Khan, K., Thompson, A. M., Blair, S. N., Sallis, J. F., Powell, K. E., Bull, F., Bauman, A. (2012). Sport and exercise as contributors to the health of nations. *The Lancet, 380*, 59-64.

Introduction

Nations bidding to host the Olympic Games usually claim that the event will promote public health. Organisers suggest that global events such as the Olympics or the Fédération Internationale de Football Association (FIFA) World Cup might inspire onlookers to be physically active, and thus obtain health benefits. Whether these events lead to an upsurge in physical activity is uncertain and has been reviewed elsewhere.[1] In this report, we examine the broader question of whether sport and exercise specifically contribute to the health of nations.

Sport and exercise versus physical activity

Because we aim to assess the contribution of sport and exercise to the health of nations, a distinction needs to be made between sport and exercise and physical activity. Physical activity is "any bodily movement produced by skeletal muscles that results in energy expenditure" and is positively correlated with physical fi tness.[2] The broad components of physical activity are occupational, transport, domestic, and leisure time, which consists of exercise, sport, and unstructured recreation. Most sports contribute to overall physical activity but someone can be very physically active through occupational labour, domestic tasks, or active transport without engaging in sport or exercise. By contrast, exercise has the features of "planned, structured and repetitive bodily movement, the objective of which is to improve or maintain physical fitness". [2] These definitions inevitably have grey areas, so that one person's enthusiastic shopping, which qualifies as physical activity but technically not exercise, might expend more energy than another person's doubles tennis played at a low intensity.

Sport is a subset of exercise that can be undertaken individually or as a part of a team. Participants adhere to a common set of rules or expectations, and a defined goal exists. If a person is training for a 10 km community run, training sessions would count as exercise because there are no rules or common expectations whereas the event itself is sport. Training for sports competition typically includes regular engagement in the activity. Figure 1 shows the usual intersection between physical activity, sport, and exercise (figure 1A), and two examples of individual activity profiles (figure 1B, 1C). In profile B, an individual drives to their office, works out at the office gym (exercise) three times a week for 30 min, and plays tennis (sport) at home for 90 min, but is otherwise sedentary. The total time spent being physically active per week is 180 min. By contrast, a second individual, profile C, accumulates 1 h of walking every day to catch public transport to work (physical activity), but does no explicit sport or exercise. Despite this absence of sport or exercise, they nevertheless accumulate 300 min of physical activity in a week. Each profile might provide different health benefits and have different injury risks.

Physical activity, exercise, and sport contribute to health in part through their effect on cardiorespiratory fi tness.[3,4] Low fitness is a better predictor of mortality than are obesity[5] or hypertension,[3,6] which are health risk factors afforded far greater emphasis than fitness by the media and by most health professionals.

Rates of participation in sports and exercise

To estimate the potential infl uence of sport and exercise, we need to assess rates of participation in those activities at a population level and information about the associations between sport, exercise, and health outcomes. Accurate, cross-sectional, population-wide data for participation in sports are rare. For example, details of participation in sport cannot be extracted from the largest physical activity questionnaire in the USA—the Behavioural Risk Factor Surveillance System.[7] Never theless, substantial participation in sport by men and women is evident in the 260 million active, registered participants in football and the large number of community running events around the

world, including 720 organised marathons every year in the USA alone. In addition to these snapshots that suggest substantial participation in sport and exercise, a few scientifi c studies have been undertaken.
In Spain, researchers systematically assessed selfreported and self-defined sports participation at a population level over 10 years, but with only one question.[8] About 52% of men and 33% of women of all ages selfreported as "participating in" at least one sport in 2010. Participation in sport at least once per week exceeded 40% in men and women aged 15–25 years and in men aged 26–35 years.[8] In the Health Survey for England,[9] which was another long-term cross-sectional study, participation was stable at about 41% in men aged 16 years or older from 1997 to 2006. In women aged 16 years or older, participation ranged from 31% to 34% in 1997–2006.9 The Eurobarometer study,[10] which assessed participation in 25 countries, concluded that "for the majority of countries, the occurrence of regular (once or more per week) sporting activity was less than 40%".[10] In Australia, 48% of adults reported playing sport in a survey three or more times a week.[11] Of the sport reported in that survey, organized sport only represented a fi fth of the total sport. This finding emphasises the importance of non-organised sport such as cycling or walking and that definitions of sport can greatly influence the reporting of participation. Of these surveys, only the Health Survey for England questionnaire was validated (against accelerometer and clinical outcomes), and thus appropriate validation of any new surveys will be a priority.

