt. 1 accompanying H.R. 1186 (Comm. on Commerce).

SENATE REPORTS: No. 104-159 accompanying S. 187 (Comm. on Commerce, Science, and Transportation).

CONGRESSIONAL RECORD:

Vol. 141 (1995):

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APPENDIX 2

AMATEUR BOXING INJURIES: DETAILS OF THE LITERATURE

Thomassen et al. [1979] performed a study of neurological, electroencephalographic and neuropsychological examinations of 53 former amateur boxers after the introduction of modern medical supervision and safety precautions. These results were compared with those of a comparison group of 53 former football players. Complaints, neurological findings, and electroencephalographic changes were identical in the boxers and comparison group. Only minor neuropsychological disturbances were found in the boxers; the most pronounced was impaired motor function of the left hand. These minor disturbances were further demonstrated by comparing 19 pairs, each consisting of one boxer and one football player, matched according to age, education, and vocabulary. No relation could be demonstrated between abnormal findings and "occupational exposure" during the boxing career. The authors concluded the existing safety precautions protected the amateur boxers against serious and permanent brain damage.

Brooks et al. [1987] performed neuropsychological examinations on 29 amateur boxers and 19 comparison groups matched for age (15 to 27 years), ethnicity, and education. No evidence was found of significantly impaired performance in the boxers. A range of cognitive procedures was used for the examinations (e.g., verbal and visuospatial memory, attention, information processing, motor function, and intellectual abilities). Within the boxing group, a variety of features of boxing history were examined as possible predictors of cognitive performance (such as number of KOs and duration of boxing career). No feature was a significant predictor of lower cognitive performance in this sample of amateur boxers that represented only 39% of the sample population initially chosen. The authors commented that those who refused to participate may have had a subjective awareness of impairments. The ratio of wins to losses (18/8) was higher than expected in those who participated in the cognitive performance test.

McLatchie et al. [1987] studied 20 active amateur Scottish boxers aged 18 to 49 (number of bouts ranged from 4 to 200) for evidence of early neurological dysfunction. Seven (35%) of these boxers had abnormal clinical neurological examination results, 8 (40%) had an abnormal EEG, and 9 of 15 examined (60%) had abnormal neuropsychometry. The CT scan, which detects severe degrees of damage, was abnormal in only one 32-year-old boxer who had fought 140 bouts. Abnormal clinical examination results correlated significantly ($P < 0.05$) with an increasing number of bouts. An abnormal EEG correlated significantly with decreasing age ($P < 0.05$) and was not thought to be due to brain damage but related to the young population with less mature brains. In several of the neuropsychometric tests, the boxers were significantly worse than the comparison group ($P < 0.05$), made up of orthopedic outpatients with limb fractures. The authors concluded that neuropsychometry was the best method for detecting neurological dysfunction.

Haglund and Persson [1990] investigated the possible chronic brain damage due to amateur boxing by studying 47 former amateur boxers in Sweden; 22 had many (HM = high-matched) and 25 had few matches (LM = low-matched) during their careers. These groups were compared with two comparison groups of 25 soccer players and 25 track and field athletes in the same age-range. No severe EEG abnormalities were found among boxers; however, a somewhat higher incidence of slight or moderate EEG deviations was found among HM (32%, 7/22) and LM (36%, 9/25) boxers than among soccer players (20%, 5/25) and track and field athletes (12%, 3/25). Brain electric activity mapping (BEAM), brain stem auditory evoked potential (BAEP), and auditory evoked P 300 potential (P 300) did not differ significantly among the groups. No abnormal neurophysiological variable was correlated to the number of bouts, number of lost bouts, or length of boxing career. The authors concluded that no signs of serious chronic brain damage were found among the amateur boxers or the soccer players and the track and field athletes. They noted that it cannot be excluded that the EEG differences between the groups may be a sign of slight brain dysfunction in some of the amateur boxers.

Heilbronner et al. [1991] assessed cognitive functions of 23 amateur boxers immediately before and after an amateur boxing event. A range of cognitive measures was employed, including tasks of verbal, figural, and incidental memory; motor functions; attention/concentration; and information processing speed. Compared with their prefight performance, boxers demonstrated impairments in verbal ($P < 0.0001$) and incidental memory ($P < 0.004$) but enhanced executive ($P < 0.0002$) and motor functions ($P < 0.003$) postfight. No differences were observed between winners and losers on any of the measures.

Murelius and Haglund [1991] investigated 50 Swedish former amateur boxers, 25 soccer players, and 25 track and field athletes using standardized neuropsychological tests. The groups differed significantly in only one test (dominant hand $P < 0.05$; non-dominant hand $P < 0.001$)—boxers who had fought a large number of bouts had a slightly inferior finger-tapping performance. None of the boxers were considered to have definite signs of intellectual impairment. The authors concluded that modern Swedish amateur boxing does not seem to lead to significant signs of neuropsychological impairment or punch drunkenness, nor does it seem to differ in this respect from soccer or track and field sports.

Haglund and Eriksson [1993] examined 50 former amateur boxers and compared them with two comparison groups of soccer and track and field athletes. All subjects were interviewed regarding their sports career, medical history, and lifestyle factors. They underwent a physical and a neurologic examination. Cerebral morphological changes were evaluated using CT and MRI. Clinical neurophysiological tests were made as well as neuropsychological tests. No significant differences were found between the groups in any of the physical or neurological examinations or in platelet monoamine oxidase activity (MAO). Increased platelet MAO activity is under strong genetic control and is inversely correlated to personality traits such as sensation seeking, monotony avoidance, and impulsiveness [Haglund et al. 1990]. Socially, the boxers had a lower degree of education and had chosen less intellectual professions than those in the comparison group, but they were less impulsive and more socialized. The CT scan and MRI studies showed

no significant differences between the groups. A significantly higher incidence was found of slight or moderate EEG deviations among the boxers. Neuropsychologically, the boxers had an inferior finger-tapping performance. According to the authors, no signs of serious chronic brain damage were found between any of the groups studied. However, the authors also noted that the EEG and finger-tapping differences between the groups might indicate slight brain dysfunction in some of the amateur boxers.

Wedrich et al. [1993] examined a group of 25 active, asymptomatic, amateur boxers to evaluate the nature and incidence of ocular pathological conditions. A group of 25 men, approximately matched for age, who were not boxers was used as a comparison group. The number of bouts varied from 1 to 220 (mean 39.4) and the number of spar rounds from 20 to 600 (mean 192.5). Visual acuity was 20/20 in all subjects of both groups, except for one boxer with keratoconus. Intraocular pressure was normal. In 19 (76%) boxers, pathological anatomical findings were attributed to contusion trauma. Lesions of the anterior eye segment included injuries of the lid in 3 eyes (12%), angle abnormalities in 5 (20%), and slight lens opacities in 5 (20%). Posterior vitreous detachment was observed in 3 (12%) boxers, and peripheral retinal scars were seen in 15 (60%). In 6 (24%) eyes, retinal tears or atrophic holes were detected, and in the 7 (28%) boxers with lesions of the anterior eye segment, the posterior segment was also affected in 6 (85%). In the comparison group, an atrophic hole was found in 1 (4%) patient with no other ocular pathological findings. The authors recommended (1) the use of head gear and thumbless gloves even for short spars, (2) the use of thumbless gloves instead of thumb-attached gloves, (3) the use of sparring head gear (with cheekbone pad) for bouts, and (4) dilated retinal examinations for licensing and periodic retinal examinations throughout the boxer's career.

Stewart et al. [1994] studied amateur boxers from six U.S. cities during the period 1986–90 to determine whether changes in central nervous system function over a 2-year interval were associated with degree of participation in amateur boxing. Four hundred eighty-four participants were examined at baseline; 393 (81.2%) were examined two years later. The tests were designed to evaluate perceptual/motor function; attention/concentration; psychomotor speed, memory, visuoconstructional ability and mental control; measures of ataxia and brainstem auditory evoked potentials; and EEG. At baseline, 22% of the participants had not yet competed, and 9% had never competed in a bout by the second examination. Approximately 12% reported having had at least one concussive head injury that resulted in unconsciousness, but these were not associated with boxing. Exposure was defined by the number of bouts, sparring years, and sparring with a professional boxer. Very few statistically significant odds ratios were found between exposure and change in perceptual/motor function. Significant tests of trend were found between the number of bouts before the baseline examination and changes in memory, visuoconstructional ability, and perceptual/motor ability. The significant trends for change in function in the latter two were common to both groups and were primarily marked by performance on the Block Design test. No statistically significant associations were found between more recent bouts (after the baseline visit) and any changes in functional domains, nor between bouts or sparring and other outcome measures. The significant trends with past bouts, but not more recent bouts, may reflect a longlatency before effects are manifest. Alternatively, the observed association may be

related to more severe exposure from bouts that occurred before 1986, when new safety measures were imposed.

Butler [1994] stated that the most sensitive measure of early neurological dysfunction is neuropsychological investigation. Ten studies using such assessments on 289 amateur boxers were reviewed. The forms of analysis in these studies included controlled comparison with other sportsmen and of both active and former boxers, detailed pre- and post-bout analyses, analysis of the influence of variables within boxing, length of career, level of competition, and prospective longitudinal investigation. In Butler's opinion, no amateur boxers exhibited signs of neuropsychological dysfunction in any analysis. However, he added that some trends suggested that a long career in amateur boxing might reduce fine motor reactions, although such findings are within the expected normal range of motor function and do not represent central neuropsychological functioning.

Porter and O'Brien [1996] determined the incidence, pattern, and severity of injuries that resulted from amateur boxing by using a prospective 5-month survey of injuries that occurred during competitive amateur boxing and training. All the competitors in the tournaments and members older than 16 of six major boxing clubs in Dublin, Ireland, were studied. The incidence of injuries in competition was 0.92 injuries per man-hour of play (or 0.7 injuries per boxer per year), and the incidence in training was 0.69 injuries per boxer per year. Cerebral injuries were reported only in competition; most were mild concussion (33 cerebral concussions and 281 partial or complete bouts), as graded according to the Colorado Medical Society system. Hand, wrist (13/281 bouts) and facial (13/281 bouts) injuries were related to direct impact and occurred more frequently in competition than training; injuries to other body parts were predominantly chronic and training-associated. Shoulder and knee injuries were the most debilitating. The authors concluded that the yearly risk of injury resulting from amateur boxing was relatively low compared with other sports, and cerebral injuries, which occur almost exclusively in competition, were predominantly mild concussions.

Kemp et al. [1995] compared two neurophysiological variables in active amateur boxers with those of nonboxing sportsmen. Psychometric tests were given to 41 boxers and 27 nonboxers, and 34 boxers underwent technetium-99m hexamethylpropyleneamineoxime single-photon emission CT (Tc-99m HMPAO SPECT) cerebral perfusion scans. The nonboxer comparison group performed better at most aspects of the psychometric tests. Boxers who had fought fewer bouts tended to perform better at psychometric tests than those boxers who had fought more bouts. Tc-99m HMPAO SPECT cerebral perfusion scanning showed that the comparison group had fewer aberrations in cerebral perfusion than the boxers. The authors concluded that the boxers and the comparison group showed significant differences in two neurophysiological variables, but the long term effects of these findings remain unknown.

Porter and Fricker [1996] used a practical battery of eight neuropsychological tests to detect an association between Irish amateur boxing and chronic traumatic encephalopathy in a controlled prospective study during a 15- to 18-month period. Twenty experienced, actively competing,

amateur boxers and 20 of a comparison group were matched for age and socioeconomic status. At the end of the study period, the boxers performed significantly better than the comparison group in both the Trail-Making Tests A and B, whereas the comparison group's scores for the Finger Tapping Tests (FTT) were significantly ($P<0.002$) higher than those of the boxers. The boxers' scores for the dominant-hand FTT showed a significant deterioration ($P<0.05$), but no association was found between this change and boxing exposure. The authors concluded that no evidence existed of neuropsychological impairment in the boxers compared with a socioeconomically, educationally, and age-matched comparison group, and no association was found between boxing exposure and performances in any of the neuropsychological tests used.

Kemp [1995] critiqued published studies on amateur boxing studies conducted after 1979 and pointed out deficiencies that may explain the lack of consensus in these studies. Potential deficiencies in these studies included:

1. Selection bias in the recruitment of boxers—that is, self-selection of volunteers leading to impaired boxers who are reluctant to participate, more representation from successful boxers, and presenile dementia that may impair volunteering.
2. Extraneous head injuries incurred outside the boxing ring.
3. Comparing the results of the boxers' investigations with established norms without comparing age, education, social class, etc.
4. Selection of inappropriate comparison groups.
5. Statistical analysis and chance findings from multiple comparisons.
6. Selection of inappropriate neuro-investigatory techniques.
7. Recruiting of ex-amateur boxers who have turned professional.

APPENDIX 3

PROFESSIONAL BOXING INJURIES: DETAILS OF THE LITERATURE

NEUROLOGICAL AND PSYCHOLOGICAL EFFECTS

Roberts [1969] and Medical aspects of boxing [1969] used a random-sampling technique to select 250 professional boxers from a population of 16,781 men registered with the British Boxing Board of Control between 1929 and 1955. Seventeen percent of 224 men from the sample showed evidence of brain damage, and one third of these had severe chronic traumatic encephalopathy. The neurological damage was multifocal, with symptoms predominantly in the cerebellar, pyramidal, or extrapyramidal systems. Very few had chronic eye or ear injuries. Roberts demonstrated that the length of a boxer's career and the total number of bouts fought were closely linked to the severity of the neurological damage. Psychometric testing showed no relation between impaired memory and length of the boxing career. The author noted that recommendations of better supervision, reduction in the number of bouts fought each year, and other safeguards introduced by boxing authorities have considerably reduced the frequency and severity of injuries.

