

Review Article

Sports and exercise medicine: An emerging medical speciality

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ABSTRACT

Sports and exercise medicine (SEM) is a relatively new medical speciality that comprises sports medicine (overall medical care of active and exercising individuals for performance optimisation and improvement) and exercise medicine (use of physical activity and exercise for health and fitness promotion and illness and injury management). Physicians with specialisation in SEM and clinical and interventional physiology (CIP) have key roles to play in combating physical inactivity and non-communicable diseases which are threatening to become epidemic proportions on the one hand, and dismal sports performance and rising doping menace on the other hand. This review provides information regarding SEM as an emerging medical speciality, its domains, key roles of the SEM and CIP physicians and future prospects of this field. CIP along with exercise physiology, as the foundation of SEM, is discussed in this review.

Keywords: Clinical and interventional physiology, Doping, Fitness, Non-communicable diseases, Performance

INTRODUCTION

Sports and exercise medicine (SEM) has been recognised as a distinct medical speciality in about 26 countries, especially during the 1980s and 1990s.^[1,2] However, a formal and universally acceptable definition of SEM as a medical speciality is still lacking.^[3] The speciality of SEM focuses on health promotion, prevention, treatment and rehabilitation of illness, diseases including chronic lifestyle or non-communicable diseases (NCDs) and injuries, by promoting and implementing regular physical activity (PA) and therapeutic use of exercise (Ex) at individual and population level.^[2-5] The speciality also deals with prevention, diagnosis, treatment and rehabilitation of injuries occurring during or after PA and/or sports; and medical conditions occurring during or after PA and/or sports at all ages and levels of participation.^[4,5] More importantly, SEM incorporates knowledge of physiology and other health, sports and exercise (SE) sciences (SES) for optimal enhancement of human performance.^[3]

Summing up, SEM can be defined as a branch of medicine that deals with PA and Ex for health promotion, fitness and medical and therapeutic use; and overall and comprehensive medical care and health management of active, exercising and sports persons with minimisation of activity-related injuries, illness and diseases with an ultimate aim to optimise health, human performance and doping-free sports performance.

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COMPONENTS OF SEM: SPORTS MEDICINE (SM) AND EXERCISE MEDICINE (EM)

Conceptually, SEM not only includes taking care of suboptimal health, promotion and maintenance of optimal health both at individual and population levels but also deals with supraoptimal health in the form of stretching human physiological limits to optimise athletic performance.^[3] Since the speciality is not restricted to cater only to sports persons or focus only on sports and human body, it should no longer be referred to as SM.^[6] SM is only one component of SEM, the other being the EM. SM mainly focuses on diagnosis and treatment of SE-related medical issues and musculoskeletal (msk) disorders with an ultimate aim to optimise and enhance athletic performance, whereas EM deals with PA and Ex for optimal physiological and psychological health promotion and maintenance, preventive health measures, treatment, complication minimisation, rehabilitation of many chronic diseases, etc.^[1,7-9] The main components and domains of SEM^[6] are illustrated in [Figure 1].

With far exceeding number of physically inactive individuals compared to active ones, EM is more relevant and beneficial for the entire population, surpassing and dwarfing its parent speciality, SM.^[8,10] The importance of clinical exercise physiology (CEP) and CIP are thus increasingly realised. Based on this, British Association of Sports Medicine has already changed its name to British Association of Sport

and Exercise Medicine in 1998.^[7] Many practitioners have also been using the terms such as fitness medicine, human performance medicine, movement or motion medicine, and CIP and sports-exercise medicine and sciences (SEMS) also form the core of obesity medicine, nutritional/biochemical/metabolic medicine, functional medicine, lifestyle medicine and other related fields.