Although these participation numbers seem large, they show only adult participation in any sport. The absence of data for frequency and duration of participation makes estimation of the contribution of sports to total physical activity impossible. Furthermore, when low-income and middle-income countries are included, self-reported data suggest that sport and organised activity make up a very small part in total physical activity in much of lowincome Africa.[12] This absence needs additional analysis by researchers and policy analysts.

Participation in sports is greatest in young individuals. In the USA, an estimated 4 million children and adolescents aged 6–18 years are engaged in organised sport.[13] 23–60% of youth physical activity is contributed bysports,[14,15] and such participation is positively correlated with overall levels of physical activity in adolescents.[16] However, one study of youth sport practice sessions suggested that only 46% of practice time in youth soccer and softball or baseball involved moderate or vigorous physical activity, so potential health benefits might be reduced in this setting.[17]

Little evidence exists to suggest that there have been substantial changes in rates of participation in sports in the past.[18] More women in the USA became able to participate in sport following the Title IX education amendments in 1972 that precluded sex discrimination in schools[19] and there were large increases in the number of women playing football since 2000 worldwide[20] and in sport club membership by boys and girls in Iceland.[21] The Amsterdam Growth and Health Study18 is one of the few repositories of data for changes in rates of participation in sports for both sexes. For men and women older than 16 years, participation in organized and non-organised sports activities contributed less to their total physical activity compared with when they were younger. To extend these longitudinal data, a substantial investment by sporting clubs, organisations, federations, or governments would be needed, but there seems little incentive for collection of such information. Tracking of participation over time would be useful to help explain behavioural maintenance (ie, whether levels of physical activity in childhood are important determinants of levels in later life).

Overall, the question of whether rates of participation in sports are sufficient to influence population health is one that will remain unanswered because of insufficient data. All present datasets have limitations, especially the inconsistent but generally poor criteria for definition of participation in sports. Definitions can also be applied loosely; for example, gym membership and health-club

attendance are reported by the Sportsclubs Association[22] but do not meet the strict definition of sport. Relatively high reported participation rates might also be caused by many people playing sports a few times per year, which is unlikely to provide many health benefits. Such low-level participation in sports, weekly or monthly, also might not provide an overall physical activity dose that is associated with health benefits (eg, that provided by physical activity 3–5 times per week). Thus, despite all the interest generated in sport globally, and the many small-scale programmes that exist to promote sport, there is little evidence of population-wide participation sufficient to increase physical activity levels enough to improve health.

Health benefits of sport

What evidence is there for direct health benefits of sport? The Physical Activity Guidelines Advisory Committee state that: "The volume of regular physical activity has been frequently and consistently related to health benefits".[20] The relation is curvilinear with the exact parameters of the curve varying for different health benefits (figure 2).[19] Physical activity inherent in sport contributes to health benefits commensurate with the proportion of total physical activity that the sport makes up. Some evidence also specifically shows the health benefits of participation in sport.

In a 5-year longitudinal analysis of 7456 men and women aged about 56 years at baseline, Sabia and colleagues[23] reported that any physical activity (apart from housework and walking <3·5 h) was associated with reduced mortality in age-adjusted analyses. Notably in fully adjusted analyses, only associations with participation in sport (hazard ratio [HR] 0·71, 95% CI 0·56–0·91) and do-it-yourself activity (0·68, 0·53–0·98) remained. These data come 12 years after Andersen and colleagues[24] reported a strong dose-response curve for greater intensity physical activity and lower mortality. Within their groupings of moderately and highly active people, participants of sports had half the mortality of non-participants after a mean follow-up of 14·5 years.[24] These epidemiological data suggesting that participation in sport predicts reduced mortality in middle age and old age come from cohort studies, but some randomised trials and well-controlled laboratory studies also point to health benefits arising from sport.

One such trial addressed the question of whether playing football two-to-three times a week for 12–16 weeks—in teams of three, four, or five players— improved the health of participants who had not played the sport previously.[25] Such a study was a rare instance of systematic data collection to connect recreational sport with health of players. In the 2-year study, health was defined objectively by clearly measurable risk factors and the findings were published in 13 reports in 2010.

