

YEAR BOOK[®]

YEAR BOOK OF SPORTS MEDICINE[®]

2007

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PAUL McCrORY
DAVID C. NIEMAN
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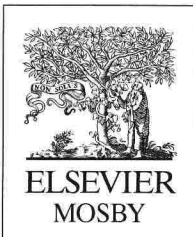
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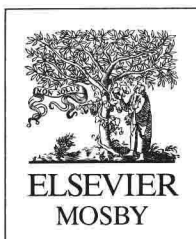
The Year Book of SPORTS MEDICINE®

Editor-in-Chief

Roy J. Shephard, MD (Lond), PhD, DPE

Professor Emeritus of Applied Physiology, Faculty of Physical Education and Health and Department of Public Health Sciences, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada





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Sports Medicine

STANDARD ABBREVIATIONS

The following terms are abbreviated in this edition: acquired immunodeficiency syndrome (AIDS), cardiopulmonary resuscitation (CPR), central nervous system (CNS), cerebrospinal fluid (CSF), computed tomography (CT), deoxyribonucleic acid (DNA), electrocardiography (ECG), health maintenance organization (HMO), human immunodeficiency virus (HIV), intensive care unit (ICU), intramuscular (IM), intravenous (IV), magnetic resonance (MR) imaging (MRI), and ribonucleic acid (RNA), and ultrasound (US).

NOTE

The YEAR BOOK OF SPORTS MEDICINE is a literature survey service providing abstracts of articles published in the professional literature. Every effort is made to assure the accuracy of the information presented in these pages. Neither the editors nor the publisher of the YEAR BOOK OF SPORTS MEDICINE can be responsible for errors in the original materials. The editors' comments are their own opinions. Mention of specific products within this publication does not constitute endorsement.

To facilitate the use of the YEAR BOOK OF SPORTS MEDICINE as a reference tool, all illustrations and tables included in this publication are now identified as they appear in the original article. This change is meant to help the reader recognize that any illustration or table appearing in the YEAR BOOK OF SPORTS MEDICINE may be only one of many in the original article. For this reason, figure and table numbers will often appear to be out of sequence within the YEAR BOOK OF SPORTS MEDICINE.

Introduction

I was a little disappointed that the promised electronic distribution of articles to section editors technical did not occur this year. However, Elsevier has now begun the process, and the YEAR BOOK OF SPORTS MEDICINE will definitely move to this system in 2008. In the meantime, the long-established, and well-tried, YEAR BOOK procedures for the rapid shipping of hard copy have continued to function well, providing all contributors with a wealth of material from which to select the most salient and pertinent articles of relevance to the practicing sports physician. The 2007 YEAR BOOK OF SPORTS MEDICINE thus offers once again a stimulating selection of current papers covering the epidemiology, prevention and treatment of a wide variety of sports injuries; biomechanics and the optimization of muscle function; current topics in the assessment of habitual activity, fitness and immune function; cardiovascular and respiratory disorders; other medical conditions; metabolism, obesity, nutritional aids and doping; environmental factors, and special considerations affecting the elderly, women, and children.

Epidemiological studies show that boating and equestrian sports are frequent sources of serious injury in Australia. A computerized counting of blows is suggested as increasing the safety of boxing. Management of orbital blow-out is described. Description is given of a new extreme sport (Parkour) that seems destined to bring its own heavy toll of injuries. Diving remains the primary recreational cause of spinal injury. Discretionary protective equipment is worn too rarely, especially in schools. There is concern over the number of head and facial injuries from many types of sport, including wakeboarding, horse-riding, and operation of ATVs by young people; snowmobiling and sledding are also too frequent causes of morbidity in children. Much interest focuses on the value, or lack thereof, of helmets in preventing concussion, with detailed discussion of the forces developed, and continuing discussion of concussion from heading the ball in soccer. Frequent head and facial injuries suggest the need for helmets in pediatric ice skaters. Chronic encephelopathy remains a distressing sequel to football competition. Symptoms are not a good guide to concussion. Signs of cerebral involvement may include impaired attention and motor function, impaired scores on neuro-cognitive tests, instability of gait, biochemical markers of tissue injury, and changes of diffusion anisotropy.