SEM: A MULTI- AND INTERDISCIPLINARY SPECIALITY

In contrast to the notion of SEM as a distinct medical speciality or a university qualification, traditionally and in some countries, the term SEM or SM is used in a much broader sense and includes both clinical and scientific professionals dealing with sports-exercise and human body. Physiology, physical education and cardiology were the predominant disciplines constituting American College of Sports Medicine (ACSM) during its founding years.^[11,12] An elite-level SEM team usually consists of multidisciplinary-multiskilled professionals from various scientific fields, not necessarily limited to SEMS, working effectively in synergy as a team, collaborating and complementing one another in a holistic way in the 'integrated performance health management and coaching model'.^[13,14] Specialist SEM doctors, unlike other health professionals who manage only msk conditions or who are non-medical team members and non-clinicians, are in the best position to provide clinical and health leadership of this integrated multidisciplinary team and also act as the expert 'case managers' to athletes and coaches, with a focus on operational integration of total and comprehensive performance health management and performance coaching to optimise and improve human performance.^[13,14]

SEM physicians should, therefore, additionally have expertise related to various overlapping medical disciplines such as msk medicine (including orthopaedic surgery, physical medicine and rehabilitation or PMR and rheumatology etc), emergency/general/internal/family medicine, paediatrics, primary care, general practice, public health medicine and military medicine or specialities dealing with specific health problems such as cardiology, neurology and endocrinology etc; but also in SES and allied disciplines including SE physiology (SEP) or kinesiology, biomechanics, general theory and methods of training, biochemistry, nutrition, anthropometry and psychology etc.^[3,7,15,16] In fact, SEM requires expertise and competency from two broad fields of science: sports-exercise and human performance sciences and medical-clinical and allied health sciences [Figure 1]. This multi- and interdisciplinary nature of SEM is also reflected in its academic curriculum.^[4,7,17] In most countries, SEM training varies widely in duration ranging from 2 to 6 years and can be done after basic medical graduation; or

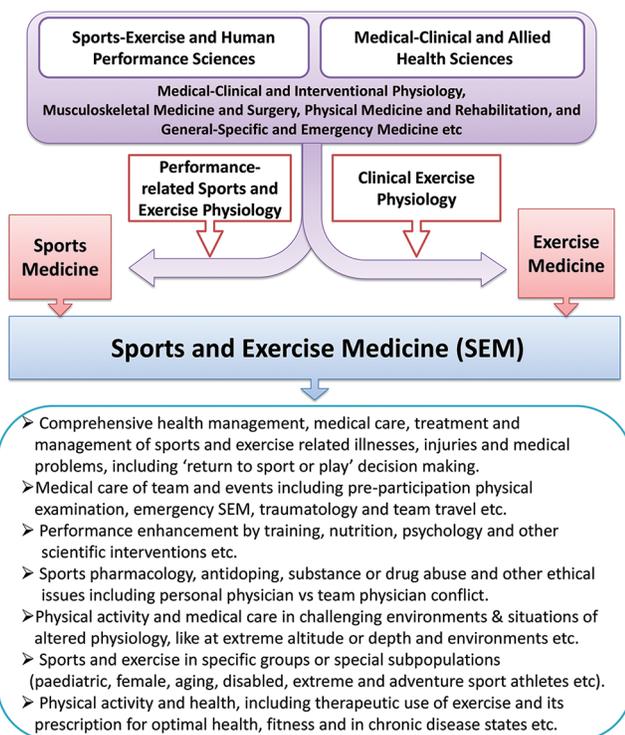


Figure 1: Components of sports and exercise medicine.

after other primary medical specialities (such as orthopaedic surgery; PMR, emergency/internal/family medicine, paediatrics and medical physiology etc for primary care SEM training) as a subspeciality or additional or super-speciality training.^[3,14,15,18-20] The majority of the training is undertaken outside hospital setting unlike the traditional medical specialities, making SEM an unconventional medical branch, and hence, SEM doctors are more familiar with the day-to-day presentations of the common as well as sports and exercise-related medical conditions, illnesses and injuries.^[8]

MAJOR DOMAINS UNDER SEM SPECIALITY

Sports performance

The increase in physical inactivity often goes hand-in-hand with increasing sports participation; and the SE-related injuries and illnesses, ranging from weekend warriors to professional elite athletes, need to be taken care of by SEM physicians.^[7,21,22]

High-performance SM (hpSM) is a sub-area of SEM and focuses on high-performance elite athletes for optimising and maintaining their health, well-being and best sports performance under high psychophysiological loads and stressful circumstances.^[23] The medical and scientific care and challenges, the working models and outcome measures are different from those of recreational and general populations.^[23] These psychosocial and biomedical differences including physiological adaptations, the extremely psychophysiological stressful working environment with different sets of rules, the distinct medical and scientific requirements and demands including tendency to prioritise performance, even if for short term, over individual player's healing and well-being should be taken into consideration; about which a SEM physician is well trained including other complex ethical issues and conflicts arising out of triad interaction between physician, patient or player and team, unlike the traditional doctor-patient relationship; whereas an inexperienced doctor could even mistakenly interpret physiological adaptations as pathologies.^[21,24,25]

