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Innovative Technology for High Performance and Mass Participation Sport

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Abstract

The chapter analyzes technological innovations used in high-level sport and how mass participants have and will benefit from these advancements. The authors discuss progressive practices of different successful sporting nations. The chapter debriefs high-performance facility development and utilization practices, as well as examples of modern equipment and technology being applied in multiple high-performance athlete service areas, such as general fitness, sport-specific training, restoration, nutrition, medicine, and psychology. This section also emphasizes examples of national and local high-performance technology practices for enhancing mass participation, such as evolving networks of comprehensive multisport training centers available for nurturing every possible age and socioeconomic group. Finally, suggestions are made to provide communities, in partnership with universities or local military installations, with recreation and sport technologies which are free or affordable for all, including instructions enabling everyone to utilize and enjoy the new technologies.

Keywords: sport technology, high performance, mass sport

1. Introduction

Throughout history, sport participants have benefited from new methods of fitness training, adaptation to extreme conditions, innovative medical care, and technology originally developed for elite military personnel. These advances are passed down to general troops and, finally, to the masses. Today, the military continues to drive fitness through sport, but

elite sport itself, when managed systematically, is becoming a leading force for mass sport participation and technological advancements, ultimately benefiting everyone [1–4]. High-performance (HP) coaches now lead teams of biomechanists, physicians, endocrinologists, engineers, and other technology specialists, developing systems and structures for the most effective and efficient preparation of athletes to competitions. Developmental level coaches and sport administrators, in turn, promote mass participation in order to maximize the pool of potential elite athletes with the ancillary benefit to their communities' well-being [5, 6].

Many advanced technologies originated in government-supported military, elite sport, or rehabilitation research programs. Over the period from 1927 to 1946, Harvard University's Fatigue Laboratory, backed by US federal funding, researched topics in the physical chemistry of blood, exercise physiology, nutrition, aging, and the stresses of high altitude and climate [7]. Beginning in 1941, many of the research reports stressed the physical fitness of soldiers, the energy cost of military tasks in extreme heat and cold, as well as developments in clothing and equipment for extreme conditions [7]. More recently, the Massachusetts Institute of Technology's Institute for Soldier Nanotechnologies [8], founded in 2002, developed new devices and textiles for health monitoring, wound healing, and atmospheric and environmental adaptation.

In the former USSR, studies of both mass/elite aspects of sport were coordinated by a central research institute, established in 1933, with studies undertaken at sport research institutes and sport universities in each of the country's 15 republics. Expert groups comprised of coaches, sport doctors, and scientists were formed in the 1970s to advise elite sport teams. The successful national USSR wrestling and boxing teams, for example, were serviced by a group of 40 specialists in pedagogical science, medicine, psychology, physiology, biomechanics, biochemistry, and engineering. The Russian scientists of the twenty-first century applied the wrestling research results to 13 other disciplines [5]. The Russian 2012 Summer Olympic sports were supported by 41 sport science groups, winter sports by 15, and Paralympic sports by 26 teams of scientists. This tailored method of sport science support has been adopted and expanded by China. There are six national laboratories and a team of 30 scientists helping national squads. To integrate resources, the Action Project for Olympic Technology has collaborated with institutions such as Beijing's Municipal People's Government, the Ministry of Education, the Chinese Academy of Science and the Commission of Science, Technology, and Industry for National Defense [5]. Of eight successful sport nations studied by Digel [9], sport science was particularly prominent in Russia, Australia, and Germany, while special research institutes and advice centers were also established in China, France, the UK, and Italy.

The government of Canada provided funds to create the Own the Podium (OTP) program for international sport success, especially for the Vancouver Winter Olympic Games, which the country hosted in 2010. In 2004, the OTP created a 5-year CAN\$8 million project called the "Top Secret Project." This project sought to use science and technology to optimize the Canadian winter athletes' performances. Top researchers in Canada worked on 55 projects prioritized into four areas: competition clothing, ice sports, snow sports, and performance [10]. The Top Secret Project investigated super-low-friction bases for snowboards and how curling brooms melt the ice during sweeping. Scientists used a missile guidance system to track skiers and built a giant catapult, a type of human slingshot, to hurl speed skaters into a turn to

practice cornering [11]. The Canadian long-track speed skaters raced in space-age bodysuits designed by the Japanese Descente apparel company in collaboration with the Canadian National Research Council's Institute for Aerospace Research and the Speed Skating Canada. The suits were the culmination of 4 years of research and testing and are more aerodynamic than human skin [12]. These new technologies very quickly become adopted by opponents and then by recreational participants.

The following sections reflect key components of an HP management model emerging across the world and currently being utilized by organizations responsible for both mass/elite sport participation [7, 8]. Each section below offers examples of several methods driven by HP sport while also proving beneficial to mass participants.