In formerly untrained middle-aged men and women, football reduced risk factors for cardiovascular disease,[26] diabetes, and osteoporosis.[27] Participation was as effective as a targeted intervention to promote healthy weight in children with obesity.[27] Football also promoted social interactions, which infl uence quality of life, and showed the potential to aid adherence to an active lifestyle. Football can thus be promoted as a leisure activity that enhances health. The strength of the analysis was reliant on the focused nature of the question in recreational athletes, the randomised controlled trial design, and the generalizability of the intervention (ie, small-sided football with five *vs* five players rather than 11 *vs* 11 players). Importantly, investigators recruited participants who were not active in sport so the controlled trial design tested the effect of sport as a therapy. Furthermore, a very consistent pattern was noted suggesting health effects across the studies. The studies had limitations, including the small, non-generalisable sample sizes. Nevertheless, these efficacy studies complement the observational studies of long-term health benefi ts[28] and risks associated with sporting careers.

Health promotion through sport

In addition to the direct health benefits derived from physical activity of sport, sport can provide indirect benefits through campaigns for health promotion. Sporting celebrities can act as spokespeople for health, especially for targeted audiences such as schoolchildren. FIFA disseminated a health education programme branded 11 for Health,[29] which used football to engage primary school students by linking each of 11 health messages with a well-known football player. For example, in one of the video clips for the education programme, Cameroonian striker Samuel Eto'o says, *"Players use their body to protect the ball from opponents. Use a treated bed net, while you sleep, to protect yourself from malaria".* Health knowledge tests revealed an 18% improvement in health knowledge after the programme was run in schools in Zimbabwe and Mauritius.[29] By June 2012, 11 for Health had been adopted (ie, incorporated into the national educational curriculum) by national governments in nine African countries, and countries in Oceania, Asia, and Central and South America.

These successful interventions by FIFA, which were critically assessed and published in peer-review journals, need to be embedded in policy and legislation, and translated into broader systems. Well executed, funded programmes contrast with politicians making unsupported claims about the benefits of sport as a health or social panacea. Coalter criticised the promises surrounding sport for development in low-income and middle-income countries.[30] According to Coalter, sport has a mythopoeic status[31]—something based on idealistic and popular ideas suggesting a certain relation without a sound basis. He disputes the claims that sport necessarily or always contributes to community development, social capital, and, where relevant, community restoration after conflicts. Despite substantial international agency funding, and almost "evangelical policy rhetoric",[30] there is very little evidence that programmes that aim to use sport for development have contributed to increases in physical activity in whole populations; although they might have begun to influence broader social and community restoration goals.[30]

By contrast with sport as a means of health and social development, the health benefi ts of exercise are very well documented.[19,32] Especially cogent summaries have
been published in the Swedish Physical Activity book,[33] the Physical Activity Guidelines for Americans,[34] and elsewhere.[19] The data for benefits of exercise are not reviewed here, but serve to underscore the potential benefits to population health through sport and exercise.

Injury risk in sport

In addition to health benefi ts, physical activity is associated with health risks, mainly musculoskeletal injuries. Injury risk is greatest when individuals perform at the highest levels of relative intensity, which is common in competitive sports. Sports injuries are not routinely reported at a national level in the way motor vehicle accidents are, but insurance data suggest that costs from sports injury are substantial. In Switzerland, 42 000 football players generated 145 million Swiss francs (£100 million) in injury costs per year.[35] In New Zealand, injuries from rugby league generated NZ$5·3 million (£2·7 million) in insurance claims per year.[36]

Some researchers provide injury-specific costs related to sport that add to our understanding of injury burden without specification of which sports contributed. Ankle injuries cost €187 million (£156 million) per year in the Netherlands.[37] In the USA, the common major knee injury of anterior cruciate ligament rupture had direct surgical costs of US $11 500 (£7100) per operation, with a net cost to the US economy of about $3·6 billion (£2·2 billion) every year.[38] In North Carolina, USA, 5013 varsity athletes participating in 12 different sports in 100 public high schools generated $10 million (£6·2 million) in directmedical costs per year from injuries.[39] A systematic review is needed of the relative health benefi ts of specific sports and associated injuries.

Efforts are being made to reduce the number of injuries from sport, which will contribute to improvement of health at a population level. Three major international congresses since 2005 have addressed the discipline of sports injury prevention.[40] Nationwide sports injury prevention initiatives have been implemented successfully. [35,41] Some international sports federations, such as those for football (FIFA) and skiing (International Ski Federation), have actively engaged with sports injury researchers and provided unrestricted grants in relation to sports injury surveillance and injury reduction. Systematic reviews suggest that randomised trials of strength and balance exercise (proprioceptive or neuromuscular training) programmes can reduce rates of lower extremity injuries overall, acute knee injuries, and ankle sprain.[42] The academic specialty of sports injury epidemiology, prevention, and health economics is one that is emerging in this century.