Thorough understanding of performance-related SEP (pSEP) including administration, interpretation and application of sophisticated physiological data and other performance sciences including psychology is essential, with the need to maintain the delicate balance between optimal performance and ill health.^[23,26,27] The difference between performance fitness and medical fitness should be considered and appreciated, the former is the readiness and ability to participate and compete at high level, and the latter deals with the athlete's safety to compete in an event.^[23,26,27] SEM physicians, who are well-trained in pSEP and hpSM, can provide sports-specific, athlete-specific overall medical and scientific care.^[23,26,27] Careful attention to minute and

marginal details is needed in hpSM which may define success or failure and reversibility of a threat to health.^[27]

Doping menace

Despite widespread information on the negative implications of doping and emphasis on staying clean in sports, doping remains a major challenge.^[27] Adherence to and respect for the World Anti-Doping Agency (WADA) Code is mandatory.^[27] The practice of genuine medical and therapeutic treatment within the WADA Code and the use of valid therapeutic use exemptions (TUEs) should not encroach into intentional, illegal and unethical manipulation of physiology perceived as pathologic physiology to only enhance the sports performance which may be transient and risk significant and permanent health damage even if the athlete agrees or insists.^[28,29]

SEM physicians have major role in spreading awareness to athletes and other athlete support personnel (ASP), especially to coaches, trainers, family or parents, relatives and friends as these are the groups of people from whom the athletes usually take advice on supplements, who themselves are not quite knowledgeable too.^[23,30-33] It has been reported that >17.4% of the supplements available on internet contained or are contaminated with banned substances.^[32,34] Some reported presence of anabolic androgenic steroids (prohormones of testosterone and nandrolone) in 14.8% of supplements; and others reported low amounts of steroids, stimulants and others not specified on the label in 3–25% of supplements, due to unintentional contamination related with poor quality control and manufacturing practice including cross-contamination between products especially for supplements in tablet and capsule forms, made at a third party manufacturer, or sometimes even intentionally added.^[33,35-38] The contamination percentage might even be higher with some reporting up to 58% in ergo-nutritional supplements.^[33] Thus, there is ever present risk of unintentional doping in daily life.^[32] This is coupled with low awareness, for example, as per one study, only 40.6% of adolescent athletes refused to take and 45.3% refused to eat unfamiliar food products and only 16.1% read ingredients table before consumption; and high pressure on athletes to perform and win result in high demand to anyhow facilitate success on ASP, which may put the unsuspecting athletes at very high risk.^[24,32,39]

The use of ergo-nutritional supplements is extremely common in sports and the onus is not only on athletes but also on ASP, who, may get sanctions including life bans in case of guilty for anti-doping rule violations.^[30,32,33,40] SEM physicians should be in-charge of not only monitoring all pharmacological treatments, including prescriptions by medical specialists other than SEM specialists and self-medication, nutritional supplementation or food or drink intake and other potentially risky substances and methods;

but also for maintaining, monitoring and interpreting the athlete biological passport, which may help in targeted and specific analytical testing for adverse analytical finding (AAF), and detecting possible violation of WADA Code Article 2.2.^[32,40] TUE application including retroactive TUE should be done by or under the supervision of SEM physicians in consultation with other medical specialists and stakeholders when needed. Furthermore, SEM physicians should be included in the TUE committee.

Although, there is a near zero-tolerance policy toward unintentional doping by WADA, SEM physicians may still help to differentiate actual accidental doping from fake one, which may sometimes be useful in the post-transgression disciplinary process even to the level of the athlete being exonerated or given 'no sanction' in the presence of strong and non-circumstantial evidence.^[32] The extent of unintentional doping is reflected in the WADA statistics containing the percentage (out of AAFs) for 'no sanction', 'no case to answer' (valid reason other than a TUE) and valid TUEs, which were 18.50%, 4.62% and 11.18% in 2016, respectively.^[32,41]