Casson et al. [1982] performed detailed neurological examinations, EEG, and CT scans of the head on 10 professional boxers aged 20 to 31 shortly after the boxers had been knocked out (bouts per boxer ranging from 2 to 52). All of the boxers had mild head injuries by clinical criteria, with loss of consciousness and post-traumatic amnesia lasting fewer than 2 minutes. CT scans revealed cerebral atrophy in the five boxers who had the most bouts. Intracerebral and subdural hematomas were not found. Two boxers had abnormal EEGs, one of which had an abnormal CT scan. The more proficient boxers had cerebral atrophy more often than the less proficient ones (no statistical analysis) (i.e., the total number of bouts correlated with the CT abnormalities). Of the 5 boxers with 20 or more bouts, 4 had cerebral atrophy; of the 5 boxers with fewer than 12 bouts, only 1 had cerebral atrophy.

Kaste et al. [1982] conducted a study of 14 boxers (mean age was 31 years, range was 19–53); who had been Finnish, Scandinavian, or European champions. Only one showed deficits in neurological status (apraxia, slight unsteadiness, slight slowness, and uncertainty in mental functions), and he and one other boxer had episodes of inappropriate behavior that were attributed to boxing. However, CT scans revealed pathological findings attributable to brain injury in four of six professional (mean age was 38 years, range was 29–53) and one of eight amateur boxers (mean age was 26 years, range was 19–36). Two of the professionals and four of

the amateurs had electroencephalographic abnormalities that may have been caused by brain injury. The rate of EEG abnormalities in 46% of the boxers in this study is comparable to rates of 37–60% found in other studies and is clearly higher than the rate of 10–15% in the general population. Twelve of the boxers had psychological test results that suggested brain injury, although only two professionals had definite deviation from the normal. The authors stated that the results indicated that modern medical control of boxing cannot prevent chronic brain injuries but may create a dangerous illusion of safety. The authors comment that the only way to prevent brain injuries is to disqualify blows to the head.

Ross et al. [1983] examined 40 ex-boxers to determine the effects of boxing on neurological status and CT appearance of the brain. Thirty-eight of these patients had a CT scan of the brain, and 24 had a complete neurological examination including an EEG. The results demonstrate a significant relationship ($P=0.0229$) between the number of bouts and CT changes that indicate cerebral atrophy. Positive neurological findings were not significantly correlated ($P=0.514$) with the number of bouts in the 24 boxers examined. Electroencephalographic abnormalities were significantly correlated ($P=0.0582$) with the number of bouts fought. On the basis of their data the authors recommended that a CT scan and an EEG of the brain be part of a regular neurological examination for active boxers. They also recommended that, if possible, the examinations be conducted before and after each match to detect not only the effects of acute life-threatening brain trauma such as subdural hematomas and brain hemorrhages but also the more subtle and debilitating long-term changes of cerebral atrophy.

Casson et al. [1984] studied 18 former and active boxers (mean age was 36 years) using neurological examination, EEG, CT scan of the brain, and neuropsychological testing; they compared the results with norms established for the general population. This group was stated to represent the modern era of boxing, defined as the post-World War II period, when modern medical controls and safeguards became available. However, the details of these controls and safeguards were not specified. The boxers were champions, as well as journeymen, with responsible jobs, secondary or college educations, and no history of substance abuse or known medical, neurological, or psychiatric illness. The subjects included 13 former boxers (aged 25 to 60), 2 active professionals, and 3 active Golden Glove boxers. Eighty-seven percent of the professional boxers had definite evidence of brain damage on at least two of the four tests. Six of 8 boxers with more than 20 professional bouts had abnormal CT scans, whereas only 2 of the 10 boxers with fewer than 20 professional bouts had abnormal CT scans ($P<0.10$). Every subject with an abnormal CT scan or an abnormal EEG had an impairment index greater than 0.50 on the neuropsychological test battery. The impairment index also correlated significantly with the number of professional bouts ($P<0.05$) and with age ($P<0.02$). The impairment index did not correlate significantly with the number of KOs or episodes of amnesia. These findings suggest that longer boxing careers result in a greater likelihood of brain damage and that the cumulative effect of multiple subconcussive blows to the head is a cause. The three Golden Glove boxers in this study all had normal neurological examination results, EEGs, and CT scans. All the boxers had abnormal results on at least one of the neuropsychological tests. The authors concluded that brain damage is a frequent result of a career in professional boxing.

Drew et al. [1986] conducted a study of 19 young, active, licensed professional boxers and found a pattern of neuropsychological deficits consistent with the more severe punch-drunk syndrome. These deficits resulted in significantly lower test performance than that of ten comparison group athletes ($P < 0.001$) matched for race, age, and educational level. Tests that showed significant differences between groups include subtests of the Quick Neurological Screening Test, subtests of the Halstead-Reitan Neuropsychological Test Battery, and the Randt Memory Test. Fifteen of the 19 boxers scored in the impaired range of the Reitan Impairment Index, compared with 2 of the 10 comparison group athletes. In multiple regression analysis, the number of bouts did not provide a significant increment to professional losses plus draws in predicting the three composite impairment scores. According to the authors, this finding is consistent with the notion that, although the number of professional bouts may be a good predictor of this cumulative impairment, the extent of brain damage is primarily a function of "the amount of punishment received." The authors concluded that on the basis of their research, the number of professional losses plus draws is a good index of the punishment dimension.

In a prospective investigation [Levin et al. 1987] of neurobehavioral functioning, 13 young boxers (11 professional and 2 amateur; mean age 20.5) and 13 matched comparison group subjects underwent tests of attention, information-processing rate, memory, and visuomotor coordination and speed. All of the professional boxers fought amateur bouts (mean 88), had a boxing career average of 7.3 years, and reported an average of 13.8 sparring days per month. More proficient verbal learning was found in the comparison group subjects, whereas delayed recall and other measurements of memory did not differ between the two groups. Reaction time was faster ($P < 0.001$) in the boxers than in the comparison group, but no other differences were significant. Ten subjects in each group were retested 6 months later and exhibited improvement in their neuropsychological performance compared with baseline measurements. However, no score differences were found between the boxers and the comparison subjects at the followup examination or in the magnitude of improvement from baseline values. MRI, which was performed on 9 boxers, disclosed normal findings.

CT scans performed on 338 active professional boxers, aged 17 to 46, were abnormal in 25 boxers (7%) [Jordan et al. 1992]. The most common CT abnormality was brain atrophy (22 cases). Three boxers had focal lesions of low attenuation consistent with post-traumatic encephalomalacia. Boxers with abnormal CT scans were similar to those with borderline or normal CT scans in regard to age, win-loss record, number of bouts, and history of an abnormal EEG. Thirty-seven boxers with borderline CT scans (49%) and 17 with abnormal CT scans (68%) reported having had a previous TKO or KO compared with only 89 (37%) of the 238 boxers with normal CT scans ($P < 0.01$). Brain atrophy was noted more frequently in boxers with a large cavum septum pellucidum (CSP) than in those with a small or no CSP ($P < 0.05$). Boxers with abnormal or borderline CT scans who had experienced a TKO or KO were slightly older than those with normal CT scans and a history of a TKO or KO ($P < 0.05$). Of the 338 boxers, 335 had an EEG, 18 (5%) of which were abnormal. Boxers with abnormal and borderline EEGs tended to have had more bouts than boxers with normal EEGs, but the difference was not

statistically significant. Twenty three (92%) of the 25 boxers with abnormal CT scans had normal EEGs.

Breton et al. [1991] investigated boxers' attention and orienting mechanisms using event-related brain potential recordings (not described as EEGs) before and after a bout. This study used only five subjects and did not reveal any abnormalities of attention or detection processes. However, a slight deficit was observed in the orienting reaction towards stimuli delivered in the right ear; it was related ($P < 0.01$) to a greater number of blows delivered on the left side of the head.

BRAIN PATHOLOGY

Corsellis et al. [1973] described the main pathological sites of change in 15 boxers. The most obvious abnormality was centered on the deep midline structures where the septa were wide apart, torn, and fenestrated. The ventricles were enlarged and the fornices atrophied. The tissue in this area, including the thalamus and hypothalamus, showed severe gliosis. In the cerebellum, atrophy and glial fibrosis affected folia that were encircled by the foramen magnum. In addition a pronounced loss of Purkinje cells was noted in the undersurface of the cerebellum. In the substantia nigra, a lack of large pigmented neurones was found; this condition is the classical neuropathological feature of a Parkinsonian state. Many neurones, mainly in the deep temporal grey matter, tended to develop abnormal neurofibrils (the so called Alzheimer tangle) without neuritic (senile) plaques.

Tokuda et al. [1991] performed a histopathological study on the brains of eight ex-boxers (aged 56 to 83) using conventional histological staining methods and immunocytochemistry with antibodies to amyloid beta-protein and the PHF-related tau protein. All cases showed a large number of tau-immunoreactive neurofibrillary tangles and beta-protein immunoreactive senile plaques in the cortex. In the areas with many neurofibrillary tangles, neuropil threads with tau-immunoreactivity were also observed, and some of the senile plaque lesions were surrounded by abnormal neurites with tau-immunoreactivity. Three cases revealed beta-protein-type cerebrovascular amyloid deposits on both leptomeningeal and cortical blood vessels. The observations indicate that the cerebral pathology of dementia pugilistica is very similar to that of Alzheimer's disease and suggest that these two disorders share some common etiological and pathogenic mechanisms.

MECHANISM OF BRAIN DAMAGE

Adams and Bruton [1989] histologically examined the brains of 22 ex-boxers to determine the frequency of recent or old hemorrhage. Four boxers had died from acute intracerebral bleeding, usually soon after a boxing bout. Seven of the other 18 showed evidence of previous perivascular hemorrhage, and a similar number showed minor degrees of meningeal or subpial siderosis; these symptoms are consistent with previous meningeal bleeding. Cerebellar siderosis was present in

six cases. Seventeen of the 22 boxers showed evidence of recent or past hemorrhage. A comparison group showed an incidence of 11% for perivascular iron deposition and only 4% for minor degrees of meningeal siderosis. The authors stated that no matter whether linear (translational) acceleration or rotational (angular) acceleration force is applied, rupture of blood vessels appears to be an important factor in the pathogenesis of head injury.

Creatine kinase isoenzyme BB (CK-BB) is found in high concentrations in the brain. Normally concentrations in blood are undetectable or low. Brayne et al. [1982] measured blood concentrations of CK-BB in 16 amateur boxers before and after a fight (three 3-minute rounds = 9 minutes) and in 16 track cyclists before and after a 40-mile race. Blood CK-BB rose to significantly higher concentrations ($P < 0.01$) in the boxers than in the cyclists. The number of blows received to the head was estimated in half the boxers and correlated significantly with the rise in CK-BB ($P < 0.05$). This increase in blood CK-BB may indicate disruption of the blood-brain barrier and is similar to blood CK-BB levels found with mild head injuries. This increase may be one of the mechanisms that account for brain damage in boxers.

LACERATIONS, CONTUSIONS, FRACTURES

Kaste et al. [1982] studied 14 boxers who had been Finnish, Scandinavian, or European champions. Of these, 13 had facial lacerations, 9 had hand fractures, and 6 had nose fractures.

OCULAR INJURY

Smith [1988] examined 118 boxers; 25 (21%) had pronounced ocular damage and 5 had multiple ocular problems. Of the 12 boxers with cataracts, 8 had posterior subcapsular opacities, including 5 with bilateral involvement. Three boxers had cortical opacities (2 bilateral) and one had anterior subcapsular involvement. Of the 68 boxers examined with dilation, 19% had vitreoretinal pathology that included holes (2 cases), retinal tears (5 cases), lattice (1 case), and old vitreous hemorrhage (5 cases). The average age of the group members was 24, and the average age of those who had pathological findings was 27. The average number of professional bouts for each group member was 15 (range 0-79), and the average number for those with pathological findings was 17. The author commented that many of the boxers had fought hundreds of amateur bouts, and all of the boxers has sparred innumerable rounds, so total exposure time was impossible to quantify. Smith [1988] also reported on an earlier unpublished study of 166 professional boxers between 1982 and 1986. Twenty percent had ocular problems; the most common was cataract formation.

Enzenauer and Mauldin [1989] studied ocular injuries attributable to military boxing as a subset of a larger study of boxing-related injuries. Ocular injuries occurred in 5% (22/401) of soldiers hospitalized for boxing-related trauma between 1980 and 1985. The 22 patients with eye injuries spent an average of 8.1 days in the hospital and 17.8 days unfit for duty. Most (15/22) had been

admitted with ocular injury as the primary cause. Ocular injuries resulted in a longer hospitalization and disability than all other boxing injuries. One soldier was blind in one eye after complications from a ruptured globe.

Reasons for such variable results may stem from the problems in the selection of a representative series of boxers. In a study of visually asymptomatic boxers, vision-threatening injuries were defined as significant damage to the angle, lens, macula, or peripheral retina; they occurred in 58% of boxers [Giovinazzo et al. 1987]. This study was performed in cooperation with the New York State Athletic Commission (NYSAC) and examined 74 boxers ranging from 16 to 42 years (mean age 25) applying for a new or yearly renewal license over a 2-year period. Sixty-six percent of boxers had at least one ocular injury. Nineteen percent of boxers had pathological cataracts; more than 70% of these were posterior subcapsular. Six boxers had macular lesions. Twenty-four percent of boxers had retinal tears. Risk factors in boxing that might predict ocular injury were identified. Variables included age, weight division, left- or right-handedness, total number of losses, and total number of bouts. Significant correlations were found between the total number of bouts (regression coefficient $P=0.01$) and the total number of losses (regression coefficient $P=0.03$), and the presence of retinal tears. The latter rises steeply after 6 bouts; and after 100 bouts, nearly all of the study boxers had suffered retinal tears. The relationship between retinal tears and losses was almost linear. College varsity athletes served as a comparison group; they were matched with boxers for age and race and did not participate in organized boxing. Significant differences were found between boxers and the college athletes for the total number of injuries ($P<0.001$), total vision-threatening injuries ($P<0.001$), and the number of retinal tears ($P<0.05$).