2. General fitness

Appropriate *fitness testing* has great unrealized potential as a critical component within physical education and mass/elite sport [13]. An examination of the differences in the most often implemented youth fitness test programs across the world, particularly the Chinese National Physical Fitness Test (CNPFT), European ALPHA-FIT (Assessing Levels of Physical Activity and Fitness), American FitnessGram®, and Russian GTO as the most widely implemented youth fitness tests in Asia, Europe, and North America, indicated key shared test components (i.e., aerobic fitness, muscular strength and endurance, and flexibility). However, Internet-based physical activity assessment and interactive technology were only utilized by GTO: its webpage (<http://gto.ru/>) offered high-quality videos with audio and text instructions, supported by interactive instant messaging/texting and voice assistance by trained operators.

Uniquely offered for each age, GTO is highly individualized, employing swimming and skiing as optional testing items in addition to running. Lifestyle-related skills such as camping, recommended weekly physical activities, and fitness knowledge tests were only included in GTO. While comprehensive and technologically advanced, GTO can be implemented at no cost to participants: hiking and camping, swimming and skiing, pneumatic and electronic weapon shooting coincide with many schools' curriculum and the lifestyles of many Russians. CNPFT can be costly, requiring expensive equipment to test Vo2max (i.e., US\$4000 per unit). The FitnessGram® in the US required a budget for equipment (i.e., sit-and-reach testing box, curl-up strips, and skin fold flips) and assessment software (i.e., US\$599 for the first year and US\$149 for renewal). The ALPHA test version developed for schools uses a dynamometer, costing around US\$350–450, and other ALPHA versions may also require a skinfold caliper costing about US\$250 [13].

Only GTO was designed to connect testing results to sporting programs, requiring a database created in the USSR. Before competing in a particular sport, USSR participants achieved the highest age appropriate GTO results and then progressed through 10 sport-specific ranks. Russia and China adopted this sport qualification system. Each rank requires specific results against increasingly stringent criteria revamped in each Olympic quadrennial through research and consultation. Russian sport scientists extended the USSR system from 60 sports in 1980 to 143 in 2011. This required advanced information management technology, playing

an important role in the success of mass/elite sport in the former USSR and in China. Sport participation rates in China are high [14], and 430 million Chinese have met governmental fitness goals [15]. After entering the Summer Olympics in 1980, China advanced to number one by gold medal count in 2008. These Chinese results have been achieved since 1958 when an integrated mass/elite sport plan set a target of 200 million people passing GTO tests; 50–70 million reaching competitive level; and 10–15 million becoming elite athletes [15]. Using big data analyses, GTO advanced eight times since it began in 1931. The unique 2014 GTO guidelines included 11 gender-specific age stages from six to over 70 years old, using over 20 mandatory and optional tests [13].

There may be a need to develop a global fitness test program as monitoring youth fitness from the international perspective is of concern. Fitness tests should include all age groups integrating knowledge tests, optional test items from Eastern exercises such as yoga, and various alternatives to running. Also, tests could be made easier to administer by participants by lowering costs. Stronger reward programs, and better instruction and promotion strategies using the latest Internet and mobile telecommunication technology for the worldwide population to track their fitness changes over their life span by lifelong fitness testing on a regular basis, should lead to improved health worldwide [13].

3. Sport-specific training

To assist mass and elite participants with healthy progression to the highest desired level of performance, sport authorities are starting to publish *long-term athlete development* guidelines specific to each sport. Assisted by statistics as well as computer and medical monitoring technology, scientific and individualized load selection and recovery intervals are becoming better understood and used for mass participants, with a critical role played by *periodization*—a systematic structuring, or cycling of short- and long-term training programs, to provide optimum performances at the required times [16]. Training concepts such as periodization have been passed from HP scientists and coaches to mass participation programs and are becoming part of education and training plans required for each coach in the twenty-first century. If taught to all as a component of PE, periodization will help recreational and competitive participants to improve their performance efficiently and minimize risks of injury and overtraining, thereby increasing productivity and reducing national healthcare costs.

Periodization can be useful in many facets of life: preparing for many events (e.g., winter season, school tests, work projects, and presentations), pacing work and rest every day, week, month, and year, as well as organizing our thoughts. While periodization played a crucial role in the development of sports science from 1970s after it was pioneered by Leo Matveev from the USSR, other advanced training concepts offering more quantitative and personalized approaches based on advanced computer and medical monitoring technology have been developed for Soviet athletes. In the twenty-first century, these sophisticated methods are becoming available to mass participants around the world. The increasingly individualized

periodization methods require more advanced technological support in order to monitor, analyze, and correlate medical and performance indicators. The technological capabilities provide both better performance and more developed, complicated and healthy training methodologies.