Travelling physician and working in altered physiological conditions

Every sports team should have SEM physicians working as team physicians or doctors and travelling with the team for competition or training, and acting as medical and scientific guardians.^[4,7,14,23,42] In fact, team care, overseas touring medicine and sporting body administration apart from anti-doping are already evolving subspecialties in SEM.^[8] Besides sports, SEM physicians should be engaged in overall medical care for individuals doing PA in altered and extreme physiological conditions, as a part of extreme medicine such as in expedition, wilderness and mountain medicine or jungle, marine and space medicine; or for those whose job is physiological challenging such as firefighters or who are in active, combat, military and emergency services.^[4,13,15]

Physical inactivity and non-communicable diseases

Many international organisations have made efforts to prioritise PA. 'Exercise is Medicine' (EIM) is a multi-organisational and multi-national initiative coordinated by ACSM, which was colunched with American Medical Association, first in the USA in 2007 and internationally with the setting up of five additional EIM regional centres in June 2010, to make PA and/or Ex an integral part of health care, and a vital sign to be addressed at each interaction between health care or primary care provider and patient.^[10]

SEM physicians have significant role to play as health promotion is an integral part of SEM, with the use of PA and Ex for premature mortality reduction; primary and secondary prevention, treatment and minimising complications of NCDs

and ageing. Hence, their training in the field of epidemiology, public health, behavioural science and medicine, and most importantly of exercise sciences in general and physiology in particular is essential.^[43-45] As an example, exercise training is associated with improved endothelial function through nitric oxide production, increased insulin sensitivity and promotion of pro-angiogenic pathways, resulting in blood pressure reduction and beneficial for hypertension.^[46] Although PA and Ex have huge psychophysiological health and other benefits with low harm, and their role in prevention and treatment of many diseases or conditions is irrefutable, there are many complex issues related to them also, such as PA and Ex dose-response curves for various conditions, exercise risk-benefit paradox, exercise as a 'double-edged sword', insufficiency of one generalised exercise regime to meet goals of each patient, need for individualisation of exercise based on physical limitations, the possibility of exercise as the cause of new injury, illness or disability and elite-level exercise training and competition causing significant health risk.^[8,14,21,47-53] This, further, necessitates the deep understanding and training in CEP and CIP.

Exercise participation is strongly predicted by the fervour of physicians' and health professionals' recommendations.^[43,54,55] Lack of knowledge, training and skill for physicians, general practitioners and other health professionals like physiotherapists who were reported to have lack of knowledge even for PA guidelines, is one of the major barriers to implementing increasing PA and Ex prescription, which is unacceptable and needs urgent attention with implementation of appropriate CEP and EM training.^[10,22,55-58] With the World Health Organization emphasising on educating health professionals on PA promotion and prescription, well-trained doctors with specialisation in SEM, CEP and CIP should be the leaders in this field.^[1,22,45,59]

MEDICAL PHYSIOLOGY AND SEM

From Harvard Fatigue Laboratory to the formation of ACSM, physiology or SEP is the primary core speciality from which SEM and human performance medicine evolve.^[11,12,42,60] pSEP forms the basis of SM and hpSM, and CEP is the basis of EM [Figure 1].^[7,8,26] With EM becoming more important and SEM starts focusing on physiologic rather than pathologic models,^[7,8,10] competency in medical physiology or physiological medicine becomes absolutely essential, and hence is an integral part of SEM training.^[11,12,20,42]

CIP forms the core foundation of SEM and deals with the use of various physiological interventions including exercise, nutrition, optimal PA to sedentary behaviour ratio, sleep, stress coping or resilience or management, psychological-behavioural or mental health intervention, meditation, addictions management, healthy and positive relationship

or social connections etc for health and fitness promotion and maintenance; illness and injury prevention, treatment, prehabilitation, rehabilitation, etc. CIP also forms the basis of functional medicine, lifestyle medicine, mind-body medicine, etc.

