



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Health benefits of different sport disciplines for adults

Citation for published version:

Oja, P, Titze, S, Kokko, S, Kujala, UM, Heinonen, A, Kelly, P, Koski, P & Foster, C 2015, 'Health benefits of different sport disciplines for adults: systematic review of observational and intervention studies with meta-analysis', *British Journal of Sports Medicine*, vol. 49, no. 7, pp. 434-440. <https://doi.org/10.1136/bjsports-2014-093885>

Digital Object Identifier (DOI):

[10.1136/bjsports-2014-093885](https://doi.org/10.1136/bjsports-2014-093885)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

British Journal of Sports Medicine

Publisher Rights Statement:

This article has been accepted for publication in British Journal of Sports Medicine, 2015, following peer review, and the Version of Record can be accessed online at <https://doi.org/10.1136/bjsports-2014-093885>
© BMJ Publishing Group Ltd

Reuse of this manuscript version (excluding any databases, tables, diagrams, photographs and other images or illustrative material included where a another copyright owner is identified) is permitted strictly pursuant to the terms of the Creative Commons Attribution-Non Commercial 4.0 International (CC-BY-NC 4.0) <http://creativecommons.org>

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



Title:

Health benefits of different sport disciplines for adults: systematic review of observational and intervention studies with meta-analysis

Corresponding author:

Postal address: Pekka Oja
UKK Institute
P.O.Box 30
33501 Tampere
Finland

e-mail: pekka.oja@uta.fi

telephone: +358-3-2829282

Authors:

Pekka Oja¹, Sylvia Titze², Sami Kokko³, Urho M. Kujala³, Ari Heinonen³, Paul Kelly⁴, Pasi Koski⁵, Charlie Foster⁴

¹UKK Institute for Health Promotion Research, Tampere, Finland

²Institute of Sport Sciences, University of Graz, Graz

³Department of Health Sciences, University of Jyväskylä, Jyväskylä, Finland

⁴British Heart Foundation Health Promotion Research Group, University of Oxford, Oxford, England

⁵Department of Teacher Education, University of Turku, Rauma, Finland

Key words: health promotion through physical activity, sports analysis in different types of sports, aerobic fitness/VO₂max, intervention effectiveness, evidence based reviews

Word count: 4526 (without abstract, references, figure/table legends, new findings)

Health benefits of different sport disciplines for adults: systematic review of observational and intervention studies with meta-analysis

ABSTRACT

Health impacts of physical activity are extensively documented but less is known about the health benefits of sports. The aim was to assess the quality and strength of the evidence for the health benefits of specific sport disciplines up to April 2013.

Electronic search of six databases yielded 2194 records. Selection against inclusion/exclusion criteria resulted in 69 eligible studies with 47 cross-sectional, nine cohort and 13 intervention designs. After data extraction and synthesis the quality of the studies and the strength of the evidence were assessed. Six football interventions provided sufficient data for meta-analyses.

105 comparisons between participation and non-participation groups in 26 different sport disciplines were reported. Most comparisons comprised running, football, gymnastics, cycling, and swimming. The quality of eight cohort studies was rated high or moderate and that of all intervention studies moderate or weak.

Intervention and cohort studies showed moderately strong evidence that both running and football improve aerobic fitness and cardiovascular function at rest, and football reduces adiposity. The effects of football were confirmed and quantified by meta-analysis. Conditional evidence showed that running benefits metabolic fitness and adiposity, and that football improves metabolic fitness, and muscular performance and results in positive cardiac adaptations. All these benefits apply to both adult women and men. Evidence for health benefits of swimming, recreational cycling and other sport disciplines was either inconclusive or tenuous.

This review demonstrates that the evidence base (up to April 2013) for the health benefits of specific sports disciplines is generally compromised by weak study design and quality. The exception is for running and cycling which provide the strongest evidence for positive effects. Future research should address the health effects of different sport disciplines using rigorous research designs.

Word count: 261

INTRODUCTION

The goal of increasing participation in sport remains a common aim of national governments and often sport is seen as a mechanism to start young people along a pathway of an active lifestyle. This notion of sport participation contributing to a physically active lifestyle is politically popular but not necessarily supported by national physical activity surveys, as sports participation appears to consistently decline with age.[1] Regular participation in sport brings well documented health benefits[2-4], but the evidence of the health impacts of specific sport disciplines largely consists of indirect inference from physiological and biomedical characteristics of different sports [5].