Siff and Verkhoshansky [17] discussed the concept of *cybernetic periodization*, in which various forms of feedback are used to make decisions in training protocols. Types of feedback gathering methods include the Rate of Perceived Effort, which the athlete gages on a scale of 1–5, where 5 is the most strenuous and 1 is the least demanding. Another method of gathering feedback is the Rate of Technique. Here, the coach gives a score on the technique efficacy of the lift. This can be done using different rating scales. Optimally, the coach and the athlete communicate to direct training intensities and volumes. Siff and Verkhoshansky [17] also discussed using other methods of monitoring in order to guide practices, prescriptions, recovery periods, etc. Such tests include measuring heart rate, soreness gaging by finger palpation, blood pressure, work capacity in a back squat, reaction time, various methods to test an athlete's velocity, as well as self-perception ratings for an athlete's mental state. Recently, in the US, *autoregulation* has been applied to vary training load prescriptions, where athletes use variations that occur in their performance daily and throughout the week to customize intensities and volume used in training. Recent research has found autoregulation approaches to be superior to linear periodization models where set numbers were prescribed over time [18]. While the above advanced training methods are becoming available to the mass participation population, coaches must acquire knowledge about the related physiological principles and technological skill in order to monitor one's biomedical parameters pushing athletes to levels where high levels of supercompensation and improved performance can occur.

The evolution of planning training strategies for athletes accurately and effectively may lie in the combination of systemized and planned periodization schemes, with goal intensities and volumes varied in a cyclical fashion, combined with monitoring and autoregulation techniques being applied to help in the process. This concept is referred to as *parametric training*, developed during 1970s–1990s by the USSR researcher Sergei Gordon [19]. Parametric method offers an alternative to the classic periodization approach, particularly in studying the development of an individual athletes' special work capacity while devising a season plan based on adaptive abilities rather than sheer training volume [19]. The method is well documented in Russian scientific and methodological literature [20] based on over 30 years of data collection and testing of training methods that produced a number of world and Olympic champions since the 1950s when Soviet sports science was heavily financed and multiple research data banks were developed. Each Olympic sport was meticulously studied and the information was processed through associated research centers [19].

One of Gordon's former doctoral students, Sergei Beliaev, consults on parametric training as the President of Super Sport Systems [19], a company that markets this proprietary training technique. The Super Sport Systems' Internet-based software was developed by the Innovation Center for the Institute of Theoretical and Experimental Physics in Moscow. Since its inception in 2001, Super Sport Systems' computer-assisted parametric training method has

been used by more than 3500 coaches from more than 50 countries by 2015. It is particularly beneficial in endurance sports: at least 5 of the top 25 American coaches in swimming disciplines were Super Sport Systems' clients in 2012 [19].

The essence of parametric training is to manage specific training variables and to maintain one parameter of training constant while changing the others. The selection of the “managed” parameter will influence the time at which the body exhausts its adaptive reserves. Therefore, the abilities developed during the training season can be related to the strategies which are most effective in each particular case or seasonal phase. Parametric training is, therefore, a multidimensional concept defined by such variables as time of work, time of rest, distance of repetitions, speed, etc., and on many levels, with multiple combinations of different training strategies. The knowledge of the relationship between specific training variables and changes in athlete's individual condition is used to create winning training strategies. The training process requires calculation of changes in related physiological parameters (e.g., heart rate, VO_2 , concentration of lactic acid in blood, heart output, and heart stroke volume) over time, during different stages of a season, and in relation to strategic purposes. Dr. Gordon and other leading American and Russian sport scientists and coaches continue to further develop the method [19].

Parametric training and other individualized training methods are going to remain a luxury for the elite with little impact on public health until generic age and gender-specific fitness requirements and training instructions based on basic periodization are taught to everyone at school and then used for rewarding fitness among all age groups. Fitness systems such as the Chinese CNPFT, European ALPHA-FIT, American FitnessGram®, and Russian GTO are instrumental in this process and can be further advanced to bring global populations to the next level of understanding, thereby improving productivity and reducing healthcare costs. New technologies developed with support from governments and corporations are going to continue driving future advancements of both general fitness tests and sport-specific training methodologies and their availability and affordability for everyone.

4. Sport restoration and medicine

US Olympic Training Centers (USOTC) lead elite and mass participants in the use of advanced technology. The utilization of *variable, sequential air-modulated compression and massage equipment* (i.e., Norma Tec) is increasingly being utilized by high-level athletes with the intended goal of facilitating faster recovery. These modalities are used in recovery labs within training facilities, particularly USOTCs, but can also be found in retail stores that cater to endurance athletes and units can also be purchased for home use. A USOTC-based study [21] showed that the peristaltic pulse dynamic compression can accelerate and enhance recovery after the normal aggressive training that occurs in Olympic and aspiring Olympic athletes. The data lean toward the benefit of this training modality to assist in recovery and may have its efficacy be increased when combined with other restorative methodologies discussed in this chapter.