No doubt, medico-physiologists were among the torchbearers of SM in India.^[6] Registered medical doctors with specialisation in physiology; having sound academic and theoretical backup, research and practical laboratory skills and clinical experience; can link and translate advanced SE and allied health science research into actual clinical practice, exercise-sports training and performance.^[6] With the advent of EIM and launching of 'Fit India', the importance of doctors specialised in CEP, CIP and hence SEM is becoming more relevant. Age-wise Fit India Fitness protocols were launched recently with a medico-physiologist as the chairman of the expert committee for the development of fitness protocols.^[61]

ROLE OF NON-GOVERNMENT ORGANISATIONS

Continuing professional development and medical education in the form of journal clubs, general congresses, conferences, workshops, symposia, educational meetings and other local or national events on various aspects of SEMS and CIP can be very helpful for evidence-based SEM and CIP practice; and hence, there is much importance of SEM and CIP organisations for SEMS and CIP development.^[27] Through the organisations, there is a networking opportunity, sharing or exchanging ideas, skills and knowledge; identifying problems or challenges, recommending and taking action through collective efforts, leading to the overall development and popularisation of both the speciality and the individual.

FUTURE PROSPECTS

Development of SEMS facilities will ensure large-scale promotion of SE and overall PA among athletes as well as general public, better human performance and health, reduction in injuries, illness and prevention of disabilities. Facilitation with adequate funding of research in SE and human performance is an equally important aspect. Medical physiologists should involve actively in SEMS and related fields such as functional and lifestyle medicine as a part of CIP. SEMS and CIP should also be incorporated into the undergraduate medical curriculum.^[6]

CONCLUSION

SEM being the combination of SM and EM, is essential not only for the fight against physical inactivity, non-communicable diseases and for maintaining or enhancing health and fitness; but also for overall medical care of active

and exercising individuals ranging from weekend warriors to elite athletes for enhancement and optimisation of doping-free performance with minimisation of injury and illness. CIP forms the core foundation of SEM and another related field of functional and lifestyle medicine, etc.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Carrard J, Pandya T, Niederhauser L, Infanger D, Schmidt-Trucksass A, Kriemler S. Should sports and exercise medicine be taught in the Swiss undergraduate medical curricula? A survey among 1764 Swiss medical students. *BMJ Open Sport Exerc Med* 2019;5:e000575.
- Tucker AM. Conflicts of interest in sports medicine. *Clin Sports Med* 2016;35:217-26.
- McCroory P. What is sports and exercise medicine? *Br J Sports Med* 2006;40:955-7.
- Humphries D, Jaques R, Dijkstra HP, International Syllabus in S, Exercise Medicine G. A Delphi developed syllabus for the medical speciality of sport and exercise medicine. *Br J Sports Med* 2018;52:490-2.
- Schwellnus MP. *The Olympic Textbook of Medicine in Sport*. Oxford, UK: Wiley-Blackwell; 2008.
- Sharma HB. Sports and exercise medicine in India: The past and the challenges. *J Clin Diagn Res* 2022;16:CE01-6.
- Cullen M. Developing a new specialty-sport and exercise medicine in the UK. *Open Access J Sports Med* 2010;1:11-4.
- Orchard JW. How exercise medicine has evolved from sports medicine. *Med J Aust* 2018;208:244-5.
- Jaques R, Loosemore M. Sports and exercise medicine in undergraduate training. *Lancet* 2012;380:4-5.
- Blair SN, Sallis RE, Hutber A, Archer E. Exercise therapy-the public health message. *Scand J Med Sci Sports* 2012;22:e24-8.
- Robergs RA. ACSM and Exercise Physiology: Past, Present, and Future. *Professionalization of Exercise Physiology Online*; 1998;1.
- Berryman JW. *Out of Many, One: A History of the American College of Sports Medicine*. Champaign, Illinois: Human Kinetics; 1995.
- Brukner P, Clarsen B, Cook J, Cools A, Crossley K, Hutchinson M, *et al*. *Brukner and Khan's Clinical Sports Medicine*. 5th ed. Chennai: McGraw Hill Education; 2018.
- Dijkstra HP, Pollock N, Chakraverty R, Alonso JM. Managing the health of the elite athlete: A new integrated performance