A detailed anatomy of the long thoracic nerve is presented for the first time. The value of MRIs in diagnosing "thrower's shoulder" and knee injuries continues a matter of heated debate. Fatigue is a strong predictor of shoulder injuries in adolescents. Central cord syndrome is particularly likely in contact sports; a central cord syndrome in a wrestler was mistaken for a brachial plexus injury. An osteochondral autograft is shown to be an effective treatment for osteochondritis dissecans of the elbow in baseball players. The association of radial physeal injuries with positive ulnar variance remains unproven. A case of lunatomalacia is described in a gymnast. An extensor retinaculum graft is suggested as a good treatment for a boxer's knuckle. Repetitive hyper-extension of the wrist from a shotgun can cause

fractures of the hamulus. A case history describes how a piso-triquetral arthrodesis allowed a gymnast with a painful wrist to return to major competition. Baseball catchers are liable to microvascular changes in their hands.

Pilates classes have proven helpful in the relief of low back pain. Two cases of proximal rectus femoris avulsion are described in footballers. One study suggests balance tests are useful in predicting vulnerability to lower limb injury, but a second report finds no impact of balance on the risk of ankle sprains. The risk of anterior cruciate injury appears to vary with ethnic group. Cooling has no impact on static knee stability. Intra-medullary nailing is recommended for the treatment of tibial fractures that fail non-surgical treatment. Peroneal tendon instability is helped by deepening the peroneal groove. A delayed neuromuscular response seems a frequent cause of ankle instability. Intermittent applications appear to increase the efficacy of cryotherapy in the relief of acute soft tissue injury.

Decline eccentric squats are the subject of a biomechanical analysis. When a skier switches to double poling, this has a major impact on leg biomechanics. The impact on gait of walking both barefoot and with unstable shoes is discussed. Orthoses have a major effect on leg electromyograms (EMGs). The stretch-shortening cycle offers a natural model to study neuromuscular fatigue. Fast MRI is shown as a valuable tool to study hind foot kinematics. Tendons are not passive components in physical activity; their metabolism is increased by mechanical loading. Resonance in the gastrocnemius is shown to be a problem in precise motor control. Impaired neck flexion hampers the visual following of objects. Reaching upward challenges balance more than reaching forwards. Tai chi improves position sense and balance, possibly protecting against falls, but other forms of exercise may be more beneficial. Stretching has no acute effect on position sense in the shoulders.

Given the diversity of body build among athletes, sports physicians need discipline-specific serum creatinine norms. Alternation between synergistic muscles attenuates muscle fatigue. Fatigued muscles have difficulty in attenuating accelerations when jumping. Anaerobic resources are important in regulating pacing. Tart cherry juice and heat wrap both reduce symptoms of exercise-induced muscle damage. Stretching after muscle injury has a strong anti-fibrotic effect. Adding sensori-motor training enhances the response to strength training. Contrary to expectation, it seems possible to increase strength without training to failure. Strength also seems increased by a combination of restricted blood flow and slow walking. Resistance exercise appears to help the muscle wasting of hyperthyroidism.

Studies of physical activity still focus on problems of methodology, and on the failure of the general population to respond to the exercise recommendations of expert bodies. Attempts to explore a person's patterns of physical activity are particularly handicapped by the poor reliability of available methods of measurement. Although the Bouchard diary is reported to agree with accelerometer data, a comparison of six methods of measuring physical activity shows remarkably little agreement between the scores obtained by these various techniques. The large majority of the US population still falls far short of the minimum daily dose of physical activity recommended for health. The necessary level of habitual effort could probably be attained

more easily if cities were redesigned to facilitate commuter cycling. Children need more than an hour of physical activity per day to counter a clustering of cardiovascular risk factors. Television does not seem an effective form of physical activity messaging for Afro-American children. In young children, at least a part of habitual physical activity is an innate behavior. A massive twin study suggests that at least a half of voluntary physical activity is genetically determined.