Hivamat and Theragun are two varieties of *handheld vibration therapy* devices based on deep oscillation therapy currently utilized in a variety of training and fitness settings including

USOTCs, professional and college sport therapy rooms, X Games athletes as well as personal/nonprofessional/elite level athletes use in strength and conditioning/CrossFit facilities as well as home use. Each modality provides percussive vibration/massage to purportedly reduce muscle and joint pain, improve mobility, and enhance performance by increasing blood and lymphatic flow, breaking up scar tissue, reducing muscle proton and hydrogen build up, and activating the nervous system and muscles. Hivamat, which is predominantly utilized within the medical and rehabilitation field, has been identified within the current research to effectively address lymphatic fluid buildup with less data on the effectiveness in managing in edema and/or muscle damage [22–26]. Theragun, however, although it is more widely utilized due to its lower cost, ease of use, and few contraindications, has limited evidence of its validity. As the utilization of these modalities increases, the likelihood of validated performance and restorative benefits is likely to surface.

Neuropriming is a process of using electrical stimulation to increase plasticity in the brain prior to an activity. According to Sharma et al. [27], neural plasticity can be defined as the ability of the central nervous system to adapt in response to changes in the environment or lesions. Used in the product Halo, this process purports to decrease the amount of input required for neurons to fire, and helps neurons fire together, enabling more rapid strengthening of connections in the brain. When paired with quality training, this results in increased strength, explosiveness, endurance, and muscle memory. Although most of the evidence is anecdotal for the product Halo at this time, many high-level athletes and coaches use this technology. According to Halo [28], athletes training for strength- and power-intensive sports received neurostimulation treatment in the form of transcranial direct current stimulation (tDCS) from the Halo Neurostimulation System and in turn demonstrated significantly greater improvement in their jumping ability compared to nonstimulation athletes. One specific example highlighted by Halo identified that even with identical training, Halo Sport users on the USA Ski team produced 13% more jump force compared to a control group, and reached goal performance 5 days sooner compared to a control group (45% faster). While these USOTC methods have anecdotal and some published evidence that they enable athletes to improve performance and recovery, more does not always mean better, and the abuse of these implementations could occur when used without professional instructions.

Dry needling (DN) is used to treat musculoskeletal injuries, pain, and muscle tension reduction [29–31]. Most of the current literature has shown the effectiveness of DN on latent trigger points [32–34], but there has also been success in its use to increase range of motion (ROM) after a muscle strain [35] and after an ACL reconstruction [30]. Myofascial pain is a common form of pain that arises from muscles or related fascia and is usually associated with myofascial trigger points (MTrP) and musculoskeletal injuries [33]. An MTrP is a highly localized, hyperirritable spot in a palpable, taut band of skeletal muscle fiber [34, 36]. Research has found that MTrPs are reported as a primary source of pain in a majority of musculoskeletal pain patients, as well as in many other types of patients from chronic widespread pain to headaches [37–40]. The most common method for MTrP is inserting a needle directly into the MTrP and leaving it in place for a short period of time (30 seconds–1 minute) [36]. A modified version of this technique is to oscillate the needle in and out of the MTrP during the treatment for the same amount of time [41]. Both techniques are effective when a local twitch response is elicited [42], most likely as a result of depolarization of the involved muscle fibers, which

expresses as local twitches [43]. Once the muscle has stopped twitching, the spontaneous electrical activity subsides and the pain and dysfunction decreases [33]. This form of intervention has seen good results in the treatment of MTrPs [33, 34, 44]. In addition to focusing on MTrPs within a muscle to release tension, there have also been studies that focus on MTrPs to increase ROM, short-term muscle endurance, and return to performance in elite athletes [45]. Most importantly, DN can help with the management of rotator cuff, as part of a conservative therapeutic intervention plan instead of surgical intervention [31]. More elite and mass sport participants may benefit from DN as health insurances in Western societies from Australia and Canada to the UK and the US increasingly cover Eastern methods of medicine, and the acceptance of formerly unique, nontraditional methods of treatment and prevention become more accepted and available to everyone in the West.

Despite the broad, varied, and long history of *cupping* as medical treatment, the technique fell out of favor in the West until a relatively recent resurgence. The common theme in all cupping practice is a suction applied to the skin using a cup-like tool [46–48]. Historically, these cups have been made out of bamboo, glass, or metal [49]. The suction can be created with a machine, as with pulsatile cupping, a hand pump, commonly included in sets of plastic cups, or with a flame inside the cup prior to application. The two major divisions of cupping are wet and dry cupping (DC) [48]. Wet cupping, also known as “traditional cupping,” involves an incision or needle prick that draws blood and other bodily fluids. The cup is then applied over the open skin to further draw fluid and blood into the cup [48, 49]. This type of cupping is practiced more in Eastern countries, such as China. During the practice of dry cupping, only the suction is applied and the skin remains intact [48]. In the US and Canada, medical practice acts regarding the incising or breaking of skin vary across professions and across states, so DC is a more appropriate technique for the treatment of musculoskeletal injuries. Even though dry cupping does not involve direct skin incisions and the availability to the tools is more widespread, those who use cupping as a therapeutic intervention should do so by an individual who has training in the skill to reduce the risk of further injury or harm to the treatment area.