Researching the health impacts of sports has tended to concentrate on studying the mortality and morbidity of ex-athletes, but such studies are limited by selection bias and confounding. Earlier studies on ex-athletes have suggested that participants of endurance type sports have reduced risk for obesity, type 2 diabetes, coronary heart disease and premature mortality, but they also have increased risk for osteoarthritis in team games with high knee injury risk.[6] These studies usually have the problem that the comparisons have been made with general populations including individuals with chronic diseases and disabilities at young age.[6] Therefore, none of these types of athlete studies can completely control for the strong selection bias as high fit individuals are selected to be participants in sports. Thus the cause-and-effect evaluation is impossible.

Recently a review of reviews identified 12 reviews on the health benefits of participation in specific sport disciplines.[5] Fewer than 20 specific sports were covered in these reviews with the majority of studies based on cross-sectional data. It was concluded that in the published literature there is an obvious shortage of higher quality evidence on the health benefits of specific sport disciplines.

In order for the sport movement to justifiably contribute to public health there is a need to better know the scientific evidence of the beneficial and adverse health effects specific to different sport disciplines. We feel it is important to place sport within the context of physical activity and exercise. “Physical activity” is “any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level”. [7] “Exercise” has the features of “planned, structured, and repetitive and purposive in the sense that the improvement or maintenance of one or more components of physical fitness is the objective” . [7] “Sport” is a “subset of exercise that can be undertaken individually or as a part of a team whereby participants adhere to a common set of rules or expectations, and a defined goal exists”. [8] For the purpose of this review we considered “sport discipline” a specific type of sport in which the activity itself consists of uniform movement patterns characteristic of that sport.

As organised sport movement encourages participation from a broad range of different sport disciplines, evidence is needed on the health and functional effects of specific sport disciplines. The aim of our review was to assess the quality and strength of the evidence for the health benefits of specific sport disciplines. This will be the first review of the evidence assessing the health benefits of specific sports.

METHODS

Data search

We used criteria for PROSPERO (International database of prospectively registered systematic reviews in health and social care) to provide the structure for our review . We identified three possible sources of potential studies, (i) electronic literature databases and websites, (ii) snowballing from reference lists of both review and retrieved articles, and (iii) from the authors' archives.

We conducted a systematic search of electronic databases including SPORTDiscus, SpoLit, Physical Education Index, Scopus, PubMed, and Web of Science from 2003 until end of April 2013. Tailored search terms were constructed for each database after several test searches and included combinations of the following key mesh terms (sports*), AND (health* OR Gesundheit*, fitness*). Search languages were English, German and Finnish. The full search strategy, identification of publications, and data extraction details are described in PROSPERO register with the registration number CRD42013006927 (http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42013006927#.VA3kFPmwL3s

Briefly, in the first stage of the search, titles and abstracts of identified articles were checked for relevance. In the second stage, full-text articles were retrieved and considered for inclusion. In the final stage, the reference lists of retrieved full-text articles were searched and additional articles known to the authors were assessed for possible inclusion.

Criteria for study inclusion/exclusion

Studies were considered to be eligible for inclusion according to the following criteria: (i) participants: healthy males and females of all ages (we excluded studies where the subjects were disabled or chronically ill patient groups), (ii) type of studies: original observational studies (cross-sectional and cohort studies) and intervention studies (randomised controlled trials and quasi-experimental studies) that were published in peer reviewed journals, (iii) study must include participation in specific sport disciplines, (iv) study design must have a non-participation comparison group, (v) outcome variables must be health- related in terms of mortality, morbidity or disease risk factors, and/or function-related in terms of cardio-respiratory, metabolic or musculoskeletal fitness (we excluded studies in which the outcome variables were injuries or other acute health problems), (vi) studies must be published in either in English, German or Finnish languages from January 2003 to April 2013.

The details of the selection process are described in the PROSPERO register as indicated above. In short, the consistency of applying the selection criteria on study titles and abstracts was first checked by two authors (PO, SK) for every 10th record. The inclusion/exclusion of potential full papers was first conducted by one author (PO) and then confirmed by two other (ST, SK).

The cross-sectional studies were considered to provide only descriptive evidence. They were included only in the general description of the identified evidence. Further analysis of the cross-sectional studies will be done separately and reported elsewhere.