Clinicians in promotion of sport and exercise

Physicians and other health professionals can contribute substantially to patients' adoption of exercise behaviours, just as they have provided smoking cessation advice and contributed to smoking reduction in many countries. A straightforward but influential step forward would be measurement of the exercise vital sign[43] in every consultation. Patients ought to report how many minutes of physical activity they undertake in an average day and how many days a week such activity takes place. This measurement provides a score (in min per week) that can alert patients and clinicians to potential risks related to inactivity. In Sweden and New Zealand, exercise by referral (including to sport and exercise facilities) is relatively well accepted and implemented in primary medical practice.[44,45] In the UK, a systematic review recommended[46] short interventions in the general practice setting. In Scotland, the ActiveScotland website allows clinicians and patients to view opportunities for sport, exercise, and physical activity in their vicinity. Other practical steps, such as motivational interviewing to help patients set goals, have been summarised elsewhere.[47] All clinicians, including nurses, physiotherapists, and dieticians, can encourage this commitment. Clinical exercise physiologists and physiotherapists have a specialised role in supporting patients to launch their preventive or therapeutic physical activity programmes.

The fitness industry could benefit from partnering with clinicians who prescribe exercise. The American College of Sports Medicine's Exercise Is Medicine programme argues for a "merging of the fitness industry with the health-care industry, so that patients can be better helped to find an appropriate fitness regimen".[48] We appreciate the need for ongoing transformational change in training of clinicians with respect to the greater evidence that now exists for exercise as therapy.[32] We also support calls for changes in systems for delivery of medical care so that physical activity counselling and referral are expected, documented, and reimbursed.

Conclusion

The evidence for physical activity as a major public health preventive approach and a potent medical therapy has increased exponentially in the 64 years since London, UK, last hosted the Olympic Games. Recent major national and international guidelines provide consistent recommendations and policy advice (eg, the Toronto Charter[49] and Physical Activity Guidelines from WHO[50] and the USA[34]). Sport is one sector that can improve the health of a nation through increased physical activity, but system-wide changes also require complementary efforts by transportation agencies, park and recreation areas, city planning, and school programmes to increase and sustain activity levels of whole populations. Sport organisations should be encouraged to make sport for all a reality, both in implementation and in population surveillance to assess the effects of these strategies on populations over time.[51] Employers and health-care systems also need to recognise the benefits of exercise for prevention, treatment, and rehabilitation.[49] We believe that small changes at the community level and large, nationwide policies and initiatives are needed to improve health at a country level. Sport is one sector represented in both the US Physical Activity Plan and the Global

Advocacy for Physical Activity list[52] of seven best investments for physical activity to make a difference to the health of nations. When physical inactivity is diagnosed, encouragement toward sport participation for some patients qualifies as evidence-based therapy.

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- Regular physical activity, even in modest doses, confers substantial health benefits
- Cohort studies and a small number of RCTs indicate that regular sports participation is likely to provide health benefits
- There are few datasets describing the population prevalence of sports participation by total minutes per week - this makes it impossible to accurately estimate the 'population health' benefit attributable to sport.
- Sports participation is very low in much of low-income Africa; sport participation data are particularly lacking in other LMICs
- The injury risk profile of sports varies widely; quality RCTs have proven that targeted warm-up/neuromuscular training programs can reduce certain common sports injuries
- FIFA have committed substantial funds to partner with 9 nations in Africa as well as in other continents so that football (soccer) can provide a vehicle to improve health and act as vehicle for health education
- Physicians and other health providers are encouraged to measure the 'exercise vital sign' in every consultation in every patient, as a central part of chronic disease prevention and screening. This is a key test when considering the diagnosis of 'physical inactivity', a risk factor as important as assessing smoking status, hypertension or obesity
- Systematic review evidence supports GP-initiated 'short interventions' to increase physical activity; encouragement toward sport participation for appropriate patients qualifies as an effective strategy within an 'evidence-based medicine' framework.