DC can be performed in several ways: static, massage, or pulsatile. Traditional static cupping involves placing the cup on the skin with suction and leaving the cup in place. The patient may be moved through passive or active range of motion during the treatment, but the cups are not moved [46, 49]. As the cups are moved across the skin, it is referred to as cupping massage. Cupping massage combines the effects of cupping with those of manual massage [49]. Pulsatile cupping is a modernized form of cupping involving the use of a mechanical device to generate a pulsatile vacuum [47, 49]. During this form of cupping, the amount of suction varies throughout treatment, whereas during static cupping and cupping massage, the suction remains consistent throughout. Pulsatile cupping is designed to combine the effects of cupping with pneumatic pulsation therapy [49].

The effects of DC have centered around pain relief as most of the research in dry cupping has focused on treatment of chronic pain in the general population. Pain relief has been found to be a major effect of cupping as reported in most studies involving DC, which supports the more widespread use of it as a therapeutic intervention [46–50]. In the athletic community,

there is often a need for immediate pain relief. The work by Cramer et al. [49] was one of the first studies to describe a decrease in pain reported with just one cupping session. As DC technology and methods are becoming more widespread across the world, more instructions and training in the cupping skill are needed.

HP athletes and mass participants in many sports have been using *water and heat treatments* based on old national traditions. For example, the following traditional Russian multimodality approach [51, 52] is used at the end of a typical training week:

- three sauna sets for 10 minutes each in temperature 70-80C/158-176F with humidity of 60%;
- during minimum 3-minute intervals between sauna sets—cold baths or showers;
- during second and third sauna set—a gentle beating massage by a fragrant bundle of leafy birch or oak tree twigs to improve blood circulation, intensify skin's capillary activities and metabolism through phytoncides and essential oils released by the twigs;
- after second and third sauna set—hand/self-massage; after third set—swimming;
- concluded by 30-minute rest in warm conditions.

According to Semenova [52], tired muscles are best restored by laying in sauna immediately after the workout for two sets—four and then 5 minutes, with 8- or 10-minute intervals, in about 90-100C/194-212F temperature with 20% humidity. Semenova's [52] work highlights the need for further research and advice specific to various medical conditions and performance objectives. Further investigation of global sauna methods by sport medicine researchers is needed to optimize the use of sauna for various objectives and periodization cycles of sports, and avoid adverse effects of incorrect sauna use. Therapeutic facilities for restoration, particularly spa/Jacuzzi and sauna, are a common feature of recreation centers worldwide. Further advancement of these facilities and instructions for correct and evidence-based use will make regeneration and immune system strengthening available for HP and recreational participants.

Balneotherapy is a cost-efficient restoration method with potential for greater use by elite athletes and the masses. Baths with natural substances such as sea salt, sodium chloride, and sulfur hydrogen are hydrotherapy methods used for mass/elite participants' overall regeneration and to treat specific conditions [53, 54]. Underground healing spring water is the main component of traditional European balneotherapy. In countries like Austria, Czech Republic, Germany, Canada, and Japan, spa treatments are covered by health insurance or as regular medical treatment in the public health care system, an approach beneficial to both athletes and the masses.

One of the most advanced balneotherapy technology centers is in the Russian Black Sea city-resort of Sochi, where mass/elite athletes utilize the region's 250 training facilities and resorts. As part of the US\$US3 billion increase in governmental support of sport leading up to the 2014 Winter Olympics, the new hydrothermal complex at the Sochi national training center was equipped with seven different kinds of hot rooms and saunas as well as pools for

hydromassage and rooms for other types of massage [55]. The government started developing this balneotherapy resort in 1934. Scientists led test boring, drilling down 2000 meters obtaining water with one of the world's highest hydrogen sulfide concentrations. The physiotherapeutic balneological complex has more than 700 baths, providing up to 6000 spa procedures a day [56].

In the US, one of the most established sulfur hydrogen centers is Safety Harbor Resort and Spa in Tampa, Florida. The 2000-year-old springs are located beneath the resort. However, no medical instructions for the use of the mineral spa are provided. In the US, more research is needed to substantiate the healing claims of balneotherapy before the American government's medical and sport specialists could utilize this natural method for treating and preventing illnesses on a mass scale as is done in Europe, such as treating common disorders like back and muscle pain [57–59]. Recreational users may benefit from specific recommendations by sport scientists for the use of ancient and modern methods of regeneration for healthy training. These techniques can be questioned, and Western sport scientists would argue there is a scarcity of research to support these methods. However, with increasing use in medical services around the world, particularly in sport and military, where a speedy recovery from exertion and injury is important, trying all possible, inexpensive, and potentially less harmful physiotherapy and nonsurgical means should be given careful consideration.