Data extraction

For prospective cohort studies the extracted data consisted of: the number, gender and age of the subjects in the cohort; duration of follow-up; type of sport discipline(s) included in the analyses with definition of the used comparison categories; name and unit of each outcome variable; used statistic and statistical adjustments; statistical significance(s) of the pre-post comparisons.

From the intervention studies the following data were extracted: specific type of study design; number, gender and age of subjects in each comparison group; type, length, intensity, frequency and bout duration in each intervention group; name and unit of each outcome variable; within and between group pre-post percent changes and their statistical significance.

Assessment of the quality of the studies

The risk of bias of the prospective cohort studies was assessed by the Newcastle-Ottawa Quality Assessment Scale (NOS) for cohort studies.[9] This scale rates the quality of three domains of a study: (1) selection, (2) comparability and (3) outcome. In the selection domain four characteristics are rated: representativeness of the exposed cohort, selection of the non-exposed cohort, ascertainment of exposure, and demonstration that outcome of interest was not present at start of study. In the comparability domain, the level of controlling the confounding factors is assessed. The outcome domain is rated for the type of the assessment, the length of the follow-up, and adequacy of the follow-up. Each of the selection and outcome characteristic is given one star and the comparability domain two stars for high rating, resulting in a total of zero to nine stars for overall quality.

The quality of the intervention studies was assessed by the Effective Public Health Practice Project Quality Assessment Tool (EPHPP).[10] The tool assesses six components of a study: (1) selection bias, (2) study design, (3) confounders, (4) blinding, (5) data collection methods, and (6) withdrawals and drop-outs. Each component is rated as strong, moderate or weak according to set criteria. The global rating is strong, if there are no weak component ratings, moderate, if there is one weak component rating, and weak, if there are two or more weak component ratings.

Full description of the quality analyses is provided in the PROSPERO register as indicated above. In short, the assessment of all included studies was first done by one author (PO), repeated half and half by two authors (ST, CF for prospective studies and ST, AH for intervention studies), and followed by consensus decision among the three.

Summary measures

For the prospective cohort studies we used statistically significant pre-post exposure/outcome associations ($p < 0.05$) between the sport participation group(s) and the no-participation group as the summary measures. Among the intervention studies statistically significant ($p < 0.05$) percent pre-post within-group differences between the means of the sport vs. no-sport groups, and the statistically significant ($p < 0.05$) between-group pre-post differences were used as the measures of intervention effect. The reported outcome variables were grouped, for the purpose of coherence,

into 13 commonly used health/fitness domains as follows: mortality, aerobic fitness, cardiovascular function at rest, cardiac adaptation, adiposity, metabolic fitness, blood lipids, bone traits, running performance, muscular performance, postural balance, other.

Meta-analyses

We completed a narrative summary of the study results and when there were sufficient data (≥ 5 studies) we completed a formal meta-analysis of the included studies using the RevMan5.0 software.[11] For each study with continuous outcomes, we expressed the effect size using the standardised mean difference (SMD) between the post-intervention values of the randomised groups. We analysed the studies using the mean and standard deviation (SD) and visualised the results using forest plots. We quantified and evaluated the heterogeneity to determine whether the observed variation in the study results was compatible with the variation expected by chance alone.[12] Heterogeneity was assessed through examination of the forest plots and quantified using the I^2 statistic.

Strength of the evidence

To assess the strength of the evidence a rating system based on previously defined best evidence synthesis was used.[13] This system rates the evidence as follows.

Strong evidence: (1) at least two randomized controlled trials (RCT) of high quality, (2) one RCT of high quality and at least two RCTs of medium quality. Effects must be consistent for both cases.

Moderate evidence: (1) one RCT of medium quality and at least one RCT of low quality or (2) one RCT of medium quality and at least one controlled trial (CT) of high quality or (3) at least three CTs of high quality or (4) one CT of high quality and at least three CTs of medium quality. Effects must be consistent for all cases.

Limited evidence: (1) more than one RCT of low quality or (2) one CT of medium quality and two CTs of low quality or (3) two CTs of low quality and at least two before-after, cohort, or longitudinal studies. Effects must be consistent for all cases.

Inconclusive evidence: (1) only one study or (2) multiple before-after, cohort or longitudinal studies or contradictory effects.

No evidence: more than one study with consistent non-significant effects.

RESULTS

Study selection

The data search yielded 2194 records (Figure 1). After removing duplicates the remaining records were assessed against the inclusion/exclusion criteria resulting in 50 unique records, for which full papers were sought. After the inclusion of 41 full papers from other sources 91 papers remained for potential inclusion. Subsequently 22 papers were excluded for not meeting the inclusion criteria.