Simple performance tests are described that can discriminate individuals with a high level of function. Scores for the six-minute walk test bear little relationship to the directly measured peak oxygen intake. Moreover, the distances covered are increased substantially if the test is performed in a group format rather than individually. A rough prediction of maximal oxygen intake can be obtained from measures of habitual physical activity and waist circumference; however, individual predictions have an error of about 15%. Debate continues on the need to use allometric scaling when comparing maximal oxygen intake in individuals who differ substantially in body size. The critical velocity is a useful simple test of endurance for swim coaches. A reduction in the oxygen cost of running at moderate speeds is reported when subjects wear compression tights. Plasma volume expansion enhances endurance, but does not speed the oxygen on-transient. Somewhat surprisingly, self-efficacy does not influence leg muscle pain during cycling.

There are continuing pointers to a favorable effect of exercise on the body's immune system. Moderate exercise appears to induce a substantial reduction in the risk of contracting the common cold, although sometimes respiratory symptoms arise without evidence of viral infection. Stressful mental arithmetic increases the antibody response to influenza vaccination. Regular physical activity and a healthy lifestyle enhance natural killer (NK) cell numbers and activity. Exercise decreases circulating levels of IL-6, independent of any weight loss. The delayed leukocytosis associated with heavy exercise may reflect in part a response to muscle damage. Fit individuals have a reduced leukocyte endothelial adherence. Several days of endurance exercise has a cumulative negative impact on salivary IgA levels. Caffeine ingestion increases salivary IgA and may thus prevent exercise-induced upper respiratory tract infections. *Lactobacillus acidophilus* also appears to restore interferon-gamma production by T-cells in over-trained athletes.

Cardiovascular screening is far from uniform, and does not meet American Heart Association recommendations. Doppler imaging is proposed as a new and more effective approach to the detection of cardiac endofibrosis. Many papers continue to underline that marathon and triathlon participation causes a release of cardiac troponin into the blood stream. Plasma markers of stroke are also increased after marathon participation. There is an associated deterioration in the cardiac ejection fraction, and a slowing of early diastolic filling. Nevertheless, a case-control study confirms the potential of regular exercise to enhance cardiac health, even if the activity program is begun relatively late in life. The pulse rate on-transient is shown to be a predictor of prognosis in coronary prone individuals, although it is less effective than maximal working capacity in terms of predicting an individual's survival. Sudden myocardial stretching can cause fatal ventricular fibrillation.

Sudden death during exercise is much less common in women than in men. Just 3 weeks of the Pritikin regimen lowers circulating inflammatory factors in patients with metabolic syndrome. Avoiding exercise after ablation for atrial flutter does not reduce the risk of a recurrence of this disorder. L-arginine supplements enhance effort tolerance in patients with heart failure. Post-exercise hypotension is a risk in patients with cervical cord injuries. In patients with spinal cord injuries, functional electrical stimulation leads to substantial vascular adaptations within 2 weeks.

There is an association between hay fever and physical inactivity. An accumulation of body fat also predisposes to asthma. An increase of humidity substantially reduces exercise-induced broncho-constriction in vulnerable individuals. Exercise-induced lipid oxidation seems to increase if there is muscle wasting in patients with chronic obstructive pulmonary disease. Women seem at particular risk of muscle loss in this condition.