5. Nutrition

Sport scientists have developed recommendations for elite athletes that are useful for mass participants and public health. The USOC Sport Performance Division published athlete eating guidelines on the USOC's Internet site, which, among other recommendations, advises to limit "sports" bars and drinks as they can deter body weight goals and can replace more beneficial calories from whole foods. Food processing technologies have a long way to develop before they could provide healthy nutritious options to HP athletes and mass participants.

Important for sport participants are technologies used to produce *micronutrient supplements* which have long been practiced with beneficial results. Numerous studies have shown a correlation with increased calcium intake and decreasing occurrences of stress fractures while increasing bone mineral density. Evidence exists correlating vitamin D supplementation with fracture prevention [60]. Research has found sustained supplementation of antioxidants to reduce the symptoms of exercise-induced muscle damage, i.e., muscle soreness, swelling, and increased intramuscular proteins circulating through the blood [61].

New technology and processes in *molecule refinement* have allowed for a more effective energy delivering liquid supplement for athletic performance and nutrient timing for positive body compositional change. Vitargo, for example, a refined starch-based product, has a high molecular weight in comparison to maltodextrin products, like Gatorade. Vitargo's preworkout and workout supplement labeled Vitargo S2 has been shown to have faster gastric emptying times, resulting in a faster rate of replenished muscle glycogen. Vitargo has also been shown to increase work output for a longer period of time as compared to maltodextrin products [62].

Current findings show modern manufacturing processes allowing more effective energy fueling for athletes and a superior postexercise restoration tactic. Vitargo is an example of providing an ergogenic aid for HP athletes and beneficial for all.

Healing food lists are incomplete requiring more research, analysis, and advancement of new and forgotten technologies. For example, kefir (yogurt's cousin), is only starting to benefit Western immunostrengthening food lists while still going through scientific validations [63] and understanding of its production technology. We will be able to take full medical advantage of culturally unique culinary solutions when isolated studies on particular foods and supplements are systematically coordinated to achieve specific health and performance improvement objectives. HP sport can lead masses in such research of nutrition: coaches and athletes experiment with advanced nutritional concepts and seek advice on such emerging dietary aspects as, for example, using antibacterial, anti-inflammatory, and bioactive foods; separating foods with different speeds and dynamics of digestion, cross-enhancing different foods as well as integration of bioactive substances and adaptogenes.

Scientists could improve both mass/elite performance, ultimately benefiting public health, through more evidence-based advice on the cross-benefits of various foods. Intuitive practices over time have led to food combinations. Such combinations as borsch and shchi soups are a daily must for many Eastern Europeans, particularly for school and sport lunches. Performance and health benefits of some soups are known in the West, especially chicken broth as a remedy for the treatment of colds and flu [64], but many soup benefits and possible harms from incorrectly prepared or canned soup [65] are to be determined by researchers. In order for mass/elite sport menus to improve performance and strengthen participants' health, effectiveness of different food combinations and preparation technologies must be confirmed through systematic studies commissioned by organizations independent of food producers, possibly by public health and sport agencies.

6. Sports and exercise psychology

Sport and exercise psychology practitioners maintain two essential objectives within the field of study and sport science; to teach mental skills in the enhancement of performance based on an understanding of the principles of how physical and motor performances are affected by one's psychology; and to promote psychological development, health, and well-being through physical activity while relying on those same principles [66]. As indicated in previous sections of this chapter, many innovations emerged from military labs. Concurrently, North American, European, and Australian university labs have spawned most of the high-tech innovations currently being perfected in applied sport and exercise psychology settings. Two noteworthy innovative advances having an impact in the applied arena of sport psychology consultation with Olympic athletes, professional organizations, and many top university athletic programs are training *biological self-regulation* skills and improving *symbolic learning techniques*. Biological self-regulation methods have been practiced for eons but high-tech advancements, such as *biofeedback* and *neurofeedback*, used to enhance sport performance

bring the technology to just about any conscientious sport participant. Symbolic learning, aka imagery or visualization, is regularly practiced in a multitude of sport settings. *Virtual* and *augmented reality* compliments the imagery practice. Due to achievements in computer miniaturization, increasing affordability of technology, and increasing portability, these innovations are filtering down to the masses. Consequently, the potential for improving mass participation in a variety of sporting activities in conjunction with both of these technological innovations is high.

As used in sport training, *biofeedback* and *neurofeedback* help athletes become aware of and eventually regulate biological functions; physiology and brain wave activity, respectively. Biofeedback involves the use of instrumentation to capture physiological measures that are immediately displayed back to the person on a wristwatch, smart phone, or laptop computer. *Biofeedback training* (BFBT) uses biofeedback to enhance skill development in one's self-regulatory capability toward heart rate, heart rate variability (HRV), respiration, muscle tension (electromyographic feedback), or skin conductivity (electrodermal feedback) regulation. As just one example, the biathlete that needs to slow down heart rate while preparing for the shooting portion of the event can practice this with BFBT. Neurofeedback training focuses on regulating brain wave activity. Medical treatment of assorted brain and cognitive functioning issues using neurofeedback is beyond the scope of this article. For sport training purposes, neurofeedback targets the brain wave activity consistent with relaxed but highly focused concentration as required in many sport tasks, including targeting and shooting skills mentioned with the biathlete above.