Thus the resulting search outcome included 69 eligible studies, of which 47 were cross-sectional, nine prospective cohort and 13 intervention studies. The cross-sectional studies were excluded and retained for separate analysis.

The participants in the prospective cohort and intervention studies were all adults between the ages of 19 to 90 years, healthy and relatively inactive.

FIGURE 1 HERE

Sport discipline specific comparisons

All together 105 comparisons between participation and non-participation groups were reported involving 26 different sport disciplines (Table 1). Sixty-eight of the comparisons came from cross-sectional studies, 15 from prospective cohort studies and 21 from intervention studies. Running and football had the most comparisons (22 and 18, respectively) most of them from prospective cohort and intervention studies. Gymnastics had 17 comparisons and they all came from cross-sectional studies. Cycling had nine, swimming eight, rowing and climbing three, tennis, squash, volleyball and hurdling two, and all other disciplines only one comparison.

Table 1. Number of comparisons by sport discipline and study design

Sport DISCIPLINE	X-S¹	RX-S²	PCS³	PP-BCS⁴	CCT⁵	RCT⁶	ALL
running	8		1	4	6	3	22
football	8				6	4	18
gymnastics	13	4					17
cycling	5			4			9
swimming	4			2		2	8
weight-lifting	2			1			3
rowing	2			1			3
climbing	3						3
tennis	1			1			2
squash	2						2
volleyball	2						2
hurdling	2						2
golf			1				1

ice-skating	1						1
ice-hockey	1						1
wrestling	1						1
bobsled	1						1
canoeing	1						1
rugby	1						1
water polo	1						1
basketball	1						1
equitation				1			1
speed skating	1						1
orienteering	1						1
c-c skiing	1						1
judo	1						1
ALL	64	4	2	13	12	9	105

¹cross-sectional, ²repeated cross-sectional, ³prospective cohort study,

⁴prospective population-based cohort study, ⁵controlled clinical trial,

⁶randomised controlled trial

Study characteristics and synthesis of results

Prospective cohort studies

Nine prospective cohort studies met the inclusion criteria, four dealt with jogging/running, four with cycling, three with swimming, and one with each of tennis, rowing, racquetball and golf (Table 2, supplementary online). Jogging/running was shown to be associated with reduced total, cardiovascular, cancer, neurological and infectious mortality and moderate disability among men and women.[14] The decrease in mortality was shown for male and female runners, who were members of a nationwide US running club and who averaged more than one hour running each week. Jogging/running was also shown to reduce weight gain among women [15, 16] and men [15]. One study showed no association between jogging/running and the risk of cardiovascular disease.[17]

To be consistent with the definition of sport discipline we used, cycling was limited to recreational cycling (we excluded cycling for transport or other utility purposes). These studies examined

associations with changes in waist circumference [18], cardiovascular disease incidence [17], incidence of colon cancer [19], and all-cause, cardiovascular and cancer mortality [20]. No statistically significant associations were found.

Of the three studies on swimming no association was shown with the risk of cardiovascular diseases [17] and weight change [15], but a significantly reduced all-cause mortality [21].

Four other sport disciplines were included in one cohort study each. Regular golf practice as a member of a golf club was shown to be associated with reduced all-cause mortality [22] and tennis practice with decreased risk of cardiovascular diseases [17]. Participation in rowing or racquetball showed no association with cardiovascular disease risk.[17]

According to the NOS tool the overall quality was high for one study, moderate for seven studies and low for one study (Table 3).

Table 3. Quality assessment of the prospective cohort studies according to the Newcastle-Ottawa Scale¹ [9]

Study	Selection				Comparability		Outcome
	Representativeness of exposed cohort	Selection of non-exposed cohort	Ascertainments of exposure	Outcome not present at onset	Controls for other PA	Controls for additional factor	Assessment
Berentzen 2008 [18]	truly representative*	drawn from same community*	written self-report	yes*	yes*	yes*	independent blind*
Chakravarty 2008 [14]	selected group	drawn from different source	written self-report	yes*	yes*	yes*	self-report
Chase 2008 [21]	selected group	drawn from same community*	written self-report	yes*	no	yes*	record linkage*
Chomistek 2012 [17]	selected group	drawn from same community*	written self-report	yes*	yes*	yes*	record linkage*
Farahmand 2009 [22]	selected group	drawn from different source	secure record*	yes*	yes*	no	record linkage*
Johnsen 2006 [19]	somewhat representative*	drawn from same community*	structured interview*	yes*	yes*	yes*	record linkage*
Littman 2005 [15]	somewhat representative*	drawn from same community*	written self-report	yes*	yes*	yes*	Self-report
Mekary 2009 [16]	selected group	drawn from same community*	written self-report	yes*	yes*	no	Self-report
Sahlqvist 2013 [20]	somewhat representative*	drawn from same community*	written self-report	yes*	yes*	yes*	record linkage*