- health management and coaching model. *Br J Sports Med* 2014;48:523-31.
15. American Medical Society for sports medicine. What is a sports medicine physician? In: Leawood KS, editor. American Medical Society for Sports Medicine; 2019. Available from: <https://www.sportsmedtoday.com/what-is-a-sports-medicine-physician.htm> [Last accessed on 2019 Nov 03].
 16. West LR, Griffin S. Sport and exercise medicine in the UK: What juniors should know to get ahead. *Br J Sports Med* 2017;51:1567-9.
 17. Medical Council of India. Guidelines for Competency Based Postgraduate Training Programme for MD In Sports Medicine New Delhi, India: Medical Council of India; 2017. Available from: <https://www.mciindia.org/CMS/wp-content/uploads/2019/09/MD-sports-medicine.pdf> [Last accessed on 2019 Nov 04].
 18. Pigozzi F. Specialisation in sports medicine: The state of the sport medicine specialty training core curriculum in the European Union. *Br J Sports Med* 2009;43:1085-7.
 19. Asif IM, Stovak M, Ray T, Weiss-Kelly A. Primary care sports medicine fellowship: AMSSM proposed standards of excellence. *Clin J Sport Med* 2017;27:231-44.
 20. Yaman H. Sports medicine training in Turkey. *Br J Sports Med* 2002;36:258-9.
 21. Heggie V. Specialization without the hospital: The case of British sports medicine. *Med Hist* 2010;54:457-74.
 22. Kordi R, Moghadam N, Rostami M. Sports and exercise medicine in undergraduate medical curricula in developing countries: A long path ahead. *Med Educ Online* 2011;16:5962.
 23. Speed C, Jaques R. High-performance sports medicine: An ancient but evolving field. *Br J Sports Med* 2011;45:81-3.
 24. Devitt BM. Fundamental ethical principles in sports medicine. *Clin Sports Med* 2016;35:195-204.
 25. Bernstein J, Perlis C, Bartolozzi AR. Ethics in sports medicine. *Clin Orthop Rel Res* 2000;378:50-60.
 26. Pate RR, Durstine JL. Exercise physiology and its role in clinical sports medicine. *South Med J* 2004;97:881-5.
 27. Speed C. High-performance sports medicine. *Clin Med (Lond)* 2013;13:47-9.
 28. Hoberman J. Sports physicians and the doping crisis in elite sport. *Clin J Sport Med* 2002;12:203-8.
 29. Wiesing U. Should performance-enhancing drugs in sport be legalized under medical supervision? *Sports Med* 2011;41:167-76.
 30. Mazanov J, Backhouse S, Connor J, Hemphill D, Quirk F. Athlete support personnel and anti-doping: Knowledge, attitudes, and ethical stance. *Scand J Med Sci Sports* 2014;24:846-56.
 31. Kim J, Lee N, Lee J, Jung SS, Kang SK, Yoon JD. Dietary supplementation of high-performance Korean and Japanese judoists. *Int J Sport Nutr Exerc Metab* 2013;23:119-27.
 32. Chan DKC, Tang TC, Yung PS, Gucciardi DF, Hagger MS. Is unintentional doping real, or just an excuse? *Br J Sports Med* 2019;53:978-9.
 33. Martinez-Sanz JM, Sospedra I, Ortiz CM, Baladia E, Gil-Izquierdo A, Ortiz-Moncada R. Intended or unintended doping? A review of the presence of doping substances in dietary supplements used in sports. *Nutrients* 2017;9:1093.
 34. Baume N, Mahler N, Kamber M, Mangin P, Saugy M. Research of stimulants and anabolic steroids in dietary supplements. *Scand J Med Sci Sports* 2006;16:41-8.
 35. Geyer H, Parr MK, Mareck U, Reinhart U, Schrader Y, Schanzer W. Analysis of non-hormonal nutritional supplements for anabolic-androgenic steroids-results of an international study. *Int J Sports Med* 2004;25:124-9.
 36. Judkins CM, Teale P, Hall DJ. The role of banned substance residue analysis in the control of dietary supplement contamination. *Drug Test Anal* 2010;2:417-20.
 37. Maughan RJ. Contamination of dietary supplements and positive drug tests in sport. *J Sports Sci* 2005;23:883-9.
 38. Judkins C, Prock P. Supplements and inadvertent doping-how big is the risk to athletes. *Med Sport Sci* 2012;59:143-52.
 39. Chan DK, Donovan RJ, Lentillon-Kaestner V, Hardcastle SJ, Dimmock JA, Keatley DA, *et al.* Young athletes' awareness and monitoring of anti-doping in daily life: Does motivation matter? *Scand J Med Sci Sports* 2015;25:e655-63.
 40. World Anti-Doping Agency. World Anti-Doping Code Montreal, Canada: World Anti-Doping Agency; 2019. Available from: <https://www.wada-ama.org/en/resources/the-code/world-anti-doping-code> [Last accessed on 2019 Dec 11].
 41. World Anti-Doping Agency. Anti-Doping Rule Violations (ADRVs) Report Montreal, Canada: World Anti-Doping Agency; 2019. Available from: <https://www.wada-ama.org/en/resources/general-anti-doping-information/anti-doping-rule-violations-adrvs-report> [Last accessed on 2019 Dec 09].
 42. Whiteside J, Andrews JR. Trends for the future as a team physician: Herodicus to hereafter. *Clin Sports Med* 2007;26:285-304.
 43. Blair SN, Franklin BA, Jakicic JM, Kibler WB. New vision for health promotion within sports medicine. *Am J Health Promot* 2003;18:182-5.
 44. Tan B. The evolution of sports medicine in Singapore. *Singapore Med J* 2013;54:552-4.
 45. World Health Organization. Global Action Plan on Physical Activity 2018-2030: More Active People for a Healthier World (Licence: CC BY-NC-SA 3.0 IGO). Geneva, Switzerland: World Health Organization; 2018.
 46. Gambardella J, Morelli MB, Wang XJ, Santulli G. Pathophysiological mechanisms underlying the beneficial effects of physical activity in hypertension. *J Clin Hypertens* 2020;22:291-5.
 47. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, *et al.* American college of sports medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Med Sci Sports Exerc* 2011;43:1334-59.
 48. Dirks-Naylor AJ, Griffiths CL, Gibson JL, Luu JA. The prevalence of exercise prescription-related course offerings in United States pharmacy school curricula: Exercise is medicine. *Adv Physiol Educ* 2016;40:319-22.
 49. Warburton DE, Taunton J, Bredin SS, Isserow S. The risk-benefit paradox of exercise. *BC Med J* 2016;58:210-8.
 50. Corrado D, Basso C, Schiavon M, Thiene G. Does sports activity enhance the risk of sudden cardiac death? *J Cardiovasc Med (Hagerstown)* 2006;7:228-33.
 51. Wasfy MM, Baggish AL. Exercise dose in clinical practice.