These biological systems, traditionally thought of as outside of voluntary control in the “western philosophy” tradition, operate under the influence of the autonomic nervous system. Eastern philosophy adherents, however, have been practicing biological self-regulation techniques for millennia. BFBT has been used in medicine for many decades [67], and while studies of BFBT in elite level sports studies date back to the 1970s, the volume of research has growing rapidly within the last few years. Recent studies illustrating the use of BFBT include speeding up reaction time for basketball players [68], penalty shot accuracy of hockey players, and a “relaxed ready state” with gymnasts [69]. This chapter's second author has used BFBT both with collegiate athletes and with nonathlete students, namely for anxiety reduction, emotion regulation, and sharpening focus [70, 71]. For a more thorough review of BFBT and neurofeedback research in sport, see [72].

In exercise psychology, Ekkekakis and Petruzzello [73] argued that BFBT can and will be effectively used to attract sedentary people to be more active. By enhancing awareness of physiological demand during exertive exercise, they theorized, it is expected more positive affect will emerge and exercise intensity suitable for each individual can be reached. The improvement of affect occurs when the BFBK helps the exerciser recognize aerobic tolerance levels, an important skill known to be related to enjoyment of the exercise activity. Often marketed as mindfulness training or meditation, companies like emWave, Unyte (formally Wild Divine), and the like sell effective software products and measuring equipment that are cost affordable (US\$300–\$500). Thought Technologies out of Canada produce more expensive (ranging from US\$2000 to US\$10,000) and sophisticated complete biofeedback and neurofeedback systems.

Although imagery, using all of the senses to create or recreate movement experience in the mind, has been a staple in sport psychology mental skills training, virtual reality (VR) offers a high-tech twist. When imagining sport skills, athletes develop a mental blueprint by creating a motor program in the central nervous system. Understanding and acquiring movement patterns is referred to as symbolic learning theory [74]. VR improves upon traditional imagery training by radically enhancing the sensory experience. Ramgopal [75] profiled a college field goal kicker who uses VR to improve technique in Stanford University's VR training room. NBC Sport broadcasted a piece showing how the National Football League (NFL) uses VR to get starting quarterbacks ready for live action and how college programs screen quarterbacks for potential starting positions. For the price of popular gaming systems, virtual reality games that involve movement, Wii games as one example, have been bringing this new technology to a wider spectrum of people, increasing a culture of movement. The technology is still improving but the trends of mass consumption of this new technology are clear.

Combined with the latest video analysis methods (Dartfish™, Krossover), video feedback training sessions between coaches and athletes to enhance practice and competition preparation are increasingly an essential of any organized sport program. Due to the technologically proficient generation of today, these powerful and sophisticated video training methods, in true grassroots fashion, seem to have been led by the athletes themselves. Relative to the exercise and health consciousness sector, VR methods can be optimized with mass sport participants by introducing new sports and movement experiences that can be tried in a safe environmental setting while not sacrificing intensity of the experience. Legrand et al. [76] examined this with over 100 university students and found that their VR protocol resulted in greater enjoyment in self-selected exercise. Such research is limited at this stage and more needs to be learned about where and how high-tech applications can be broader.

Whether these technological advances are cultivated in military training or the university research and sport team setting, the speed with which advancements trickle down to the masses continues to increase. Biofeedback and imagery tools, for example, are wonderfully suitable for college course units. This chapter's second author introduces these applications to athletes and recreational exercisers alike, as well as to students undergoing coaching education training and physical education preparation. University coaching education curricula typically orient and train students to enter at the youth sport level coach, and physical educators to teach and inspire lifelong movement learning. As most institutions in North America and Europe naturally cultivate a civic relationship within the community they are located, advances such as the ones described in this section find their way to the health conscious populace more quickly than ever before.

7. Equipment and facilities

The *high-altitude simulation* technologies developed for elite athletes are now benefiting mass participants. To improve performance of US distance runners, Nike House was opened in

2001. It was equipped with US\$110,000 worth of air-thinning technology. In the five-bedroom 3000-square-foot bungalow, oxygen was partially removed from the air, simulating altitudes from 9000 to 14,000 feet, which helped runners to increase their red blood cell count by 11%. Nike House was decommissioned in 2005, and the athletes involved with the Oregon Project found their own accommodations outfitted upon request with reduced-oxygen rooms or sleeping tents [77]. Elite USSR wrestlers have been leading squads of mass participants in other sports training while wearing face masks and constricting chest expansion with elastic bands in order to reduce oxygen athletes breathe in so when more of it becomes available, the athlete receives a competitive advantage [51]. While the success of Soviet wrestlers is supported by hard data and explanation of some specific practices, methods used to achieve this overall success are complex, interrelated, and applied by highly educated coaches and sport scientists [5, 51]. These methods should be considered integrally and should be implemented by qualified professionals. Training devices developed with limited expert advice and used in isolation from other necessary programs and conditions might not achieve expected results. One such sports training device used by athletes despite the lack of its empirical evidence and instructions for its effective use is the Elevation Training Mask 2.0, High Altitude Simulator, which was sold online for US\$79 on Amazon.com.