APPENDIX 4

RECOMMENDATIONS FROM THE LITERATURE: CHRONOLOGICAL PRESENTATION

Numerous medical organizations have made official statements calling for significant boxing reforms or for a total ban on boxing. In 1984, the American Medical Association called for a ban on all boxing, amateur and professional, in the United States. The British, Canadian, and Australian medical associations as well as the World Medical Association have recommended that boxing be banned. Sweden banned professional boxing in 1969, and in 1982 the Swedish government explored the possibility of forbidding amateur boxing [Swedish government 1982]. In 1984, the American Academy of Pediatrics opposed boxing in any sports programs for children and young adults [American Academy of Pediatrics 1984]. The American Neurological Association and the American Academy of Neurology have called for a ban on boxing [1983]. The *Journal of the American Medical Association* [Lundberg 1983, 1985] has printed several opinions calling for the banning of boxing. The U.S. Air Force Academy ended mandatory boxing in 1995 [Swartzberg 1995].

The following recommendations on health and safety issues are summarized from the literature review in chronological fashion and can be found as a categorical listing in Appendix 5.

The American Medical Association Committee on Medical Aspects of Sports made the following recommendations in 1962:

- A thorough medical examination of each contestant prior to bouts by a physician responsible for determination of the boxer's fitness to participate.
- At least one physician present at all bouts with absolute authority to terminate the contest for medical reasons.
- Interruption by the referee or physician of any bout with the opponent declared winner when a contestant sustains more than one knockdown in any one round or evidences inability to control the position of the head.
- Automatic suspension of any participant who sustains a KO, TKO, or other severe injury for as long as medical consultants feel it necessary.
- The universal adoption of the new unapproved shock-absorbing ring padding under the canvas and on the posts of the ring to aid in prevention of injuries caused by striking the head against unpadded surfaces.

- The required use of headgear to minimize lacerations and contusions, and properly fitted mouthpieces to protect the teeth and supporting tissues.
- Coaching and training of a quality to assure the maximum protection that skillful performance and good condition can provide.
- Referees familiar with, and alert to, the health hazards inherent in boxing.

According to Jordan [1988], the committee also suggested that other potential safety measures be considered, including less padding in the glove and the prohibition of wrapping the hands to reduce the force of the blow. The committee also suggested that the system of point scoring be revised to emphasize skillful offensive and defensive maneuvering instead of the KO blow. Research designed to develop protective headgear was also suggested.

The National Health and Medical Research Council of Australia has recommended that, before a contestant is permitted to box, several medical contraindications be observed [Health hazards of boxing 1975]. These include schizophrenia, manic depression, recurrent neurotic breakdown, aggressive psychopathy, drug dependence, hysterical personality disorders; epilepsy, previous intracranial hemorrhage or severe head injuries, previous craniotomy; severe hypertension, coronary artery disease, other heart diseases, cardiac arrhythmias; spontaneous pneumothorax, lung cyst, active lung disease including emphysema; active renal disease and kidney lesions susceptible to trauma such as polycystic kidney, renal calculus and hydronephrosis; eye abnormalities; and blood dyscrasia, generalized bone and joint disorders, unilateral blindness, and absence of a kidney or testicle. The Council further recommended the establishment of a clinic to study the effects of boxing and proposed guidelines for statutory controls and supervision of boxing training and competition. These include compulsory medical examination before boxers may compete; attendance by accredited medical officers at boxing contests; central registration of all boxers with details of bouts and injuries; medical instruction for referees; fight limitations for boxers who are above a certain age, have a lack of experience, or who have been injured; provision of protective equipment; and elimination of hazardous practices such as “crash” weight reduction and “doping.”

Strano and Marais [1983] stated that when serious injury has occurred, the bout should be stopped immediately since the potential for serious damage is greatly increased in the dazed defender with altered muscle tone and reaction time.

LaCava [1983] recommended that professional bouts be limited to 6 rounds to reduce the risk of brain injury. Morrison [1986] agreed with this proposal and added that amateur boxers, who fight only three rounds per bout and therefore receive fewer blows to the head, appear to be less susceptible to brain damage. Morrison also reviewed a number of other proposals in the literature, such as, disqualifying blows to the head; wiring of boxers so that scoring points are measured electronically, as in fencing; making hard punches unnecessary; and the banning of

boxing gloves to increase pain and injury to the ungloved hand and decrease the number and force of the punches thrown.

The American Medical Association Committee Council on Scientific Affairs [1983] made the following recommendations, which were reconfirmed by the World Medical Association [1984]:

- Encourage the establishment of a National Registry of Boxers for all amateur and professional boxers including sparring mates. The proposed functions of a computer-based central registry are to record the results of all licensed bouts (including TKOs, KOs, and other boxing injuries) and to compile injury and win-loss records for individual boxers.
- Plan and conduct a conference with representatives of the American Association of Ringside Physicians, medical representatives, medical representatives of the various State and local boxing commissions, and representatives of organized professional and amateur boxing organizations. The representatives would review criteria for the physical examination of boxers, determine other comprehensive medical measures necessary for the prevention of brain injury in the sport, and develop specific criteria for the discontinuance of a bout for medical reasons.
- Recommend to all boxing jurisdictions that the ring physician be authorized to stop any bout at any time to examine a contestant and to terminate a bout that might, in his or her opinion, result in serious injury for either contestant.
- Urge boxing jurisdictions to conduct frequent medical training seminars for all ring personnel.
- Recommend to all boxing jurisdictions that no amateur or professional boxing bout be permitted unless (1) the contest is held in an area where adequate neurosurgical facilities are immediately available for skilled emergency treatment of an injured boxer, (2) advanced life-support systems are available at ring side, and (3) a comprehensive evacuation plan for the removal of any seriously injured boxer to hospital facilities is ready.
- Inform State legislatures that unsupervised boxing competition between unlicensed boxers in tough man contests is a most dangerous practice that may result in serious injury or death to contestants and should be condemned.
- Urge State and local boxing commissions to mandate the use of safety equipment, such as plastic safety mats and padded corner posts, and to encourage continued development of safety equipment.
- Urge State and local boxing commissions to extend all safety measures to sparring partners.

- Urge State and local boxing commissions to upgrade, standardize, and strictly enforce medical evaluations for boxers.

One shortcoming of these recommendations is that they do not address sparring sessions, which may lead to additional injury and KOs.

McCunney and Russo [1984] recommended the formation of a National Boxing Council similar to the central commissions of baseball, football, and basketball. The council would be composed of State commission members and recognized leaders in boxing and funded by a levy on all championship bouts and events televised nationally. The authors recommended the following functions of the council:

- State commissions would have access to the national council's records, ensuring uniform application of medical and licensing requirements.
- The council would license managers, promoters, and seconds.
- The council would sponsor seminars for physicians and other ringside personnel.
- The council would direct a comprehensive medical surveillance program to help detect illness at a preclinical phase and to serve as a basis for ongoing research, including answering scientific questions such as: What level of participation results in irreversible changes? What factors should be included when determining the level of participation-sparring, length of career, number of bouts? Which changes and medical methods are the most predictable of the response? What is the proper glove weight and protective head gear design?
- Boxers who receive a national boxing license should be required to have a passport-like booklet listing the results of medical examinations and dates and results of prior matches.
- In addition to a medical history and physical examination, the EEG should be considered an integral component of the program to detect chronic encephalopathy. CT scans should also be used to detect changes associated with encephalopathy and to evaluate acute head injuries. Psychological testing should also be performed including baseline evaluations. Additional tests could be performed at the discretion of the State commissions.
- Decisions about test frequency should be made by an American Medical Association Committee panel formed to investigate brain damage in boxers. The panel could also advise the national council about issues such as baseline medical standards for participation; suspension periods for conditions such as KOs, amnesia, and detached retina; and conditions that dictate retirement.

Charnas and Pyeritz [1986] echoed the recommendations of the American Medical Association Committee for the State athletic commissions to adopt the following practices:

- Review current medical regulations, examinations, and educational practices at least annually.
- Retain physicians competent in the medical, particularly the neurological, aspects of boxing to serve as advisers to the commission and at ringside.
- Sponsor an annual neurological examination for all boxers, performed by a specialist in neurology or neurosurgery.
- Maintain a neurologist or neurosurgeon at ringside.
- Do not hold a contest in a location more than 10 minutes by ambulance from a hospital with a neurosurgeon in attendance.

The following are medical interventions recommended in 1987 by the USAABF:

- Form a national regulatory agency, the USAABF, to enforce uniform medical standards.
- Maintain one or more physicians at all amateur boxing shows who are prepared to deal with any emergency.
- Examine contestants thoroughly immediately before and after each bout.
- Permit a physician, at his or her discretion, to enter the ring immediately if a bout ends in a KO or if it is stopped because of an injury.
- Allow the attending physician to suspend a bout at any time if in his or her opinion a contestant is in danger of further physical injury.
- Medically suspend any boxer rendered unconscious or who receives excessive blows to the head.
- Require the boxer to undergo a medical examination before he resumes boxing, after medical suspension.
- Issue a Restrictions Affidavit to any boxer who is medically suspended secondary to head blows.

Giovinazzo et al. [1987] proposed a series of recommendations to aid in the early detection and prevention of serious ocular injuries. These recommendations closely follow those of the American Medical Association Committee and World Medical Association listed above.

- Establish a National Registry of Boxers in the United States for all amateur and professional boxers, including sparring mates. A computer-based central registry would be effective in recording licensed bouts and specifically noting technical KOs, KOs, and significant ocular injuries. When a bout is stopped because of an ocular injury, proper records and documentation would ensure adequate examinations of injured boxers.
- Institute a program for training and recertification of ringside physicians in the proper identification of serious eye injuries sustained in the ring. The diagnosis of serious eye injuries and specific criteria for suspension of a bout should be emphasized during this training. Seminars should be planned and conducted in cooperation with the American Association of Ringside Physicians and possibly the American Academy of Ophthalmology.
- The State and local licensing agencies should adopt a uniform code of safety specifying ocular injuries that are sufficient to stop a boxing match.
- State and local licensing agencies should adopt adequate safety equipment to minimize ocular injuries. The thumb of most regulation boxing gloves is small enough to penetrate the orbital rim. It is an important cause of much blunt ocular trauma. Boxers with shallow orbits may not have adequate protection for the eye. Periorbital edema or myopia may also induce greater exposure of the globe to the thumb of a boxing glove. The use of the thumbless glove should be required in all amateur and professional bouts and in sparring matches.
- The following rules should be established regarding ocular examinations of boxers:
 - Require an initial examination before licensure for either amateur or professional boxing. This initial examination should include visual acuity, visual fields, slit-lamp biomicroscopy, intraocular pressure measurement, gonioscopy, and a dilated vitreoretinal examination including indirect ophthalmoscopy with scleral depression by an ophthalmologist. This type of comprehensive examination is required by the Vision Safety and Performance Committee of the United States Olympic Committee [Vinger 1986].
 - Institute a repeat, complete eye examination after 1 year, six bouts, two losses, the stopping of a fight because of an eye injury, or at the discretion of the ringside physician.

- Require a mandatory temporary suspension from sparring and boxing for specific ocular pathology. When a retinal tear is identified and treated, a 30-day suspension from the ring should be enforced. When a retinal detachment is treated and if a boxer is to resume a boxing career, a minimum 60-day mandatory suspension should be enforced.
- Establish the following minimal visual requirements: (1) a visual acuity of 20/40 or better in each eye, and (2) a full, central visual field not less than 30 degrees in each eye.

Smith [1988] recommended at least one complete ophthalmic examination annually and agreed with the suggestion of Giovinazzo et al. [1987] that a national registry of boxers be established for all professional and amateur boxers. He further added that each boxer should be issued a photograph identification card. A central registration system was suggested that would allow ophthalmologists to follow boxers who had ocular problems and to ensure that they are examined more frequently.

Guterman and Smith [1987] recommended improved medical supervision including comprehensive medical and neurological evaluation of all boxers before they enter training. This supervision should include a complete medical history and physical examination with a comprehensive neurological examination that included a 16-channel EEG in waking and sleeping states, a CT scan of the brain with and without contrast, and a formal battery of neuropsychological tests such as the WAIS-revised, Boston Naming Test, Controlled Oral Word Association Test, Benton Visual Retention Test, Wechsler Memory Scale, Ravens Colored Progressive Matrices, Trail Making, and the Halsted-Raitan. Either the entire medical workup or portions felt to be clinically indicated should be repeated at least every 6 months, but every boxer should have the complete series done yearly. They further recommended that as soon as significant abnormalities are seen in any of the tests, a boxer's active career be halted for formal re-evaluation of the boxer's suitability to continue. Evidence of any irreversible neurological deficit should end a boxer's career. They also recommended that the ringside physician have the ability to and be willing to halt any bout. The authors cited the requirement of protective headgear in Olympic competition but questioned the effectiveness because of its design. They raised the issue of using any headgear "short of a really efficient crash helmet which effectively absorbs these forces without transmitting through the skull" because it does not protect the boxer from head trauma.

Acunto [1987] described the position of the American Association for the Improvement of Boxing (AAIB). The recommendations included the following:

- Place greater emphasis on the science of the sport (details not given).
- Administer CT scans to every boxer before every match.

- Staff State athletic commissions throughout the United States with neurologists at ringside; dental surgeons; eye, ear, and nose specialists; orthopedic doctors; chiropodists; and general practitioners who deal with sports medicine. (Whether all of these specialists were recommended to be present at the ringside was unclear.) The recommendation further stated that the latest medical equipment should be at their disposal.
- Establish a National Boxing Commission to transfer information between existing boxing commissions nationally and internationally. A center from which the results of all boxing contests around the world can be monitored should be established immediately. (Whether the second part of the recommendation was to be administered by the National Boxing Commission was unclear; however, the AAIB noted that 85% of the world's boxing takes place in the United States.)
- Ringside physicians should have board certification as established by the American Academy of Neurological and Orthopedic Surgeons to improve the game of boxing.
- Adopt the NYSAC's reforms on preflight examinations, equipment, authority of ringside physicians to halt matches, training of referees in recognizing neurological injury, increases in suspension periods for KOs, and inspectors to observe corner men between rounds.
- Adopt a manual of procedures for all promoters and matchmakers to ensure that their employees are familiar with the safety equipment and proper facilities.