¹ http://www.ohri.ca/programs/clinical_epidemiology/oxford.htm

²The selection domain is given four stars, the comparability domain two stars, and the outcome domain three stars for 9 stars for overall quality.

* A “Star” is provided if the defined quality has been achieved; y=years

Intervention studies

Thirteen intervention studies met the inclusion/exclusion criteria (Table 4, supplementary online). According to the EPHPP tool five of these were Randomised Controlled Trials and eight Controlled Clinical Trials with randomised intervention groups (randomized into different sport interventions) and non-randomised but matched control groups. Nine of the intervention studies came from the same laboratory (Department of Exercise and Sport Sciences, University of Copenhagen, Denmark). Of these, two studies among women and two studies among men reported results from the same intervention experiment.

The intervention studies reported effects of four different sport disciplines; recreational small-field football (10 studies), running (9 studies), swimming (1 study) and equitation (1 study).

Football was shown to consistently improve aerobic fitness [23-27], measures of cardiovascular function at rest [23, 25, 26, 28, 29], metabolic fitness [24, 26, 28], running performance [30, 26, 28], and reduce adiposity [23-27, 29]. Improved cardiac adaptation [31, 26], blood lipids [29, 27] and muscular performance [32, 29] were indicated in two studies each, and increased bone mineral density and improved postural balance each in one study [32].

Running was shown to improve aerobic fitness in four studies [23, 25, 26, 28], cardiovascular function at rest in three studies [24-26], and running performance in three studies [30, 23, 26]. Some but fewer evidence was shown for improvement in metabolic fitness [24, 25], cardiac adaptation [24], muscular performance [32], and postural balance [32].

There was only one study on swimming and one on equitation. Body mass index decreased slightly but significantly in the swimming group, and muscle strength in trunk flexion and knee extension decreased significantly in both swimming and control group but less in the swimming group [33]. Equitation training showed significant increase in muscle strength and decrease in fatigue index [34].

According to the EPHPP tool (Table 5) all thirteen studies used either randomized control trial design or controlled clinical trial design and were rated strong for the design. The “representativeness” component, or selection bias, was rated weak for all studies. The global rating of the intervention studies yielded no “strong” scores, six “moderate scores” and seven “weak” scores.

Table 5. Quality assessment of the intervention studies according to the EPHPP tool¹

Study	Component rating						Global rating
	Representativeness	Design	Confounders	Blinding	Methods	Drop-outs	
Andersen 2010 [31]	weak	strong	strong	moderate	strong	moderate	moderate

Bangsbo 2010 [30]	weak	strong	strong	moderate	strong	strong	moderate
Carrasco 2010 [33]	weak	strong	strong	weak	strong	moderate	weak
Helge 2010 [32]	weak	strong	strong	moderate	strong	moderate	moderate
Knoepfli-L. 2010 [23]	weak	strong	moderate	moderate	strong	moderate	moderate
Krustrup 2009 [24]	weak	strong	strong	weak	strong	strong	weak
Krustrup 2010a [25]	weak	strong	strong	moderate	strong	moderate	moderate
Krustrup 2010b [26]	weak	strong	strong	weak	strong	moderate	weak
Krustrup 2010c [28]	weak	strong	strong	weak	strong	strong	weak
Meyers 2006 [34]	weak	strong	weak	weak	strong	strong	weak
Nybo 2010 [37]	weak	strong	weak	weak	strong	strong	weak
Randers 2010 [29]	weak	strong	strong	moderate	strong	moderate	moderate
Randers 2012 [27]	weak	strong	strong	weak	strong	weak	weak

¹Effective Public Health Practice Project [10], see details in the text.

Meta-analysis

There was sufficient data for the meta-analysis of the effect of football on three outcomes: VO_{2max} , fat mass and resting heart rate (Figure 2). For any other sport discipline the data was insufficient for meta-analysis.