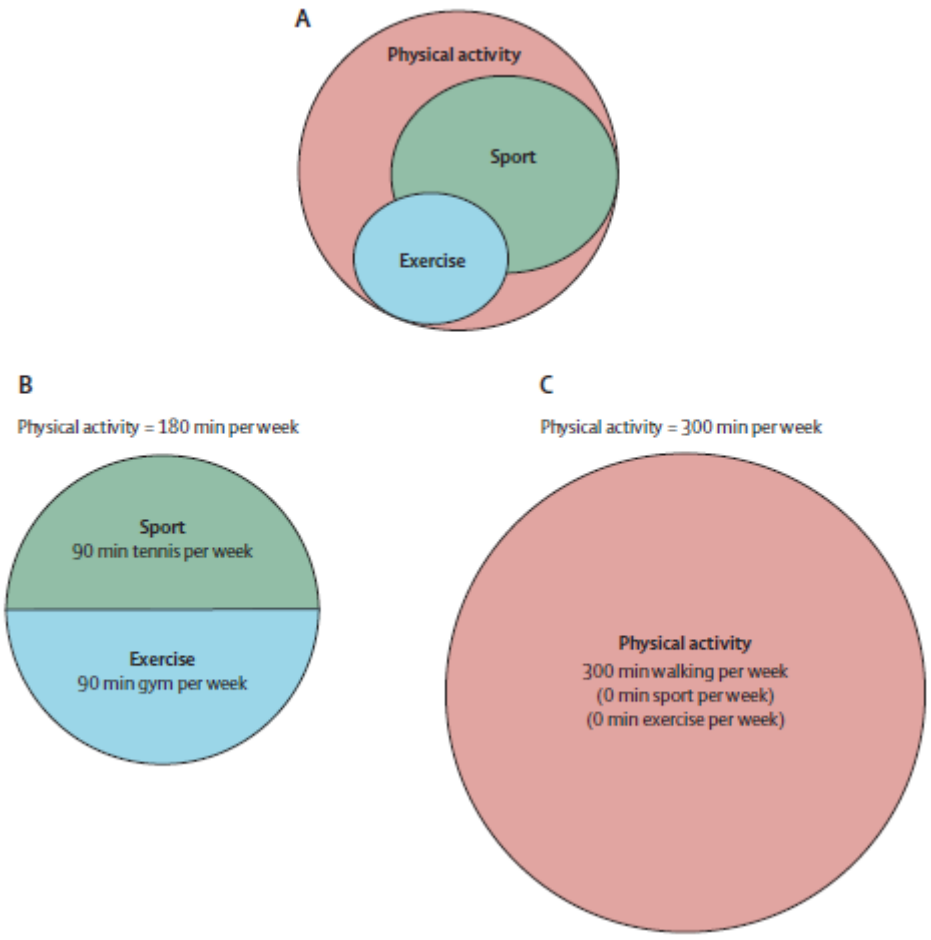

Figure 1. 'Sport', 'exercise' and 'physical activity' are related but not synonymous. They may provide different health benefits and they have different injury risks. Fig. 1a represents time spent in each of these three domains for an office worker who drives to and from work, parks next to an elevator that takes him/her to the office and is essentially sedentary at work. This person 'exercises' at the office gym 3 times a week for 30 minutes and plays tennis ('sport') at the home court for 90 minutes on the weekend. As he/she accumulates no recreational physical activity time, the total time spent being physically active per week is 180 minutes. The circles are proportional to the time spent.
Contrast this with Fig 1b which represents time spent in domains of physical activity, sport and exercise for a person who uses transit and walks from the office to get lunch. This person walks for 10 minutes to catch the local train, 10 minutes to the office from the train. This is repeated at the end of the work day. At lunch, this person walks for 10 minutes to a destination and 10 minutes back. If this person does no 'sport' or 'exercise' he/she nevertheless accumulates 300 minutes of physical activity in the week.

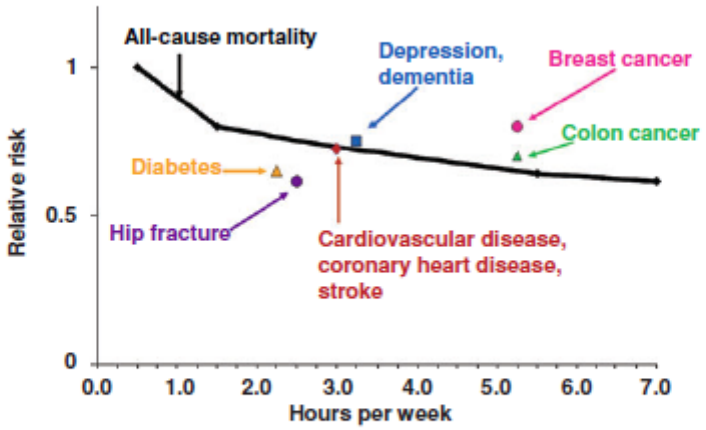

Figure 2

Risk of selected health events by hours/week of moderate to vigorous physical activity.