Novich and Amboy [1988] described numerous administrative controls recommended by a former Commissioner of the NYSAC:

- Congress must establish a regulatory agency professionally staffed with those meeting civil service qualifications and adequately financed so that the mandates, regulations, and rules can be effectively and efficiently administered. The office staff must be qualified by education, training, and experience; to have been involved in boxing is not enough.
- The National Boxing Commission must be vested with the sole direction, management, control, and jurisdiction over boxing and related activities.
- All persons involved with boxing must be licensed—corporations, promoters, referees, judges, matchmakers, timekeepers, box office employees, ticket takers, inspectors, doormen, ushers, professional boxers, managers, trainers, seconds, sparring mates, announcers, gym owners, operators, and special police.
- The national body must establish rules, regulations, and standards for all individuals involved in the boxing profession. All applicants must complete a personal application form and submit to fingerprinting, which will be on file with the national and State Boxing Commissions. The National Boxing Commission or the local one must provide training

courses, medical seminars, and boxing safety conferences and require mandatory attendance for license approval and renewal.

- The Commission must establish requirements for each job classification, including trainers, managers, judges, seconds, promoters, and boxers.

Novich and Amboy [1988] reported that the New Jersey State Athletic Commission has the following responsibilities to ensure the safety and welfare of boxers:

- The Commission licenses boxers to assure that they are medically fit to box professionally.
- The Commission licenses and assigns referees, promoters, inspectors, seconds, and matchmakers.
- The Commission assigns licensed ringside physicians and a second physician in the dressing room. Post-bout examinations are conducted by physicians, and, if necessary, treatment is performed by the physician in the dressing room, or the boxer is referred to a local hospital emergency room.
- Inspectors oversee how hand wraps and gloves are applied in the dressing room. Their duty is to monitor the methods seconds use to freshen boxers between rounds. Assigned inspectors are encouraged to go to gymnasiums to determine whether boxers are following appropriate pre-bout fitness and training routines. They also should attempt to detect training injuries that may be hidden from the physician at pre-bout examinations.
- The Commission requires bonding of promoters and managers, termination of options, and monopoly of a boxer by a promoter, as recommended by the AAIB [Acunto 1987].

Jordan [1988] also related the lack of uniform standards of medical supervision for professional boxing to the lack of a formal national regulatory agency and stated that medical supervision is fragmented because of regulation at the State or local level. He stated that the NYSAC is probably the most strictly medically regulated boxing commission in the country. The NYSAC has implemented the following medical interventions:

- Two ringside physicians at all bouts who have the authority to terminate the fight.
- Medical Advisory Board that advises the NYSAC regarding medical aspects of boxing.
- Use of the thumbless glove.
- Mandatory suspension of boxers who lose six consecutive bouts.
- Medical supervision for a boxer who sustains a KO or TKO.

- Mandatory neurological examination, CT scan, and EEG for boxers medically suspended after a KO or TKO (for a minimum of 45 days).
- Annual dilated eye examination by an ophthalmologist.
- Annual neurological examination, CT scan, and EEG.

Kelly et al. [1991] recommended the adoption of guidelines for reducing the risk of such catastrophic outcomes after concussion in sports. These guidelines are based on levels of injury and the actions that should be taken if such injury is suspected. They are as follows:

Grade 1. Confusion Without Amnesia, No Loss of Consciousness

Remove from contest. Examine immediately and every 5 minutes for the development of amnesia or postconcussive symptoms at rest and with exertion. Permit return to contest if amnesia does not appear and no symptoms appear for at least 20 minutes.

Grade 2. Confusion With Amnesia, No Loss of Consciousness

Remove from contest and disallow return. Examine frequently for signs of evolving intracranial pathology. Re-examine the next day. Permit return to practice after 1 full week without symptoms.

Grade 3. Loss of Consciousness

Transport from field to nearest hospital by ambulance (with cervical spine immobilization if indicated). Perform thorough neurological evaluation emergently. Admit to hospital if signs of pathology are detected. If findings are normal, instruct family for overnight observation. Permit return to practice only after 2 full weeks without symptoms.

Prolonged unconsciousness, persistent mental status alterations, worsening postconcussion symptoms, or abnormalities on neurological examination require urgent neurosurgical consultation or transfer to a trauma center.

Jordan [1990b] reviewed and described other field evaluation and management systems of head injury. He suggested a rating scale for boxing-related acute neurological injury that consists of four grades and is based on loss of consciousness. He also offered a general outline of clinical criteria for diagnosis of probable, possible and unlikely boxing-related chronic neurological injury [Jordan 1991]. Kelly [1995] compared several grading systems for severity of concussions and offered guidelines for return to play after concussion.

O'Connor and Tucker [1991] addressed guidelines for the physician for the preparticipation evaluation and specific disqualifying conditions that are used at the U.S. Army base in Fort Dix. They recommended that the medical/surgical/family history and the physical examination be performed in a private, quiet, well-lit room and should be individualized rather than conducted in groups. In addition to checking vital signs, the authors used an organ systems review and examination form that included eyes, ears, face and mouth, cardiac, lung, abdomen, musculoskeletal, skin, central nervous system, blood, and lymphatic system. Particular emphasis

was placed on the central nervous and cardiovascular systems as representing the areas of greatest potential risk.

Jordan et al. [1992] recommended that neurological evaluation of an active boxer include a CT scan or MRI for detection of anatomic lesions and an EEG for detection of electrophysiologic dysfunction.

The NYSAC proposed that the ABC set national medical standards for boxers [Marwick 1993]. These standards would allow a boxer who passes an examination in one State to be allowed to fight in any State. The medical and safety recommendations of the ABC are the following [Jordan 1988]:

- Establish a minimal standard for medical examinations.
- Develop a nationwide computer network to track activities of professional boxers.
- All States develop a boxer passport and enforce its use (similar to the amateur passport system and the Swedish startbook system).
- All States attempt to regulate and inspect boxing gyms.
- Allow no one to begin training as a professional boxer without first having a complete physical examination.
- All States recognize the medical suspensions of other States.
- All States establish medical advisory boards.

Senator William V. Roth (R, Del) introduced a bill in Congress that would establish a national professional boxing commission to enforce uniform rules and regulations across all 50 States [Marwick 1993]. The Richardson Boxing Bill (HR 2127) called for the formation of the United States Boxing Commission (USBC), a federally chartered, nonprofit corporation that would regulate professional boxing on a national level [Jordan 1988]. The purposes of the USBC were to be similar to those of the ABC and were the following:

- Propose rule changes in boxing to ensure the safety of its participants and establish uniform rules for State athletic or boxing commissions.
- Research the causes of boxing-related injuries and recommend preventive steps.
- Establish minimum standards and procedures for physical and mental examinations.

- Establish minimum standards and procedures for the availability of medical services at professional boxing matches.
- Establish voluntary life and health insurance funds for professional boxers.
- Establish a national computer system to collect, store, and retrieve medical information and boxing histories of professional boxers.
- Research and establish minimum standards for the manufacture and use of boxing equipment.
- Provide a mechanism for the national certification of professional boxing assistants, including trainers, referees, judges, and ringside physicians.
- Work with international boxing organizations to establish international standards.
- Review existing State athletic or boxing commission rules and regulations for professional boxing and provide assistance in meeting minimum safety and health standards.

Marwick added that as the national regulatory agency for professional boxing, the USBC could establish a voluntary life and health insurance program for professional boxers [Marwick 1993]. The USBC could also serve as a resource for the medical investigation of boxing-related injuries.

New York State offered, as an alternative, the setting up of a nationally recognized medical standards committee to review findings by State boxing commission physicians. If the committee finds that the boxer should not fight, that decision would be binding nationwide. The NYSAC also suggests that boxers be banned from the sport by the time they are 35 years old.

The latest recommendations to be published in the literature are from Cantu [1995] and are very similar to the ABC and USBC proposals mentioned earlier. They include:

- Establish a national registry of all professional boxers including a Professional Boxing Corporation to oversee the registry, issue certificates of licensing and registration, and create a national set of regulations. The executive director would be appointed by the President of the United States, would name a professional boxing board of five members, and establish a Congress of State Boxing Administrators.
- Authorize the ringside physician to stop or terminate bouts.
- Hold frequent medical training seminars for ring personnel.
- Provide adequate ringside life support systems and evacuation plans.

- Hold boxing matches only when proper neurosurgical facilities are nearby.
- Establish mandatory safety standards for ringside equipment.
- State boxing commissions upgrade and enforce the medical evaluation, including MRI and CT scans, as well as a psychological profile, of boxers.
- Eliminate all tough man contests.
- Use better criteria to select ringside physicians.
- Do not allow the round-ending bell to save a boxer from a KO.
- Suspend boxers who are rendered unconscious or whose bouts are terminated because of head blows received (i.e., 30 days for stoppage due to minor head blows or excessive standing-eight counts, 90 days if boxer is unresponsive for less than 2 minutes or has been given multiple 30-day suspensions in the same year, and 180 days if the boxer is unresponsive for more than 2 minutes).
- Apply the same suspensions and medical clearance restrictions for sparring as for competition.
- Improve coaching and possibly certify trainers and managers.
- Improve and certify boxing equipment.
- Continue research on chronic brain injury.

Jordan et al. [1996] recommended that measures to prevent brain injury include supervision of sparring bouts and reassessment by boxers of the amount and intensity of sparring that they do.

Acunto [1997] submitted the following safety and health recommendations on behalf of the AAIB as a result of the peer review of this Congressional Report:

- Commissions should use a rotation system for referees and judges.
- The ABC should establish a rule that champions or other professional boxers require only the sanction of the athletic commission in whose jurisdiction they are going to box.
- Translate rules to boxers from other countries and explain what money they are entitled to.
- Boxers should use thumbless gloves and 10-ounce gloves, rather than 8-ounce gloves, in future contests.

- License gyms and maintain attendance records of boxers' training in the facility. Names and dates should be included.
- Report all injuries sustained in the gym, while sparring, immediately to the State commission in that jurisdiction. This action would prevent boxers who sustained an injury from going into a fight without having the effects of the gym injury evaluated medically by the commission [Jordan et al.1996].
- In order to reduce injuries to the neck, jaw, and abdomen, intensify exercises to strengthen those parts, since blows are directed mostly to the head and abdomen.
- The AAIB agrees with the recommendation of training ring personnel at least once or twice a year.
- Use thicker corner pads and covering of turnbuckles, as well as four strands of ring ropes.
- Maintain records, train ring personnel adequately, enforce minimum standardized medical examinations for licensing with greater enforcement of any suspension, and have doctors play a greater role in all State athletic commissions regarding the capability of boxers to continue or to be terminated.
- Place greater emphasis on the science of boxing by having stringent licensing of only qualified trainers and managers with proven expertise and background (as exists in other major sports). These experts would teach defensive tactics so that a boxer could reduce to a minimum the blows assimilated during the course of the boxer's ring career. Also, place greater emphasis on the prevention of mismatches by commissions.
- If possible, administer CT scans to every boxer, before each match and particularly, main event contests. New York State requires EEG and CT scan examinations for boxers who have suffered KOs or TKOs and had been automatically suspended. Boxers can only be reinstated if they have undergone the required examinations.
- Staff the State ABC in the 46 States with neurologists who can teach the sports medicine doctors and ringside physicians signs and symptoms to look for. This rule should pertain to referees as well, and referees should undergo an intense training course.
- Make dental surgeons; eye, ear, and nose specialists; orthopedic doctors; and chiropractors part of the commission staff and available when required.
- Make the latest medical equipment available at all bouts and ready for use at ringside.

- The Senate should establish a National Boxing Commission that includes the 46 existing members of the commissions legislated by law. They would work in concert to transfer information nationally.
- The Association of State Boxing Commissions should (1) establish uniformity of operation on all matters (i.e., scoring systems, medical examinations, pension plans, pension funds, maintenance of records of all matches worldwide), (2) authorize State Commissions to rate champions and contenders, sanction title bouts and any suspensions, revoke licenses, etc., and (3) make passbooks and licenses available for inspection by any State commission when a boxer performs in that State.
- The Association of Boxing Commissioners should certify ring physicians and bond all matchmakers, managers, and promoters.
- Adopt NYSAC's reforms on pre-fight examinations, equipment, authority of ringside physicians to halt matches, training of referees in recognizing neurological injuries, increases in suspension period for KOs, mandatory standby ambulance to be at arena before bouts begin, inspectors assigned to each corner, and a ringside doctor to be seated close to either boxer's corner during a contest.
- Issue a Manual of Procedure to all promoters and matchmakers—to insure that their employees are familiar with the ring, safety equipment, proper facilities for boxing, and personnel at boxing shows.

Nadorf [1997] submitted the following recommendations on behalf of the Everlast Sports Manufacturing Corporation as a result of the peer review of this Congressional Report:

- Have detailed specifications for boxing gloves:
 - Type of padding.
 - Areas to be padded.
 - Minimum weight of padding in the knuckle (punch) area versus weight of padding in the nonprotected (cuff) area.
 - Use of thumbless gloves made and patented by Everlast at the request of the then New York State Boxing Commissioner, Floyd Patterson. The Everlast patent has expired and may be imitated by anyone. Use of thumbless gloves, according to the author, would unquestionably reduce the incidence of retinal injury. He added that correction is possible if gloves do not fit or are not comfortable.

- Leather should be top grain cowhide or sheepskin with a minimum of 1.5-oz to 1.75-oz leather (ounces of leather refers to the thickness of leather as measured by a leather gauge).
- Cause for concern in use of boxing gloves made outside the United States:
 - The leather tanning process in countries such as India, China, Pakistan, and Thailand may include chemicals that exacerbate an injury. For example, if a boxer is cut and the opponent hits the cut area, the boxer could be injured more seriously than from the original cut. Recently, Everlast made shipment of weight lifting belts to a sporting goods chain in Germany. The leather was purchased from Pakistan. This dealer was required to send the belt to a German laboratory for inspection. The leather reportedly contained a cancer producing element and was rejected in Germany.
 - The materials (padding) provided outside the United States are unsatisfactory. Such materials are placed and worked upon the earthen floor, which is laden with rat feces and other highly contagious vermin.
 - Non-use of cutting dies makes each glove different. A pattern is laid atop the leather skin (which is placed upon the earthen floor). Workers usually use a pencil to mark the pattern on the leather. Leather pieces are cut by scissors—one worker may cut pieces on the line; another may cut inside the line and another may cut outside the line. Such a method of manufacturing cannot produce a true set of gloves.
 - Gloves with welting that could cut a boxer should be disallowed.
 - Mexican gloves, favored by hard hitting boxers, have such a dense pad that they were referred to as KO gloves. (This type of glove is probably not recommended.)
 - Nadorf [1997] believes that the quality of the product, if in full adherence to specifications, should be the primary cause of selection rather than promotion of commercial value through televised events.
- Everlast is running tests by Wayne State University (Michigan) to determine the point at which boxing gloves lose their original protective quality. (It is assumed that this type of research is recommended to help establish standards for glove performance.)
- Use of head guards would definitely reduce head-butt injuries and bout stoppage and greatly reduce concussion potential.
- Boxers should be required to wear trunks with a different color waistband than the body of the trunks to designate clearly a foul blow below the belt.