FIGURE 2 HERE

Pooled estimate of effect for football showed a statistically significant overall increase of 4.11 ml/kg/min (CI: 1.10 to 7.12) in VO_{2max} and a decrease of 6.25 beats per minute (CI: -8.90 to -3.61) in resting heart rate. The pooled effect for VO_{2max} was positive and moderate but with significant heterogeneity ($I^2 = 69\%$). Fat mass decreased by 2.64 kg (CI: -6.06 to 0.78) but the change was borderline statistically significant. There was no evidence of heterogeneity in pooled effects for resting heart rate ($I^2 = 0\%$) or fat mass ($I^2 = 16\%$). We found no evidence of publication bias.

DISCUSSION

Strength of the evidence on health benefits of sport disciplines

Our review identified the associations with or effects on health and functional outcomes for 26 different sport disciplines. This is the first time this evidence has been collated and compared in a systematic review. The most commonly studied sport disciplines were running (22 comparisons participation vs. no participation), football (18), gymnastics (17), recreational cycling (9) and swimming (8).

According to the used scale of the strength of the evidence [13] the health benefits of these disciplines can be summarized as follows.

For running moderate evidence shows improvements in aerobic fitness, cardiovascular function at rest and running performance; all these changes are shown for both women and men. Limited evidence for improvements was shown in metabolic fitness and adiposity, also for both genders. Inconclusive evidence was shown in cardiac adaptation, muscular strength, postural balance and all-cause and disease-specific mortality.

Moderate evidence shows that recreational football improves aerobic fitness, cardiovascular function at rest and adiposity in both genders. These observations are corroborated and quantified by the performed meta-analyses: pooled data shows 11 % increase in aerobic power, 10 % decrease in resting heart rate, and 13 % decrease (borderline significant) in fat mass. These changes were accrued with football dose of 12 to 16 weeks duration, about 80%HRmax intensity, about two sessions per week frequency, and one hour bout duration. The degrees of improvements can be clinically significant based on recent findings showing that those who have 10 METs or greater exercise capacity have an extremely low risk of death from cardiovascular disease [35], and those who have low resting heart rate have a lower risk of CVD and all-cause mortality [36]. Limited evidence shows improvements in metabolic fitness, cardiac adaptation and muscular performance, also in both genders, and in blood lipids among men. Inconclusive evidence is shown for benefits in bone mineral density and postural balance.

For swimming we found some evidence for reduced total and cardiovascular disease mortality and adiposity, but it was inconclusive. Evidence for improved muscle strength in equitation was also inconclusive. There was no evidence to show that recreational cycling has beneficial effects on total, cardiovascular and cancer mortality, cardiovascular disease incidence, or adiposity.

All these findings pertain to ostensibly healthy and relatively inactive middle-aged persons.

Due to the small number of studies reporting the effects of other sport disciplines conclusion of the health benefits cannot be drawn.

One new study eligible for our review has been published after the closure of the data search. Mendham et al. [38] studied rugby and ergometry cycling and showed that regular rugby training for eight weeks improved submaximal power output, decreased fat mass and increased fat-free mass in middle aged men. This is the first intervention study showing effects of recreational rugby.

After the submission of this review a special issue of Scandinavian Journal of Medicine & Science in Sports [39] has published 16 original articles on the health and functional effects of recreational football. Reported results show that football improves the structure and function of the heart, lowers blood pressure, reduces blood lipids and body fat, and improves functional capacity [40]. The presented observations strengthen the evidence on the benefits of football found in the present review.

Risk of sports injuries

From the public health perspective the health benefits due to participation in different sport disciplines have to be balanced with the possible health risks involved. Especially the sport injuries are of potential concern. The reviewed intervention studies provide some relevant information. No injuries were reported in swimming [33] and in equitation [34] interventions among women. Of the four interventions with football and running training among women two reported no training-related injuries [31, 26]. Both other studies in women [32, 25] reported four injuries among 78 women for both football and running. The studies among men reported 2 out of 15 [23], 1/13 [24], 0/10 [29] and 1/27 [27] football-related, and 0/15 [23], 2/12 [28] and 2/9 [37] running-related injuries. These injury rates add up to approximately one injury per 700 hours of football training and 500 hours of running training. In high-intensity interval running relatively more training-related injuries (5/8) were reported although three of them were transient in nature [37].