Recent literature has reported interactions between exercise and a variety of medical complaints. Marathon runners with bloody diarrhea may suffer from ischemic colitis. The administration of proton pump inhibitors may limit gastro-intestinal bleeding in distance runners. Lactate clearance appears normal in sickle cell trait carriers. There is a major rise of intraocular pressure during professional weight lifting, and this may increase the risk of glaucoma. Dynamic stability in the blind is considerably greater if they play goal ball. The importance of regular exercise for the patient receiving hemodialysis is again been underlined. Patients with chronic fatigue syndrome have a normal response to exercise unless they also suffer from fibromyalgia. Two weeks of maximal exercise testing leads to decreases in several measures of male reproductive function. The likelihood of benign prostatic hyperplasia is reduced by an active lifestyle. Vigorous physical activity also protects middle-aged women against breast cancer. A combination of aerobic and resistance training is recommended for those surviving breast cancer, and in men, resistance training may counter the adverse effects of androgen administration in prostate cancer.

Glycogen depletion leads to a loss of speed at the end of a soccer game. Patients with G6PD deficiency cannot recycle oxidized glutathione, but they appear to have developed some alternative protection against oxidative stress. In men, waist circumference offers the best measure of risk from obesity. Debate continues on the merits of exercise versus dieting in control of the obesity epidemic. Repeated cycles of weight loss seem to predispose to obesity. Obesity prone rats gain weight more readily than obesity resistant animals, despite following a similar regimen of physical activity. The participation of obese subjects in an exercise program is hampered because of a heightened perception of effort. Habitual activity is negatively related to body mass index and perceived disability. The loss of weight achieved in a dieting program is not enhanced by exercise, but there are many other benefits of combined therapy. For example, regular physical activity diminishes the size of abdominal fat cells, an outcome not achieved by dieting. Moreover, obesity has less effect on insulin resistance in those who are aerobically fit, and regular exercise can slow the development of debilitating neuropathies in those who have developed diabetes mellitus. However, three months

of aerobic exercise fails to reverse the adverse lipid profile associated with the administration of antiretroviral agents. The risks of bariatric surgery are substantially increased in patients with a low level of physical fitness.

Chromium supplements do not enhance glycogen resynthesis. Likewise, claims of immune benefits from bovine colostrum remain controversial. Vitamin C is claimed to speed the recovery of maximal muscle force after running a race, but offers little protection against depressed neutrophil function with 2.5 hours of cycling. Contrary to animal experiments, phosphatidyl serine does not seem to protect against delayed onset muscle soreness. However, conjugated linoleic acid may reduce the catabolic effect of resistance training on muscle protein. Amino-acid supplements also accelerate recovery between bouts of resistance training. Surprisingly, Ibuprofen does not attenuate muscle soreness, and may actually increase inflammation and endotoxemia in a 160 km race.

Use of smokeless tobacco in baseball now seems to be waning. Small amounts of caffeine enhance intermittent sprints. This benefit appears to be recognized by many competitors, since cyclists and power sport participants have higher average urinary caffeine levels than other athletes. However, part of the caffeine response can be achieved by placebo tablets that are labeled as caffeine. Pseudo-ephedrine enhances the performance of 1,500 meter runners. Nevertheless, it is argued that restrictions on therapeutic use of β^2 agonists may be excessive. Some 80% of the millions of current steroid abusers are body builders. Abuse of androgenic steroids increases hematocrit and plasma levels of homocysteine, and also depresses thyroid function.

The risk of adverse environments continues to be the focus of attention. A new American College of Sports Medicine "position stand" on fluid needs in sport is now available. A 3% decrease of body mass is well-tolerated by triathletes. Pre-game cooling enhances the sprint performance of the soccer player under hot and humid conditions. Telemetric thermometers document the very high core temperatures that develop in some distance runners. Appropriate fluid intake helps conserve the integrity of the blood brain barrier. Loss of weight and a high urinary specific gravity underline continuing inadequate fluid replacement in US high school sport. A case report describes an incident of heat stroke following a marathon at an environmental temperature of only 9°C. Intravenous fluids offer no advantage over oral rehydration if a subsequent bout of exercise must be performed in the heat.