Sirb [1997] recommended the following in his review of this Congressional Report:

- Gloves should weigh a minimum of 10 oz. He added that the larger glove size may add to the force of the blow but that during the course of a bout, especially during the latter rounds, the boxers will feel the weight of the 10-ounce gloves and thus not be able to deliver the same speed on their punches, thus lessening the force of the blow.
- Gloves should be thumbless or thumb-attached.
- One set of standard rules should govern the scoring and conduct of all professional boxing matches. His rationale is that individual sets of rules by each boxing organization, as well as each State, can lead to confusion of some referees who may forget to enforce safety-first techniques. One set of standard rules should improve the safety aspects of boxing and give referees and boxers a better understanding of the rules and their enforcement.
- A new, increased minimum in the thickness of ring-padding should be introduced since no universal rules appear to regulate ring padding.

Giovinazzo [1997] recommended the use of contact lenses in professional boxing which is now permitted by the U.S. Olympic Committee's amateur boxers association. He added that the likelihood of damage from contact lenses is small and that it is more likely that a contact lens would be lost from the eye following a severe blow. If contact lenses are used in the ring, provisions should be made to stop the bout if a boxer loses a contact lens. No attempt should be made to retrieve or replace the lost contact lens, but spare lenses should be kept in the corner, and both corner men and the referee should be trained in contact lens insertion. Only soft contact lenses should be used, preferably the large diameter, which would help to reduce the risk of displacement during the bout. Giovinazzo also mentioned that guidelines should be established for boxers returning to the ring after retinal detachment surgery and after cataract surgery.

APPENDIX 5

RECOMMENDATIONS FROM THE LITERATURE: CATEGORICAL PRESENTATION

Numerous medical organizations have made official statements calling for significant boxing reforms or for a total ban on boxing. In 1984, the American Medical Association called for a ban on all boxing, amateur and professional, in the United States. The British, Canadian, and Australian medical associations as well as the World Medical Association have recommended that boxing be banned. Sweden banned professional boxing in 1969, and in 1982 the Swedish government explored the possibility of forbidding amateur boxing [Swedish government 1982]. In 1984, the American Academy of Pediatrics opposed boxing in any sports programs for children and young adults [American Academy of Pediatrics 1984]. The American Neurological Association and the American Academy of Neurology have called for a ban on boxing [1983]. The *Journal of the American Medical Association* [Lundberg 1983, 1985] has printed several opinions calling for the banning of boxing. The U.S. Air Force Academy ended mandatory boxing in 1995 [Swartzberg 1995].

I. NATIONAL REGISTRY SYSTEM

- Encourage the establishment of a National Registry of Boxers for all amateur and professional boxers including sparring mates. The proposed functions of a computer-based central registry are to record the results of all licensed bouts (including TKOs, KOs, and other boxing injuries) and to compile injury and win-loss records for individual boxers [American Medical Association 1984; World Medical Association 1984].
- Establish a National Boxing Commission to transfer information between existing boxing commissions nationally and internationally. AAIB also called for the immediate establishment of a center from which the results of all boxing contests from around the world can be monitored [Acunto 1987].
- Establish a National Registry of Boxers in the United States for all amateur and professional boxers, including sparring mates. A computer-based central registry would be effective in recording licensed bouts and specifically noting TKOs, KOs, and significant ocular injuries. When a bout is stopped because of an ocular injury, proper

records and documentation would ensure adequate examination of injured boxers [Giovinazzo et al. 1987; Smith 1988].

- Issue each boxer a photograph identification card. A central registration system was suggested that would allow ophthalmologists to follow boxers who had ocular problems and to ensure that they were examined more frequently [Smith 1988].
- Develop a nationwide computer network to track activities of professional boxers [Jordan 1988].
- All States should develop a boxer passport similar to the amateur passport system and the Swedish startbook system and enforce its use [Jordan 1988].
- Establish a national computer system to collect, store, and retrieve medical information and boxing histories of professional boxers [Jordan 1988].
- Establish a national registry of all professional boxers including a Professional Boxing Corporation to oversee the registry and issue certificates of licensing and registration [Cantu 1995—see related recommendation by this author on governing bodies].
- Fight Fax, which was adopted by the ABC as its official recordkeeper, has been keeping records since the early 1980s. This group is respected worldwide and boasts an accuracy rate of over 95%. Fight Fax will have the record of any boxer in the country with a professional record. Because of the Federal Act (Professional Boxing Act of 1996), sending all results to Fight Fax within 48 hours after each event will now become mandatory. This rule will no doubt enhance the accuracy of Fight Fax [Sirb 1997].

II. GOVERNING BODIES

A. National

- Form a National Boxing Council similar to the central commissions of baseball, football, and basketball. The council would be composed of State commission members and recognized leaders in boxing and funded by a levy on all championship bouts and events televised nationally [McCunney and Russo 1984]. The authors recommended the following functions of the council:
 - State commissions would have access to the national council's records, ensuring uniform application of medical and licensing requirements.
 - The council would license managers, promoters, and seconds.

- The council would sponsor seminars for physicians and other ringside personnel.
 - The council would direct a comprehensive medical surveillance program to help detect illness at a preclinical phase and to serve as a basis for ongoing research, including answering scientific questions such as: What level of participation results in irreversible changes? What factors should be included when determining the level of participation—sparring, length of career, number of bouts? What changes and medical methods are the most predictable of the response? What is the proper glove weight and protective head gear design?
 - Boxers who receive a national boxing license should be required to have a passport-like booklet listing the results of medical examinations as well as dates and results of prior matches.
 - In addition to a medical history and physical examination, the EEG should be considered an integral component of the program to detect chronic encephalopathy. CT scans should also be used to detect changes associated with encephalopathy and to evaluate acute head injuries. Psychological testing should also be performed including baseline evaluations. Additional tests could be performed at the discretion of the State commissions.
 - Decisions about test frequency should be made by an American Medical Association Committee panel formed to investigate brain damage in boxers. The panel could also advise the national council about issues such as baseline medical standards for participation; suspension periods for conditions such as KOs, amnesia, and detached retina; and conditions that dictate retirement.
- Jordan [1988] also related the lack of uniform standards of medical supervision for professional boxing to the lack of a formal national regulatory agency and stated that medical supervision is fragmented because of regulation at the State or local level. He stated that the NYSAC is probably the most strictly medically regulated boxing commission in the country. The NYSAC has implemented the following medical interventions:
 - Two ringside physicians at all bouts who have the authority to terminate the fight.
 - Medical Advisory Board that advises the NYSAC regarding medical aspects of boxing.
 - Use of the thumbless glove.
 - Mandatory suspension of boxers who lose six consecutive bouts.

- Medical supervision for a boxer who sustains a KO or TKO.
 - Mandatory neurological examination, CT scan, and EEG for boxers medically suspended after a KO or TKO (for a minimum of 45 days).
 - Annual dilated eye examination by an ophthalmologist.
 - Annual neurological examination, CT scan, and EEG.
- A former Commissioner of the NYSAC recommended the establishment of a National Boxing Commission with the following functions [Novich and Amboy 1988]:
 - Congress must establish a regulatory agency professionally staffed with those meeting civil service qualifications and adequately financed so that the mandates, regulations, and rules can be effectively and efficiently administered. The office staff must be qualified by education, training, and experience; to have been involved in boxing is not enough.
 - The National Boxing Commission must be vested with the sole direction, management, control, and jurisdiction over boxing and related activities.
 - All persons involved with boxing—corporations, promoters, referees, judges, matchmakers, timekeepers, box office employees, ticket takers, inspectors, doormen, ushers, professional boxers, managers, trainers, seconds, sparring mates, announcers, gym owners, operators, and special police— must be licensed.
 - The national body must establish rules, regulations, and standards for all individuals involved in the boxing profession. All applicants must complete a personal application form and submit to fingerprinting, which will be on file with the National and State Boxing Commission. The national or local boxing commission must provide training courses, medical seminars, and boxing safety conferences and require mandatory attendance for license approval and renewal.
 - The commission must establish requirements for each job classification, including trainers, managers, judges, seconds, promoters, and boxers.
 - Senator William V. Roth (R, Del) introduced a bill in Congress that would establish a national professional boxing commission to enforce uniform rules and regulations across all 50 States [Marwick 1993]. The Richardson Boxing Bill (HR 2127) called for the formation of the USBC, a Federally chartered, nonprofit corporation that would regulate professional boxing on a national level [Jordan 1988]. The purposes of the USBC, which were similar to those of the ABC, follow:

- Propose rule changes in boxing to ensure the safety of its participants and establish uniform rules for State athletic or boxing commissions.
 - Research the causes of boxing-related injuries and recommend preventive steps.
 - Establish minimum standards and procedures for physical and mental examinations.
 - Establish minimum standards and procedures for the availability of medical services at professional boxing matches.
 - Establish voluntary life and health insurance funds for professional boxers.
 - Establish a national computer system to collect, store, and retrieve medical information and boxing histories of professional boxers.
 - Research and establish minimum standards for the manufacture and use of boxing equipment.
 - Provide a mechanism for the national certification of professional boxing assistants, including trainers, referees, judges, and ringside physicians.
 - Work with international boxing organizations to establish international standards.
 - Review existing State athletic or boxing commission rules and regulations for professional boxing and provide assistance in meeting minimum safety and health standards.
 - As the national regulatory agency for professional boxing, the USBC could also serve as a resource for the medical investigation of boxing-related injuries [Marwick 1993].
- A Professional Boxing Corporation should be established to oversee the registry (see above), issue certificates of licensing and registration, and create a national set of regulations. The executive director, who would be appointed by the President of the United States, would name a professional boxing board of five members and establish a Congress of State Boxing Administrators [Cantu 1995]. (Note: The specific recommendations for a national set of regulations are mentioned elsewhere in this document and referenced to Cantu 1995.)
 - The Senate should establish a National Boxing Commission that includes the 46 existing members of the legislated commissions. They would work together to transfer information nationally [Acunto 1997].

- The Association of State Boxing Commissions should (1) establish uniformity of operation on all matters (i.e., scoring systems, medical examinations, pension plans, pension funds, and maintenance of records of all matches worldwide); (2) authorize State Commissions to rate champions and contenders, sanction title bouts and any suspensions, revoke licenses, etc.; and (3) make all passbooks and licenses available for inspection by any State commission when a boxer performs in that State [Acunto 1997].
- Acunto [1997] recommended adoption of the NYSAC's reforms on prefight examinations, equipment, authority of ringside physicians to halt matches, training of referees in recognizing neurological injuries, increases in suspension period for KOs, mandatory standby ambulance at arena before bouts begin, inspectors assigned to each corner, and a ringside doctor seated close to either boxer's corner during a contest.
- Sirb [1997] stated that one set of standard rules should govern the scoring and conduct of all professional boxing matches. His rationale is that individual sets of rules by each boxing organization, as well as each State, can lead to confusion of some referees who may forget to enforce safety-first techniques. One set of standard rules should improve the safety aspects of boxing and give referees and boxers a better understanding of the rules and their enforcement.

B. State and Local

- Charnas and Pyeritz [1986] echoed the recommendations of the American Medical Association Committee for the State athletic commissions to adopt the following practices:
 - Review current medical regulations, examinations, and educational practices at least annually.
 - Retain physicians competent in the medical, and particularly the neurological, aspects of boxing to serve as advisers to the commission and at ringside.
 - Sponsor an annual neurological examination for all boxers, performed by a specialist in neurology or neurosurgery.
 - Retain a neurologist or neurosurgeon at ringside.
 - Do not hold a contest in a location more than 10 minutes by ambulance from a hospital with a neurosurgeon in attendance.

- The State athletic commissions throughout the United States should be staffed with neurologists at ringside; dental surgeons; eye, ear, and nose specialists; orthopedic doctors; chiropractors; and general practitioners who deal with sports medicine [Acunto 1987].
- All States should establish medical advisory boards similar to the current Medical Advisory Board that advises the NYSAC regarding medical aspects of boxing [Jordan 1988; Marwick 1993].
- All States should recognize the medical suspensions of other States [Marwick 1993].
- Use better criteria to select ringside physicians [Cantu 1995].
- Commissions should use a rotation system for referees and judges [Acunto 1997].
- The Association of Boxing Commissioners should establish a rule that champions or other professional boxers require only the sanction of the athletic commission in whose jurisdiction they are going to box [Acunto 1997].

III. MEDICAL ADVISORY BOARDS

- Plan and conduct a conference with representatives of the American Association of Ringside Physicians, medical representatives, medical representatives of the various State and local boxing commissions, and representatives of organized professional and amateur boxing organizations to review criteria for the physical examination of boxers, to determine other comprehensive medical measures necessary for the prevention of brain injury in the sport, and to develop specific criteria for the discontinuance of a bout for medical reasons [American Medical Association 1984; World Medical Association 1984].
- An American Medical Association panel formed to investigate brain damage in boxers should make decisions on the frequency of the tests (EEG, CT scans, and psychological examinations). The panel could also advise the proposed National Boxing Council about issues such as baseline medical standards for participation; suspension periods for conditions such as KOs, amnesia, and detached retina; and conditions that dictate retirement [McCunney and Russo 1984].
- All States should establish medical advisory boards similar to the current Medical Advisory Board that advises the NYSAC regarding medical aspects of boxing [Jordan 1988; Marwick 1993].