- Circulation 2016;133:2297-313.
52. Vina J, Sanchis-Gomar F, Martinez-Bello V, Gomez-Cabrera MC. Exercise acts as a drug; the pharmacological benefits of exercise. *Br J Pharmacol* 2012;167:1-12.
 53. Tew GA, Copeland RJ, Till SH. Sport and exercise medicine and the Olympic health legacy. *BMC Med* 2012;10:74.
 54. Ades PA, Waldmann ML, McCann WJ, Weaver SO. Predictors of cardiac rehabilitation participation in older coronary patients. *Arch Intern Med* 1992;152:1033-5.
 55. Chatterjee R, Chapman T, Brannan MG, Varney J. GPs' knowledge, use, and confidence in national physical activity and health guidelines and tools: A questionnaire-based survey of general practice in England. *Br J Gen Pract* 2017;67:e668-75.
 56. Connaughton AV, Weiler RM, Connaughton DP. Graduating medical students' exercise prescription competence as perceived by deans and directors of medical education in the United States: Implications for healthy people 2010. *Public Health Rep* 2001;116:226-34.
 57. Cardinal BJ, Park EA, Kim M, Cardinal MK. If exercise is medicine, where is exercise in medicine? Review of U.S. medical education curricula for physical activity-related content. *J Phys Act Health* 2015;12:1336-43.
 58. Yona T, Ami NB, Azmon M, Weisman A, Keshet N. Physiotherapists lack knowledge of the WHO physical activity guidelines. A local or a global problem? *Musculoskelet Sci Pract* 2019;43:70-5.
 59. Sirisena D, Lim S, Teh KC. Sports medicine in Singapore: Integrating into public hospitals and secondary care. *Br J Sports Med* 2016;50:1234-5.
 60. Kenney WL, Wilmore JH, Costill DL. *Physiology of Sport and Exercise with Web Study Guide*. 5th ed. Champaign: Human Kinetics; 2019.
 61. Fit India. What is Fit India Movement? New Delhi, India: Ministry of Youth Affairs and Sports, Government of India; 2019. Available from: <https://www.fitindia.gov.in/about> [Last accessed on 2019 Nov 30].

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