Use of a nitroglycerin spray is recommended to reduce the risk of decompression sickness during diving. Airway narrowing can be detected after Scuba diving. Alternobaric vertigo caused no dangerous incidents in a series of nearly 15,000 dives by vulnerable individuals. An analysis of low-frequency variations in systolic blood pressure may help to identify those who are vulnerable to mountain sickness. Patent foramen ovale increases the risk of high altitude edema. Tadalafil and dexamethasone appear to control pulmonary blood pressures, and thus reduce the risk of high altitude pulmonary edema. Bosentan has a similar effect, but has the side-effect of delaying fluid volume adjustments to high altitudes. The risks that high altitude exposure may cause a heart attack are discussed.

Meaningful change in gait and walking speed are defined for an elderly population. Sprint-trained athletes lose fast twitch fibers as they age, but less rapidly than their sedentary peers. Slow movement and tonic force generation seem useful ways to boost muscle size in older adults without causing orthopedic injuries. In men, androgens increase the response to strength training. A physiologically useful exercise intensity can be developed by walking with a "Rollator." Inactivity continues to be a risk factor for coronary artery disease, even in advanced age. Weight-bearing exercise addresses extra-skeletal risk factors for hip fracture, but may be insufficient to increase bone density. Unipedal standing may reduce the risk of falls. Gender differences in knee injury rates cannot be explained by differences in knee alignment. Female recruits to the military need to increase their fitness if they are to avoid overuse injuries. A validated method of predicting the maximal oxygen intake of pregnant women is proposed. Women with physical disabilities are often affected by secondary disorders. Sports motivation is gender specific in children. Physical activity programs do not seem very effective in preventing obesity in children, but participation in some video games offers a useful level of energy expenditure. There seems little tracking of physical activity from youth to adult life, but gains in bone mineral density during the period of growth can be detected 20 years later. Animal experiments support earlier observations of children, suggesting that regular exercise programs also enhance the learning process.

As always, I would like to conclude my introduction by acknowledging the sterling efforts of my associate editors, who have continued to promptly submit their insightful comments on recent articles that are important to the practice of Sports Medicine. This year we have welcomed to our editorial team Dr. Michael Pierrynowski, who brings a broad knowledge of biomechanics to the YEAR BOOK OF SPORTS MEDICINE. I am sorry to report that pressure of other duties will rob us of the contributions of Dr. Charlotte Sanborn, but Dr. Catherine Jankowski will be a strong replacement in the area of women in sport. At Elsevier/Mosby, we have continued to appreciate the efficient service of Ruth Malwitz as our managerial associate. Her vigilant eye has caught many a small error in our work, and she has played a major role in producing the finished volume. Reviewing and commenting on progress in Sports Medicine has been a stimulating experience for all of us. I hope you will find the selected material and the editorial annotations as interesting and helpful as we have.

Roy J. Shephard

Hype or Hyponatremia?

Roy J. Shephard, MD, PhD, DPE, LLD

Faculty of Physical Education and Health, and Department of Public Health Sciences, Faculty of Medicine, University of Toronto, Toronto, Ontario

Introduction

Some laboratories have based much of their reputation upon repeated warning about the dangers of hyponatremia.¹ But how far does the development of a low serum sodium present a real danger to the average exerciser? Is our attention being drawn to a rare and esoteric condition, at the peril of forgetting the very real risk of neglecting the hypohydration that threatens many North American athletes in the summer months? Or are we confronting a sinister and life-threatening campaign of misinformation conducted by the shadowy minions of sport drink manufacturers? This short paper looks at the prevalence, incidence and mortality associated with exercise-related hyponatremia. It then considers possible underlying mechanisms, and concludes by suggesting some simple preventive tactics.

Prevalence, Incidence and Mortality

Is hyponatremia an inconceivable situation?