- Establish a nationally recognized medical standards committee to review findings by State boxing commission physicians. If the committee finds that the boxer should not fight, that decision would be binding nationwide [Marwick 1993].
- Establish a Professional Boxing Corporation and a Congress of State Boxing Administrators to upgrade and enforce the medical evaluation, including MRI and CT scans, and a psychological profile of boxers by State boxing commissions [Cantu 1995].
- Make dental surgeons; eye, ear, and nose specialists; orthopedic doctors; and chiropodists part of the commission staff and make them available when required [Acunto 1997].

IV. TRAINING, CERTIFICATION, AND AUTHORITY

A. Referees

- Referees should be familiar with, and alert to, the health hazards inherent in boxing [American Medical Association Committee 1962].
- The referee or physician should interrupt any bout with the opponent declared winner when a contestant sustains more than one knockdown in any one round or shows inability to control the position of the head [American Medical Association Committee 1962].
- State and local commissions should conduct frequent medical training seminars for all ring personnel [American Medical Association 1984; World Medical Association 1984].
- A National Boxing Council should sponsor seminars for physicians and other ringside personnel [McCunney and Russo 1984].
- The NYSAC's reforms should be adopted for prefight examinations, equipment, authority of ringside physicians to halt matches, training of referees in recognizing neurologic injury, increases in suspension periods for KOs, and inspectors to observe corner men between rounds [Acunto 1987].
- The New Jersey State Athletic Commission currently licenses and assigns referees, promoters, inspectors, seconds, and matchmakers (this statement is assumed to imply a recommended practice for all State commissions [Novich and Amboy 1988]).

- All persons involved with boxing must be licensed—corporations, promoters, referees, judges, matchmakers, timekeepers, box office employees, ticket takers, inspectors, doormen, ushers, professional boxers, managers, trainers, seconds, sparring mates, announcers, gym owners, operators, and special police [Novich and Amboy 1988].
- The proposed National Boxing Commission must establish rules, regulations, and standards for all persons involved in the boxing profession. All applicants must complete a personal application form and submit to fingerprinting, which will be on file with the National and State Boxing Commissions. The National Boxing Commission or the local one must provide training courses, medical seminars, and boxing safety conferences and require mandatory attendance for license approval and renewal [Novich and Amboy 1988].
- Provide a mechanism for the national certification of professional boxing assistants, including trainers, referees, judges, and ringside physicians [Jordan 1988; Marwick 1993].
- Hold frequent medical training seminars for ring personnel [Cantu 1995].
- The AAIB recommends training of ring personnel at least once or twice a year [Acunto 1997].
- Staff the State ABC throughout the 46 States with neurologists who can teach the sports medicine doctors and ringside physicians what signs and symptoms to look for. This training should pertain to referees, as well, and referees should undergo an intense training course [Acunto 1997].

B. Physicians

- Retain at least one physician at all bouts with absolute authority to terminate the contest for medical reasons [American Medical Association Committee 1962].
- Allow the referee or physician to interrupt any bout with the opponent declared winner when a contestant sustains more than one knockdown in any one round or evidences inability to control the position of the head [American Medical Association Committee 1962].
- Urge State and local commissions to conduct frequent medical training seminars for all ring personnel [American Medical Association 1984; World Medical Association 1984].

- A proposed National Boxing Council would sponsor seminars for physicians and other ringside personnel [McCunney and Russo 1984].
- Retain physicians competent in the medical, particularly the neurological, aspects of boxing to serve as advisers to the commission and at ringside [Charnas and Pyeritz 1986].
- Review current medical regulations, examinations, and educational practices at least annually [Charnas and Pyeritz 1986].
- Acunto [1987] mentioned board certification for ringside physicians, as established by the American Academy of Neurological and Orthopedic Surgeons, as an aid in improving boxing.
- Adopt the NYSAC's reforms on preflight examinations, equipment, authority of ringside physicians to halt matches, training of referees in recognizing neurological injury, increases in suspension periods for KOs, and inspectors to observe corner men between rounds [Acunto 1987].
- Institute a program for training and recertification of ringside physicians in the proper identification of serious eye injuries sustained in the ring. Emphasize the diagnosis of serious eye injuries and specific criteria for suspension of a bout during this training. Plan and conduct seminars in cooperation with the American Association of Ringside Physicians and possibly the American Academy of Ophthalmology [Giovinazzo et al. 1987].
- The proposed National Boxing Commission must establish rules, regulations, and standards for all persons involved in the boxing profession. All applicants must complete a personal application form and submit to fingerprinting, which will be on file with the National and State Boxing Commission. The National or Local Boxing Commission must provide training courses, medical seminars, and boxing safety conferences and require mandatory attendance for license approval and renewal [Novich and Amboy 1988].
- The NYSAC currently assigns two physicians at ringside before the start of any boxing program; each physician can enter the ring at any time and stop the fight for medical reasons. (Jordan [1988] implied that this current practice should be universally adopted.)
- The New Jersey State Athletic Commission currently assigns licensed ringside physicians and a second physician in the dressing room. Postbout examinations are conducted by physicians, and, if necessary, treatment is performed by the physician in

the dressing room or the boxer is referred to a local hospital emergency room. (Novich and Amboy [1988] implied that this current practice should be universally adopted.)

- Hold frequent medical training seminars for ring personnel [Cantu 1995].
- The State ABC throughout the 46 States should be staffed with neurologists who can teach the sports medicine doctors and ringside physicians what signs and symptoms to look for [Acunto 1997].
- The Association of Boxing Commissioners should certify ring physicians and bond all matchmakers, managers, and promoters [Acunto 1997].

C. Others

- The proposed National Boxing Council would license managers, promoters and seconds [McCunney and Russo 1984].
- Give a manual of procedures to all promoters and matchmakers to ensure that their employees are familiar with the safety equipment and proper facilities [Acunto 1987].
- Adopt the NYSAC's reforms on preflight examinations, equipment, authority of ringside physicians to halt matches, training of referees in recognizing neurological injury, increases in suspension periods for KOs, and inspectors to observe corner men between rounds [Acunto 1987].
- The New Jersey Athletic Commission currently requires bonding of promoters and managers, termination of options, and monopoly of a boxer by a promoter [Novich and Amboy 1988; Acunto 1987].
- All persons involved with boxing must be licensed—corporations, promoters, referees, judges, matchmakers, timekeepers, box office employees, ticket takers, inspectors, doormen, ushers, professional boxers, managers, trainers, seconds, sparring mates, announcers, gym owners, operators, and special police [Novich and Amboy 1988].
- The proposed National Boxing Commission must establish requirements for each job classification, including trainers, managers, judges, seconds, promoters, and boxers [Novich and Amboy 1988].
- The New Jersey State Athletic Commission currently licenses and assigns referees, promoters, inspectors, seconds, and matchmakers (Novich and Amboy [1988]—this statement is assumed to imply a recommended practice for all State commissions).

- The New Jersey State Athletic Commission Inspectors oversee how handwraps and gloves are applied on a boxer in the dressing room. It is their duty to observe what methods seconds use to freshen boxers between rounds. Assigned inspectors are encouraged to go to gymnasiums to determine whether boxers are following appropriate prefight fitness and training routines. They also should attempt to detect training injuries that may be hidden from the physician at prefight examinations (this statement is assumed to imply a recommended practice for all State commissions [Novich and Amboy 1988]).
- All applicants must complete a personal application form and submit to fingerprinting, which will be on file with the National and State Boxing Commission. The national or local boxing commission must provide training courses, medical seminars, and boxing safety conferences and require mandatory attendance for license approval and renewal [Novich and Amboy 1988].
- Improve coaching and possibly certify trainers and managers [Cantu 1995].
- Translate rules for boxers from other countries and explain what money they are entitled to [Acunto 1997].
- Issue a Manual of Procedure to all promoters and matchmakers to insure that their employees are familiar with the ring, safety equipment, proper facilities for boxing, and personnel at boxing shows [Acunto 1997].

V. FIGHT PRE-CONDITIONS AND AUTHORITY OVER FIGHT STOPPAGE

- Retain at least one physician at all bouts with absolute authority to terminate the contest for medical reasons [American Medical Association Committee 1962].
- Permit no amateur or professional boxing bout unless (1) the contest is held in an area where adequate neurosurgical facilities are immediately available for skilled emergency treatment of an injured boxer; (2) advanced life-support systems are available at ringside; and (3) a comprehensive evacuation plan for the removal of any seriously injured boxer to hospital facilities is ready [American Medical Association 1984; World Medical Association 1984].
- Authorize the ring physician to stop any bout at any time to examine a contestant and to terminate a bout that might, in his or her opinion, result in serious injury for either contestant [American Medical Association 1984; World Medical Association 1984].
- Retain a neurologist or neurosurgeon at ringside [Charnas and Pyeritz 1986].

- Hold no contest in a location more than 10 minutes by ambulance from a hospital with a neurosurgeon in attendance [Charnas and Pyeritz 1986].
- The State and local licensing agencies should have a uniform code of safety specifying those ocular injuries sufficient to stop a boxing match [Giovinazzo et al. 1987].
- Adopt the NYSAC's reforms on preflight examinations, equipment, authority of ringside physicians to halt matches, training of referees in recognizing neurological injury, increases in suspension periods for KOs, and inspectors to observe corner men between rounds [Acunto 1987].
- The New Jersey State Athletic Commission currently assigns licensed ringside physicians and a second physician in the dressing room. Postbout examinations are conducted by physicians; and, if necessary, treatment is performed by the physician in the dressing room, or the boxer is referred to a local hospital emergency room (Novich and Amboy [1988] implied that this current practice should be universally adopted).
- NYSAC currently assigns two physicians at ringside before the start of any boxing program; each physician can enter the ring at any time and stop the fight for medical reasons (Jordan [1988] implied that this current practice should be universally adopted).
- Establish minimum standards and procedures for the availability of medical services at professional boxing matches [Jordan 1988].
- O'Connor and Tucker [1991] addressed guidelines for the physician for the pre-participation evaluation and disqualifying conditions that are used at the U.S. Army base in Fort Dix. They recommended that the medical/surgical/family history and the physical examination be performed in a private, quiet, well-lit room and should be individualized rather than conducted in groups. In addition to vital signs, the authors used an organ systems review and examination form that included eyes, ears, face and mouth, cardiac, lung, abdomen, musculoskeletal, skin, central nervous system, blood, and lymphatic system. Particular emphasis was placed on the central nervous and cardiovascular systems as representing the areas of greatest potential risk.
- Authorize the ringside physician to stop or terminate bouts [Cantu 1995].
- Provide adequate ringside life support systems and evacuation plans [Cantu 1995].
- Hold boxing matches only when proper neurosurgical facilities are nearby [Cantu 1995].

- Make the latest medical equipment available at all bouts and ready for use at ringside [Acunto 1997].

VI. PROTECTIVE EQUIPMENT

A. Fighting Rings

- Encourage the universal adoption of the new unapproved shock-absorbing ring padding under the canvas and on the posts of the ring to aid in prevention of injuries caused by striking the head against unpadded surfaces [American Medical Association Committee 1962].
- Urge State and local boxing commissions to mandate the use of safety equipment, such as plastic safety mats and padded corner posts, and encourage continued development of safety equipment [American Medical Association 1984; World Medical Association 1984].
- Research and establish minimum standards for the manufacture and use of boxing equipment [Jordan 1988].
- Establish mandatory safety standards for ringside equipment [Cantu 1995].
- Improve and certify boxing equipment [Cantu 1995].
- The AAIB recommends thicker corner pads and covering of turnbuckles, as well as four strands of ring ropes [Acunto 1997].
- A new increased minimum in the thickness of ring padding should be established since no universal rules of ring padding appear to exist [Sirb 1997].

B. Gloves

- Strano and Marais [1983] recommended the use of brightly colored gloves (e.g., orange) so that they would be more noticeable, thus providing the defender with more time to prepare for oncoming blows.
- Morrison [1986] suggested the banning of boxing gloves to increase pain and injury to the ungloved hand and decrease the number and force of the punches thrown.
- State and local licensing agencies should adopt adequate safety equipment to minimize ocular injuries. The thumb of most regulation boxing gloves is small enough to penetrate the orbital rim. It is an important cause of much blunt ocular trauma. Boxers

with shallow orbits may not have adequate protection for the eye. Periorbital edema or myopia may also induce greater exposure of the globe to the thumb of a boxing glove [Giovinazzo et al. 1987].

- The thumbless glove should be required not only in all amateur and professional bouts, but also in sparring matches [Giovinazzo et al. 1987].
- The American Medical Association Committee [1962] suggested other potential safety measures including less padding in the glove and the prohibition of wrapping the hands to reduce the force of the blow.
- Smith [1988] recommended thumbless gloves to reduce eye injuries.
- The NYSAC currently uses thumbless gloves. (Jordan [1988] implied that this current practice should be universally adopted.)
- Research and establish minimum standards for the manufacturing and use of boxing equipment [Jordan 1988].
- Improve and certify boxing equipment [Cantu 1995].
- Require the use of thumbless gloves by all boxers and 10-ounce gloves, rather than 8-ounce gloves, in future contests [Acunto 1997].
- According to Nadorf [1997], boxing gloves should have detailed specifications such as the following:
 - Type of padding.
 - Areas to be padded.
 - Minimum weight of padding in the knuckle (punch) area versus weight of padding in the nonprotected (cuff) area.
 - Thumbless gloves are made and patented by Everlast at the request of the New York State Boxing Commissioner, Floyd Patterson. The Everlast patent has expired and may be imitated by anyone. Use of thumbless gloves, according to the author, would unquestionably reduce the incidence of retinal injury. He added that correction is very possible if gloves do not fit or are not comfortable.
 - Leather should be top grain cowhide or sheepskin with a minimum of 1.5-oz to 1.75-oz leather (ounce equal thickness of leather as measured by a leather gauge).