Barns et al. [78] concluded that the Elevation Training Mask 2.0 showed promise for facilitating increases in aerobic training when used in conjunction with evidence-based High-Intensity Interval Training, but other studies showed less positive results, which should deter sport programs and athletes from investing in such a tool without more detailed investigation of this device and programs which could make it an efficient addition in reaching specific performance and health objectives, based on consultations with doctors and expert coaches. The use of similar equipment by inexperienced participants and without accompanying personalized programs is unlikely to reach desired results and is a good reminder for all involved in the sports industry to use empirical evidence and expert advice as a guide versus popular trends.

One trend that has been driving the development of fitness technologies has been *multijoint multipurpose exercises*. According to Stone et al. [79], the use of free weight, multijoint exercises is more efficient and produces improved results when compared to machine strength training. Many reasons account for the superiority, with major benefits coming from mechanical specificity toward athletic motor patterns, force application for sport, and velocity of movement causing a more effective training effect to be useful in the realm of athletic competition. Time is saved by using multijoint movements, also called compound exercises (e.g., doing lunge and lifting weight) are an efficient way to get a full-body workout done in less time, targeting multiple muscle groups at once and stimulating the athlete's nervous system and creating a more significant neuroendocrine response increasing the production, release, and utilization of testosterone as compared to more isolation-type exercises. However, machines are also increasingly used to achieve multiple training purposes for both elite and recreational participants. As recreation venues in every community of the twenty-first century are expected to include parks with play and fitness grounds as well as strength training and swimming facilities free or affordable for all, everyone needs skills and instructional programs to utilize these venues to achieve desired results.

Systematic efforts to build integrated hubs of multisport facilities and infrastructures which benefit both HP athletes and mass participants have resulted from adequate government support. Two sport hubs developed in different historical and socioeconomic conditions serve as models for the integration of facilities and programs. Each occurred before the respective country hosted an Olympic Games. The first being Moscow in 1980 and the second London at the University of Bath (UK) in 2012 [5]. In the Izmailovo district in northeastern Moscow, a sport hub was formed around a sport-oriented university. An important feature of both hubs was the integration of sport facilities and programs with their cities' socioeconomic infrastructures. Both hubs have been part of historical and recreational tourist destinations conveniently connected by public transport with the center of London in the UK and Moscow in Russia. Both hubs attempted to attract everyone to sport by giving children the same standard of facilities and coaching used by elite athletes. Elite athletes share the facilities with recreational users, inspiring community participation while producing world records [6]. Cities such as Melbourne, Moscow, Toronto, and Singapore placed successful bids for major events after attempts to build sport hubs integrating entertainment, HP training, and mass participation utilizing public/government resources. Many countries, from Australia, France, and Germany to Russia, China, and Cuba, contribute to equal opportunities for citizens by publically funding the best training conditions at both national and regional levels. National sport authorities could raise administrative efficiencies through the creation of more sport hubs. Coaches, facility managers, school administrators, teachers, sport scientists, medical and other sport personnel could be concentrated in these hubs. Sport and medical scientists could be invited to use sport facilities, events, and athlete data for research and further advancement. Well-planned public transportation systems could better connect residents with the hub's sport, educational, medical, sport science, and administrative facilities [5].

8. Conclusions

As these innovative approaches become more affordable, portable, and popular, the challenge will continue to be, how to bridge the gap between high-tech and common use appropriately? How can we design these new technologies so that the masses improve their lives? And finally, how can we effectively teach all users to interpret the data generated by the innovative techniques? The era of big data is upon use. When understood and used properly, the ultimate goal of mass participation fueling elite sport which circles back to mass sport involvement will be realized. These issues and recommendations given in this chapter should be considered by sport, health, education, and defense departments of national governments. Sport governing bodies, universities, and research centers, and corporations should be stimulated and coordinated to devote more effort toward studies, development strategies, and policies for technological innovations which benefit both HP and public health. While the marketplace continues to produce many of these technologies for the general public, sport science experts have to be present to smooth the transition from the lab to the household. The responsibility of bridging this gap falls on schools and universities, in coordination with local government officials, to revise training programs of sports scientists for this new age of big data analysis and individualization of these high-tech innovations the wider public can safely and effectively utilize.

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