A large volume of hypotonic sweat is secreted when an athlete runs a marathon race on a hot day.² There are some technical problems in collecting representative samples of sweat during competition, but our observations suggest a sodium ion concentration ranging from 20 to 80 mE/L, as opposed to typical values of 140 mE/L for plasma and 145 mE/L for interstitial fluid.² Furthermore, the total volume of sweat secreted by a marathon contestant ranges from 3-4.5 L (Table 1), only partially offset by a much smaller fluid intake of 1 L (3) or less than 500 mL (4). Recent data for soccer players indicate a similar net deficit (sweat secretion averaging >3 L, offset by a water

TABLE 1.—Average Weight Loss, Sweat Loss and Increase of Plasma Sodium Concentration in Four Marathon Events, with Subjects Consuming Various Types of Fluid. Based on Data Accumulated by Shephard, Kavanagh and Associates on Middle-aged "Post-coronary" Patients.

Race	n	Fluid Consumed	Weight Loss (kg)	Estimated Sweat (L)	Increase of Na+ (mE/L)
Boston 1973	8	Lucozade etc.	4.0	4.6	6.5
Hawaii 1974	3	Erg	1.3	2.9	0.3
Toronto 1974	3	Erg	2.3	3.5	2.0
	4	Special fluid	2.3	3.0	3.0
	2	Water	2.0	3.4	1.5
Boston 1975	6	Saline 50 mE/L	2.8	4.5	4.0

intake of only 1.0-1.2 L).^{5,6} Likewise, American football players lose 4.8 L of sweat during a practice, countered by a fluid intake of less than 3 L.⁷ As a result, athletes usually show a rise as opposed to a fall in serum sodium concentration while they are exercising.³ We studied participants in four marathon runs. Subjects drank various fluids such as water, Lucozade, Erg, and a 50 mEq/L saline solution, yet plasma sodium ion concentrations increased by 0.3 to 6.5 mEq/L (Table 1); further, there was little difference in outcome between the various forms of fluid replenishment. Conventional wisdom thus suggests that hyponatremia is “inconceivable” during a marathon run.^{8,9}

Potential factors allowing development of hyponatremia

Variables influencing fluid balance during a marathon run include the effective environmental temperature (over-hydration is more likely if conditions are cool), and the duration and intensity of effort. Competitors typically exercise at about 75 percent of their maximal aerobic power, and as our early studies showed, it is difficult to achieve a fluid intake of more than 0.6-1.0 L/h under such conditions. The total volume of fluid ingested over a 3 hour run is then 1.8-3.0 L, much less than the volume of sweat usually secreted. However, a greater total fluid intake is possible if the duration of a run is extended (ie, an older person who moves more slowly). Because there is more time to ingest an excess of fluid, the risks of hyponatremia are also much greater for ultra-endurance events such as a triathlon or an ultramarathon.

Several recent reviews have now indicated a significant prevalence of the hyponatremia in distance competitors. One article accumulated a series of 57 cases among endurance exercisers, with serum sodium concentrations ranging from 109 to 131 mEq/L.¹⁰ Reports from U.S. military training camps noted at least three deaths from cerebral edema secondary to ingestion of 5-10 L of water and resulting hyponatremia^{11,12}; one reviewer spoke of six deaths, but this appears to be the number of hospitalizations as opposed to the number of fatalities.

The first case reports of hyponatremia in standard marathon runs appeared in the late 1980s.¹³ At least four fatalities among U.S. marathon runners have been blamed on hyponatremia,¹ although several of these attributions rest on the uncertain evidence of newspaper reports. The prevalence of hyponatremia depends, of course, on the criteria adopted by the investigator. Clinical diagnosis alone is unreliable. Many of the symptoms associated with hyponatremia (lethargy, malaise, headache, nausea, dizziness, light-headedness, and vomiting,¹⁴ can be confused with the various forms of heat stress that present in the runners' emergency tent; even seizures and changes of mental status¹⁵ require careful differentiation from responses to hypoglycemia or hyperpyrexia, preferably by demonstration of concomitant peripheral and pulmonary edema. Casual reports are difficult to interpret unless there have been accompanying measurements of serum sodium concentration.

Clinical concern arises if the patient is symptomatic and serum sodium concentrations are <130 mEq/L. However, some studies have listed as “hyponatremic” all individuals whose sodium concentrations fell outside