- The leather tanning process in countries such as India, China, Pakistan, and Thailand may involve chemicals that exacerbate an injury such as that reported from Germany where the leather contained a cancer-producing element and was rejected for use.
 - The materials (padding) provided outside the United States is unsatisfactory because those materials are placed and worked upon the earthen floor. Such flooring is laden with rat feces and other highly contagious vermin.
 - Nonuse of cutting dies should be prohibited since it makes each glove different. A pattern is laid atop the leather skin (which is placed upon the earthen floor) and usually traced with a pencil. Leather pieces are cut by scissors—one laborer may cut pieces on the line while another may cut inside the line or outside the line. This method of manufacturing does not produce a true *set* of gloves.
 - Gloves with welting that could cut a boxer should be disallowed.
 - Mexican gloves, favored by hard hitting boxers, have such a dense pad that they were referred to as KO gloves. (This type of glove is probably not recommended.)
 - Nadorf [1997] believes that the quality of the product, if in full adherence to specifications, should be the primary cause of selection of the product used rather than for further promotion of commercial value through televised events.
- Everlast is running tests by Wayne State University (Michigan) to determine the point at which boxing gloves lose their original protective quality [Nadorf 1997]. (This type of research is assumed to be recommended to help establish standards for glove performance.)
 - Sirb [1997] recommended that gloves be thumbless or thumb-attached and weigh a minimum of 10 oz. He added that the larger glove size may add to the force of the blow but that during the course of a bout, especially during the latter rounds, the boxers will feel the weight of the 10-oz. gloves and not be able to deliver the same speed on their punches; therefore, the force of the blow will be lessened.

C. Headgear and Mouthpieces

- The American Medical Association Committee [1962] recommended requiring (1) headgear be required to minimize lacerations and contusions, and (2) properly fitted mouthpieces to protect the teeth and supporting tissues.

- Guterman and Smith [1987] cited the requirement of protective headgear in Olympic competition but questioned the effectiveness because of its design. They raised the issue of using any headgear “short of a really efficient crash helmet which effectively absorbs these forces without transmitting through the skull” because it does not protect the boxer from head trauma.
- The American Medical Association Committee [1962] suggested research designed to develop a protective headgear.
- Jordan [1988] suggested the research and establishment of minimum standards for the manufacturing and use of boxing equipment.
- Nadorf [1997] recommended head guards to reduce head-butt injuries and bout stoppage in addition to adding a much reduced concussion potential.

D. Other Practices

- LaCava [1983] recommended that professional bouts be limited to six rounds to reduce the risk of brain injury. Morrison [1986] agreed with this proposal and stated that amateur boxers, who fight only three rounds per bout and therefore receive fewer blows to the head, appear to be less susceptible to brain damage.
- Morrison [1986] reviewed a number of proposed practices such as disqualifying blows to the head and wiring of boxers so that scoring points are measured electronically (as in fencing), making hard punches unnecessary.
- Acunto [1987] recommended placing greater emphasis on the science of the sport (details not given).
- The American Medical Association Committee [1962] suggested that the system of point scoring be revised to emphasize skillful offensive and defensive maneuvering instead of the KO blow [Jordan 1988].
- Boxers should be required to wear trunks with a different color waistband than the body of the trunks to designate clearly a foul blow below the belt [Nadorf 1997].

VII. MEDICAL EVALUATIONS

A. Medical Fitness Evaluations and Annual Testing

1. General fitness and health

- In 1992 the American Medical Association Committee recommended a thorough medical examination of each contestant before bouts by a physician responsible for determination of the boxer's fitness to participate.
- The American Medical Association Committee [1962] recommended coaching and training that would assure the maximum protection that skillful performance and good condition can provide.
- The National Health and Medical Research Council of Australia recommended that, before a contestant is permitted to box, several medical contraindications be observed [Health hazards of boxing 1975]. These include schizophrenia, manic depression, recurrent neurotic breakdown, aggressive psychopathy, drug dependence, and hysterical personality disorders; epilepsy, previous intracranial hemorrhage or severe head injuries, previous craniotomy; severe hypertension, coronary artery disease, other heart diseases, cardiac arrhythmias; spontaneous pneumothorax, lung cyst, active lung disease including emphysema; active renal disease and kidney lesions susceptible to trauma such as polycystic kidney, renal calculus and hydronephrosis; eye abnormalities; and blood dyscrasias, generalized bone and joint disorders, unilateral blindness, and absence of a kidney or testicle. The Council also recommended including compulsory medical examination before boxers may compete.
- The American Medical Association [1984] and the World Medical Association [1984] urged State and local boxing commissions to upgrade, standardize, and strictly enforce medical evaluations for boxers.
- The proposed National Boxing Council should assure that boxers who receive a national boxing license should be required to have a passport-like booklet listing the results of medical examinations and dates and results of prior matches [McCunney and Russo 1984].
- The minimal visual requirements for boxing should be (1) a visual acuity of 20/40 or better in each eye, and (2) a full, central visual field not less than 30 degrees in each eye [Giovinazzo et al. 1987].
- Guterman and Smith [1987] recommended improved medical supervision with comprehensive medical and neurological evaluation of all boxers before they train. This evaluation should include a complete medical history and physical examination with a

comprehensive neurological examination comprised of a 16-channel EEG in both waking and sleeping states, a CT scan of the brain with and without contrast, and a formal battery of neuropsychological tests such as the WAIS-revised, Boston Naming Test, Controlled Oral Word Association Test, Benton Visual Retention Test, Wechsler Memory Scale, Ravens Colored Progressive Matrices, Trail Making, and the Halsted-Raitan. Either the entire medical workup or portions felt to be clinically indicated should be repeated at least every 6 months, but every boxer should have the complete series done yearly.

- The New Jersey State Athletic Commission currently licenses boxers to assure that they are medically fit to box professionally (This statement is assumed to imply a recommended practice for all State commissions [Novich and Amboy 1988]).
- O'Connor and Tucker [1991] addressed guidelines for the physician for the pre-participation evaluation and specific disqualifying conditions that are used at the U.S. Army base in Fort Dix. They recommended that the medical/surgical/family history and the physical examination be performed in a private, quiet, well-lit room and should be individualized rather than conducted in groups. In addition to vital signs, the authors used an organ systems review and examination form that included eyes, ears, face and mouth, cardiac, lung, abdomen, musculoskeletal, skin, central nervous system, blood, and lymphatic system. Particular emphasis was placed on the central nervous and cardiovascular systems as representing the areas of greatest potential risk.
- No individual should be allowed to begin training as a professional boxer without first having a complete physical examination (Jordan [1988] reporting on the ABC).
- A minimum standard should exist for medical examinations (Jordan [1988] reporting on the ABC).
- Minimum standards and procedures should exist for physical and mental examinations (Jordan [1988] reporting on the recommendations of the ABC).
- The same suspensions and medical clearance restrictions should be applied for sparring as for competition [Cantu 1995].

2. Neurological evaluations

- State commissions should organize an annual neurologic examination for all boxers, performed by a specialist in neurology or neurosurgery, and a neurologist or neurosurgeon should be present at ringside [Charnas and Pyeritz 1986].
- CT scans should be administered to every boxer before every match [Acunto 1987].

- The NYSAC mandates an annual neurological examination, CT scan, and EEG [Jordan 1988] (assumed to imply universal application to all commissions).
- O'Connor and Tucker [1991] emphasized the central nervous and cardiovascular systems as the areas of greatest potential risk.
- Jordan et al. [1992] recommended that neurological evaluation of an active boxer include a CT scan or MRI for detection of anatomic lesions and an EEG for detection of electrophysiological dysfunction.
- State boxing commissions should upgrade and enforce the medical evaluation, including MRI and CT scans, as well as a psychological profile, of boxers [Cantu 1995].
- CT scans should be administered to every boxer before each match, particularly for main event contests. New York State requires EEG and CT examinations for boxers who have suffered KOs or TKOs and had been automatically suspended. Boxers can only be reinstated if they have undergone these tests [Acunto 1997].

3. Eye evaluations

- Giovinazzo et al. [1987] recommended an initial ocular examination before licensure for either amateur or professional boxing that includes visual acuity, visual fields, slit-lamp biomicroscopy, intraocular pressure measurement, gonioscopy, and a dilated vitreoretinal examination including indirect ophthalmoscopy with scleral depression by an ophthalmologist. The Vision Safety and Performance Committee of the United States Olympic Committee requires this type of comprehensive examination [Vinger 1986].
- The minimal visual requirements for boxing should be (1) a visual acuity of 20/40 or better in each eye, and (2) a full, central visual field not less than 30 degrees in each eye [Giovinazzo et al. 1987].
- Giovinazzo et al. [1987] recommended a repeat, complete eye examination after 1 year, six bouts, two losses, the stopping of a fight because of an eye injury, or at the discretion of the ringside physician.
- Smith [1988] recommended at least one complete ophthalmic examination annually.
- NYSAC currently mandates an annual dilated eye examination by an ophthalmologist (Jordan [1988], assumed to imply universal application to all commissions).

- Giovinazzo [1997] recommended contact lenses in professional boxing, which are now permitted by the U.S. Olympic Committee's amateur boxer's association. He added that the likelihood of damage from contact lenses in the boxing ring is small, and a contact lens is more likely to be lost from the eye following a severe blow. If contact lenses are used in the ring, provisions should be made to stop the bout if a boxer loses a contact lens. The lost contact lens should not be retrieved or replaced, but spare lenses should be kept in the corner, and both corner men and the referee should be trained in contact lens insertion. Only soft contact lenses should be used, preferably the large diameter because they would reduce the risk of displacement during the bout. Giovinazzo also mentioned that guidelines should be established for boxers returning to the ring after retinal detachment surgery, and after cataract surgery.

B. Indicated Medical Evaluations (Secondary to Fighting)

1. Neurological

a. Knockouts

- The American Medical Association [1984] and the World Medical Association [1984] recommended a conference with representatives of the American Association of Ringside Physicians, medical representatives, medical representatives of the various State and local boxing commissions, and representatives of organized professional and amateur boxing organizations. The participants would review criteria for the physical examination of boxers, determine other comprehensive medical measures necessary for the prevention of brain injury in the sport, and develop specific criteria for the discontinuance of a bout for medical reasons.
- Strano and Marais [1983] stated that when serious injury has occurred, a bout should be stopped immediately since the potential for serious damage is greatly increased in the dazed defender with altered muscle tone and reaction time.
- In addition to a medical history and physical examination, the EEG should be considered an integral component of the program to detect chronic encephalopathy. CT scans should also be used to detect changes associated with encephalopathy and to evaluate acute head injuries. Psychological testing should also be performed including baseline evaluations. Additional tests could be performed at the discretion of the State commissions [McCunney and Russo 1984].
- An American Medical Association Committee panel formed to investigate brain damage in boxers should make decisions on the frequency of the tests. The panel could also advise the national council about issues such as baseline medical

standards for participation; suspension periods for conditions such as KOs, amnesia, and detached retina; and conditions that dictate retirement [McCunney and Russo 1984].

- CT scans should be administered to every boxer before every match [Acunto 1987].
- Guterman and Smith [1987] recommended that as soon as any of the tests mentioned above (see V.A.1. above) show significant abnormalities, a boxer's active career should be halted for formal re-evaluation of the boxer's suitability to continue and evidence of any irreversible neurological deficit should end a boxer's career.
- Guterman and Smith [1987] recommended that the ringside physician have the ability to and be willing to halt any bout.
- NYSAC requires mandatory neurological examination, CT scans and EEGs for boxers medically suspended for a minimum of 45 days after a KO or TKO (Jordan [1988] implied that this current practice should be universally adopted).
- Kelly et al. [1991] recommended the adoption of guidelines to reduce the risk of such serious catastrophic outcomes after concussion in sports. These are based on levels of injury and the actions that should be taken if such injury is suspected. They are as follows:

Grade 1. Confusion without Amnesia, No Loss of Consciousness

Remove from contest. Examine immediately and every 5 minutes for the development of amnesia or postconcussive symptoms at rest and with exertion. Permit return to contest if amnesia does not appear and no symptoms appear for at least 20 min.

Grade 2. Confusion with Amnesia, No Loss of Consciousness

Remove from contest and disallow return. Examine frequently for signs of evolving intracranial pathology. Reexamine the next day. Permit return to practice after 1 full week without symptoms.

Grade 3. Loss of Consciousness

Transport from field to nearest hospital by ambulance (with cervical spine immobilization if indicated). Perform thorough neurological evaluation emergently. Admit to hospital if signs of pathology are detected. If findings are normal, instruct family for overnight observation. Permit return to practice only after 2 full weeks without symptoms.

Prolonged unconsciousness, persistent mental status alterations, worsening postconcussion symptoms, or abnormalities on neurological examination require urgent neurosurgical consultation or transfer to a trauma center.

- Jordan [1990b] reviewed and described other field evaluation and management systems of head injury. Jordan [1991] suggested a rating scale for boxing-related acute neurological injury consisting of four grades and based on loss of consciousness. He also offered a general outline of clinical criteria for diagnosis of probable, possible, and unlikely boxing-related chronic neurological injury. Kelly [1995] compared several grading systems for severity of concussions and offered guidelines for return to play after concussion.
- The Centers for Disease Control and Prevention [1997] produced a summary of recommendations for the management of concussion in sports originating from the American Academy of Neurology [1997]. They are as follows:

A concussion is defined as head-trauma induced alteration in mental status that may or may not involve loss of consciousness. Concussions are graded in three categories. Definitions and treatment recommendations for each category are:

Grade 1 Concussion

- *Definition:* Transient confusion, no loss of consciousness, and a duration of mental status abnormalities of <15 minutes.
- *Management:* The athlete should be removed from sports activity, examined immediately and at 5-minute intervals, and allowed to return that day to the sports activity only if postconcussive symptoms resolve within 15 minutes. Any athlete who incurs a second Grade 1 concussion on the same day should be removed from sports activity until asymptomatic for 1 week.

Grade 2 Concussion

- *Definition:* Transient confusion, no loss of consciousness, and a duration of mental status abnormalities of ≥15 minutes.
- *Management:* The athlete should be removed from sports activity and examined frequently to assess the evolution of symptoms, with more extensive diagnostic evaluation if the symptoms worsen or persist for >1 week. The athlete should return to sports activity only after asymptomatic for 1 full week. Any athlete who incurs a Grade 2 concussion subsequent to a Grade 1 concussion on the same day should be removed from sports activity until asymptomatic for 2 weeks.