The present information, limited to relatively small short-term intervention studies, suggests that while many types of sport disciplines may induce significant cardio-metabolic and musculo-skeletal benefits, football and running training in particular among previously untrained women and men may expose them to increased risk of injuries, albeit mostly minor ones. Thus, when implementing such sport disciplines as health-enhancing physical activity, the known effective injury prevention measures [41] should be built in as an integral part of the intervention programmes. The reviewed trials are too small and too short in duration to evaluate the possible occurrence of uncommon severe complications and longer trials are needed to assess the sustainability of benefits and participation over time.

Methodological considerations

Overall the evidence base of the health benefits of different sport disciplines is diverse comprising of many relatively simple cross-sectional studies addressing a mixed variety of single sport disciplines and fewer prospective cohort and intervention studies. The latter two types of published studies focus mainly on running and football. According to the NOS tool [9] the quality of eight of the nine prospective cohort studies were rated overall at least moderate. Particularly strong aspects

were the selection of non-exposed cohort, outcome not present at onset, control of potential confounders, and the duration of the follow-up. A weaker aspect was the ascertainment of exposure due to the use of physical activity self-report.

According to the EPHPP tool [10] the “representativeness” component, or selection bias, was rated weak for all intervention studies, because in these types of exercise interventions the participants are typically highly selected due to the multi-step screening procedure including a clinical health assessment for the safety of the exercise stress test and the training. This limitation may reduce the potential reach of sports programmes to less active groups. “Blinding” was also a weak component in these studies due to the fact that in exercise interventions of this type, it is difficult to blind both the subjects and the assessors; the exercise intervention cannot be blinded from the subjects and the assessors are typically involved not only in the measurements but also in providing the interventions.

Sport for public health?

Khan et al. states that sport is one sector that can improve the health of nations through increased physical activity.[8] Sport for all movement has increasingly used the improvement of health as its social justification.[42] The potential of different sport disciplines to promote public health depends on one hand on the prevalence of a given sport and on the health benefits of that sport, on the other. Apart from the study-specific synthesis of the data it is clear from the meta-analysis that significant improvements in cardiovascular function can be achieved by participation in twice weekly football sessions. The potential public health impact of regular twice weekly participation would ensure for all participants to achieve existing physical activity guidelines. The challenge is to see if such programs can attract and retain participants to enjoy the benefits of regular participation.

In order to promote sport for all effectively as evidence-based physical activity for public health the focus and type of research need to be appraised according to the largest possible population impact. Especially there is a need for both prospective cohort studies and intervention trials on those sport disciplines that are prevalent among populations. We suggest any assessment of national surveys of physical activity include discipline specific assessments of sport, e.g. the UK’s Health Survey for England [1].

CONCLUSIONS

The present review indicates that there is considerable amount of published evidence on the health benefits of different sport disciplines, but the information is fragmentary. Most identified studies have used cross-sectional design addressing a large number of single sport disciplines but not allowing to demonstrate the cause and effect nature of the found relationships. More substantial evidence was found from prospective cohort and interventions studies focusing in particular on recreational football and running. According to the synthesis of the data there is conditional evidence to show that recreational football can benefit aerobic fitness, cardiovascular function, metabolic fitness, adiposity, cardiac adaptation and muscular performance. Such physiological effects can be conducive for reduced risk of cardiovascular and all-cause mortality. For running similar evidence shows benefits in aerobic fitness, cardiovascular function, running performance,

metabolic fitness and adiposity. All these benefits apply to both adult women and men. Found evidence for health benefits of other sport disciplines was either inconclusive or tenuous.

Our review shows evidence (up to April 2013) for the potential public health impact of different sport disciplines but the evidence base appears currently underdeveloped in both quantity and quality. We call on the research community to tackle this deficiency by examining the impacts of the most popular sports, based on participation levels, using appropriate and high quality study trial designs.

What are the new findings:

1. Sport as a general domain of physical activity is often claimed to benefit health. Published evidence on the health benefits of specific sport disciplines is scarce and impaired by weak study designs. Rigorous evidence on the health benefits of different sport disciplines would support the sport movement to take a stronger role in promoting participation in sports for public health.
2. We found evidence on the sport-health relationship for 26 different sport disciplines. Most evidence came from cross-sectional studies and less from prospective cohort and intervention studies.
3. Studies on only five sport disciplines (running, football, cycling, gymnastics, swimming) provided more than three comparisons between participant and non-participant groups.
4. Best evidence was found for recreational football and running. They can benefit especially cardio-vascular and metabolic fitness.
5. There was some but inconclusive evidence for health benefits of recreational cycling and swimming. No solid evidence showed health benefits for any other sport discipline.