Grade 3 Concussion

- *Definition:* Loss of consciousness, either brief (seconds) or prolonged (minutes or longer).
- *Management:* The athlete should be removed from sports activity for 1 full week without symptoms if the loss of consciousness is brief or 2 full weeks without symptoms if the loss of consciousness is prolonged. If still unconscious or if abnormal neurologic signs are present at the time of initial evaluation, the athlete should be transported by ambulance to the nearest hospital emergency department. An athlete who suffers a second Grade 3 concussion should be removed from sports activity until asymptomatic for 1 month. Any athlete with an abnormality on computed tomography or magnetic resonance imaging brain scan consistent with brain swelling, contusion, or other intracranial pathology should be removed from sports activities for the season and discouraged from future return to participation in contact sports.

b. Number of bouts or losses

- Cantu [1995] recommended suspending boxers rendered unconscious or who participated in bouts terminated because of head blows: 30 days suspension for stoppage due to minor head blows or excessive standing eight counts, 90 days if boxer is unresponsive for less than 2 minutes or has been given multiple 30-day suspensions in the same year, and 180 days if the boxer is unresponsive for more than 2 minutes.
- The round-ending bell should not be allowed to save a boxer from a KO [Cantu 1995].
- The NYSAC suggests that boxers be banned from the sport by the time they are 35 years old [Marwick 1993].

2. Eye Injury

- Strano and Marais [1983] stated that in bouts in which serious injury has occurred, the bout should be stopped immediately since the potential for serious damage is greatly increased in the dazed defender with altered muscle tone and reaction time.
- An American Medical Association Committee panel formed to investigate brain damage in boxers should make decisions on the frequency of the tests. The panel could also advise the national council about issues such as baseline medical standards for participation; suspension periods for conditions such as KOs, amnesia, and detached retina; and conditions that dictate retirement [McCunney and Russo 1984].
- A repeat, complete eye examination should be instituted after 1 year, six bouts, two losses, the stopping of a fight because of an eye injury, or at the discretion of the ringside physician [Giovinazzo et al. 1987].
- Guterman and Smith [1987] recommended that the ringside physician have the ability to and be willing to halt any bout.
- The State and local licensing agencies should adopt a uniform code of safety specifying ocular injuries that are sufficient to stop a boxing match [Giovinazzo et al. 1987].

C. Medical Suspensions (Specific Injury-related)

1. Lacerations and Eye Injuries

- Giovinazzo et al. [1987] recommended a mandatory temporary suspension from sparring and boxing for specific ocular pathology. When a retinal tear is identified and treated, a 30-day suspension from the ring should be enforced. When a retinal detachment is treated and if a boxer is to resume a boxing career, a minimum of 60 days mandatory suspension should be enforced.
- If he sustains lacerations of the face, a boxer may be suspended for 60 days (Jordan [1988] implied that this current practice by NYSAC should be universally adopted).

2. Knockouts

- The referee or physician should be able to interrupt any bout with the opponent declared winner when a contestant sustains more than one knockdown in any one round or shows inability to control the head position [American Medical Association Committee 1962].
- The American Medical Association Committee [1962] recommended that at least one physician be present at all bouts with absolute authority to terminate the contest for medical reasons.
- The American Medical Association Committee [1962] recommended automatic suspension of any participant who sustains a KO, TKO, or other severe injury for as long as medical consultants feel it necessary.
- NYSAC requires mandatory neurological examination, CT scan, and EEG for boxers medically suspended after a KO or TKO for a minimum of 45 days (Jordan [1988] implied that this current practice should be universally adopted).
- Jordan [1988] implied that the current practice by NYSAC of medical supervision for a boxer sustaining a KO or TKO should be universally adopted.
- A TKO for minor injuries entails a suspension of 30 days and those with head injuries receive a 45-day suspension. Boxers with immediate response to a KO receive a 60-day suspension (Jordan [1995] implied that this current practice by NYSAC should be universally adopted).
- Boxers with a slow response receive a 90-day suspension plus a computed axial tomographic scan and EEG within 24 hours (Jordan [1995] implied that this current practice by NYSAC should be universally adopted).

3. Losses

The NYSAC has implemented mandatory suspension of boxers who lose six consecutive bouts (Jordan [1988] implied that this current practice should be universally adopted).

D. Medical Surveillance

The proposed National Boxing Council would direct a comprehensive medical surveillance program to help detect illness at a preclinical phase and to serve as a basis for ongoing research, including answering scientific questions such as: What level of participation results in irreversible changes? What factors should be included when determining the level of participation—sparring, length of career, number of bouts? What changes and medical methods are the most predictable of the response? What is the proper glove weight and protective head gear design? [McCunney and Russo 1984].

VIII. SPARRING PARTNERS AND OTHER BOXERS

- The American Medical Association [1984] and World Medical Association [1984] recommended that State legislatures be informed that unsupervised boxing competition between unlicensed boxers in tough man contests is a most dangerous practice that may result in serious injury or death to contestants and should be condemned [American Medical Association 1984; World Medical Association 1984].
- State and local boxing commissions should extend all safety measures to sparring partners [American Medical Association 1984; World Medical Association 1984].
- Giovinazzo et al. [1987] recommended that thumbless gloves be required not only in all amateur and professional bouts but also in sparring matches.
- All States should attempt to regulate and inspect boxing gyms [Marwick 1993].
- Cantu [1995] recommended elimination of all tough man contests.
- Cantu [1995] recommended that the same suspensions and medical clearance restrictions be applied for sparring as for competition.
- Jordan et al. [1996] recommended that measures to prevent brain injury include supervision of sparring bouts and reassessment by boxers of the amount and intensity of sparring that they do.
- Acunto [1997] recommended licensing of gyms, attendance records of boxer's training in the facility.

- Acunto [1997] recommended that all injuries sustained in the gym, while sparring, be reported immediately to the State commission in that jurisdiction. He added that this would prevent boxers who sustain an injury from going into a fight without having the effects of the injury evaluated medically by the commission [Jordan et al. 1996].
- In order to reduce injuries to the neck, jaw, and abdomen, exercises should be intensified to strengthen those parts, since, in boxing, blows are directed mostly to the head and abdomen [Acunto 1997].
- Greater emphasis should be placed on the science of boxing by having stringent licensing of only qualified trainers and managers with proven expertise and background (as exists in other major sports). These experts would teach the art of boxing and defensive tactics so that a boxer could reduce to a minimum the blows assimilated during the boxer's ring career. The prevention of mismatches by commissions should be emphasized [Acunto 1997].

IX. AMATEUR RECOMMENDATIONS

A. United States of America

Recommendations by the USAABF (1987) included:

- Form a national regulatory agency, the USAABF, to enforce uniform medical standards.
- Retain one or more physicians at all amateur boxing shows who are prepared to deal with any emergency.
- Thoroughly examine contestants immediately before and after each bout.
- Allow a physician, at his or her discretion, to enter the ring immediately if a bout ends in a KO or if it is stopped because of an injury.
- Allow the attending physician to suspend a bout at any time if in his or her opinion a contestant is in danger of further physical injury.
- Medically suspend any boxer rendered unconscious or who receives excessive blows to the head.
- Before boxing is resumed, after medical suspension, have the boxer undergo a medical examination.

- Issue a Restrictions Affidavit to any boxer who is medically suspended after receiving head blows.

B. Sweden

The Swedish model for amateur boxing consists of the following [Ludwig 1986]:

- No boxing is allowed before the age of 15 and from the ages of 10 to 15 only technical training is permitted. In competition, points are counted for different technical details; a boxer earns a diploma for good technique.
- Boxers younger than 19 are scored on points. If knocked out, the boxer is forced to rest for at least 1 month. A second KO requires 3 months rest, and each period of rest requires neurological examination before fighting can resume. A ring physician can order rest after an extremely hard fight in which a boxer received many blows to the head.
- Every boxer must have a startbook from the boxer's first fight. It contains a photograph, name, address, and club. Initial medical examination findings and a record of every match are entered, including the opponent's name, result of the fight, any KO, and the physician's notes.
- A committee checks the startbooks each year before the boxer is allowed to continue fighting. Each boxer has one major medical examination each year that includes tests of fitness, vision, hearing, and a neurological examination. A neurologist examines every boxer who has had more than 100 matches and administers an EEG. This same examination applies to all boxers over 30 years old.
- Before every match, the ring physician examines the boxer for heart rate, temperature, inspects the eyes, throat, and hands, and auscultates the heart and lungs. If the boxer has more than one fight in a tournament, the boxer is examined between bouts for pupil reaction, finger-nose and finger-finger coordination, diadochokinesis, strength of the hands, and given the Romberg test with the eyes shut. The ring physician examines the boxer after each fight.

APPENDIX 6

COMPARISON OF AMATEUR VERSUS PROFESSIONAL BOXING

Item	Amateur	Professional
1. Organization	All amateur boxing comes under the jurisdiction of a single, unified national governing body (NGB). As an NGB, U.S. Amateur (USA) Boxing has jurisdiction over the administration and rules of competition for amateur boxing in the United States.	Many State-controlled commissions have different sets of rules. Therefore, no such single, unified body nor one singular set of standards, rules and guidelines exists.
2. International rules	Amateur boxing uses the same set of rules worldwide. While USA Boxing's rules conform completely with the international rules, USA Boxing has more stringent rules in some areas for safety.	Professional boxing has different sets of rules; those of the WBO, IBF, etc., and those set by State commissions.
3. Philosophy	The main objective is to score points. In amateur boxing, the force of a blow or its effect on the opponent does not count. Therefore, the KO is a byproduct in amateur boxing. A blow that knocks a boxer to the mat receives no more credit than a regular blow. A knockdown is scored as a single blow and does not necessarily make the boxer a winner of that round.	Added weight is given to a blow based on its impact and effect on the opponent. Therefore, the knockdown and/or KO is an objective in professional boxing. In rare cases, a boxer who scores a knockdown may lose the round.

Item	Amateur	Professional
4. Safety during the competition	Form-fitted mouthpieces are required and must be worn at all times; if it falls out, it is replaced immediately. Headguards are mandatory in the United States and in major international competitions. Boxers receive standing eight-counts. This is a safety precaution that gives the referee eight seconds to evaluate the condition of the boxer. On the basis of his/her decision, the bout may continue or be stopped. Injury—a referee stops the action and takes the boxer to the corner for the doctor to examine the injury and get an opinion. Based on the physician's opinion, the bout will continue or be stopped. The physician may suspend the action, at his/her discretion, at any point during the match to examine a boxer. The physician may also examine a boxer between rounds. The physician's decision to stop or continue a match is binding.	The rule applies to professional contests in certain States but is not uniform. Prohibited Certain State and world bodies have recently adopted this rule. In some States, this rule is the same for amateur and professional boxing.

Item	Amateur	Professional
4. Safety during the competition (continued)	More control is exercised by the referee in the ring. Referees caution boxers to let them know that they are violating fundamentals and rules. A referee will stop the bout if a boxer is outclassed. If a bout is stopped because of blows to the head, the boxer is not allowed to compete or work out in the gym for a specified period of time. All amateurs are registered with USA Boxing. The criteria for stopping bouts because of injury are stricter, i.e., lacerations or swelling that block vision will cause a bout to be stopped. The use of head (butting) is strictly regulated—boxers are cautioned but then may be warned or lose points if they continue.	A boxer is only warned for a harm foul, blow-type infraction—not for technique. A referee is authorized to stop the bout but rarely does because of financial and TV arrangements. Rules vary from State to State. No single system exists; control rests with local groups. Rules are less strict on injuries that stop a bout (i.e., a boxer will continue to box if the eye is swollen shut or if a cut around the eye, nose, or mouth is badly bleeding). Poorly controlled.

Item	Amateur	Professional
4. Safety during the competition (continued)	A blow counts for scoring only if the knuckle surface is used; slapping, etc., is not allowed nor does it count for points. Therefore, the striking area is limited to the knuckle of the fist and must hit the front and side of the body and head and above the waist. The bell cannot save a boxer from a stopped contest. The count continues to completion, regardless of when the bell rings (except in finals of a tournament, such as the Olympics, Pan Am Games or U.S. Championships). Three standing-eight counts in one round or four in a match automatically stops the bout.	Not as much attention is given to the placement of scoring blows. A boxer can be saved from a KO by the ringing of the bell, depending on State rules. Is waived in some circumstances.
5. Gloves	Internationally: 8-ounce gloves are used for 106 through 147 pounds; from 156 through 201+ pounds, 10-ounce gloves are used. In U.S. competition, 10-ounce gloves are used for 106–156 pounds and 12-ounce for 165 to 201+ pounds. Gloves must be thumb-attached or thumbless.	8-oz gloves are used.

Item	Amateur	Professional
5. Gloves (continued)	Gloves are designed to absorb shock. Striking surface is indicated by a white area on the gloves to aid judges in scoring.	Gloves are designed to transmit force, except in rare instances, where groups are attempting to improve. The striking surface is not indicated.
6. Physical	Pre- and post-bout physicals are mandatory. In a tournament, the boxer has an initial physical and then has one each day he competes.	Same.
7. Attire	A boxer wears a top to aid in identification as well as to absorb sweat, dirt and keep gloves cleaner. No foreign substances are permitted on the body, i.e., greasing up. A boxer may not wear a beard or goatee; a thin, pencil-line moustache is allowed. Hair may not impair vision.	Male boxers do not wear tops. Boxers are allowed to grease up. No rules exist concerning hair.
8. Rounds	Three 3-minute rounds are fought, with a 1-minute break in between. For Junior Olympic boxers, rounds are graduated in length from 1 to 2 minutes, depending on age-group. Internationally, may use five 2-minute rounds; may also do so in the United States.	Vary considerably from 4 to 15 rounds, even in the same State, under the same commission.

Item	Amateur	Professional
9. Rules	Can refer to specific rules that govern or regulate a point or area. Are recorded in a rule book.	No single rulebook is complete or universally used.

Adapted from Ley [1997] and Jordan [1995].