Acknowledgements: We thank graduate student Tero Pasanen for his help in extracting the cross-sectional data.

Competing interests: None.

Provenance and peer review: Not commissioned, externally peer reviewed.

REFERENCES

[1] Bélanger M, Townsend N, Foster C. Age-related differences in physical activity profiles of English adults. *Preventive Medicine* 2011, doi:10.1016/j.ypmed.2011.02.008.

[2] Booth FW, Roberts CK, Laye MJ. Lack of exercise is a major cause of chronic diseases. *Compr Physiol* 2012;2:1143-1211.

- [3] Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act* 2010;7:40-56.
- [4] Murphy MH, Blair SN, Murtagh EM. Accumulated versus continuous exercise for health benefit: a review of empirical studies. *Sports Med* 2009;39:29-43.
- [5] Oja P, 2010. Sport for all for health – fact or fiction? In: Brown WJ, Havas E, Komi PV, eds. Promoting Sport for All. Benefits and Strategies for the 21st Century. Proceedings of the XIII World Sport for All Congress. 14-17 June 2010, Jyväskylä Finland. Keuruskopio OY, Keuruu, Finland, 2010:49-53.
- [6] Kujala UM, Marti P, Kaprio J et al. Occurrence of chronic disease in former top-level athletes. Predominance of benefits, risks or selection effects? *Sports Med* 2003;33:553-561.
- [7] US Department of Health and Human Services. Physical Activity Guidelines Advisory Committee. Physical Activity Guidelines Advisory Committee Report, Washington, DC: 2008, 683. Accessed June 2010 from www.health.gov/paguidelines/.
- [8] Khan KM, Thomson AM, Blair SN et al. Sport and exercise as contributors to the health of nations. *Lancet* 2012;380:59-64.
- [9] Wells GA, Shea B, O'Connell D et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Accessed September 2013 from http://www.ohri.ca/programs/clinical_epidemiology/oxford.html.
- [10] National Collaborating Centre for Methods and Tools 2008. **Dictionary for the Effective Public Health Practice Project Quality Assessment Tool For Quantitative Studies**. Accessed October 2008 from <http://www.ehphp.ca/tools.html>.
- [11] The Nordic Cochrane Centre, The Cochrane Collaboration. Review Manager (RevMan). 5.2. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2012.
- [12] Deeks JJ, Higgins JPT, Altman DG. Chapter 9: Analysing data and undertaking meta-analyses. In: Higgins JPT, Green S, editor(s). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 (updated March 2011). The Cochrane Collaboration, 2011. Available from www.cochrane-handbook.org.
- [13] De Bourdeaudhuij I, Van Cauwenberghe E, Spittaels H et al. School-based interventions promoting both physical activity and healthy eating in Europe: a systematic review within the HOPE project. *Obes Rev* 2011;12:205-216.
- [14] Chakravarty EF, Hubert HB, Lingala VB et al. Reduced disability and mortality among aging runners: a 21-year longitudinal study. *Arch Intern Med* 2008;168:1638-1646.
- [15] Littman AJ, Kristal AR, White E. Effects of physical activity intensity, frequency, and activity type on 10-y weight change in middle-aged men and women. *Int J Obes* 2005;29:524-533.
- [16] Mekary RA, Feskanich D, Malspeis S et al. Physical activity patterns and prevention of weight gain in premenopausal women. *Int J Obes* 2009;33:1039-47.

- [17] Chomistek AK, Cook NR, Flint AJ et al. Vigorous-intensity leisure-time physical activity and risk of major chronic disease in men. *Med Sci Sports Exerc* 2012;44:1898-905.
- [18] Berentzen T, Petersen L, Schnohr P et al. Physical activity in leisure-time is not associated with 10-year changes in waist circumference. *Scand J Med Sci Sports* 2008;18:719-27.
- [19] Johnsen NF, Christensen J, Thomsen BL et al. Physical activity and risk of colon cancer in a cohort of Danish middle-aged men and women. *Eur J Epidemiol* 2006;21:877-84.
- [20] Sahlqvist S, Goodman A, Simmons RK et al. The association of cycling with all-cause, cardiovascular and cancer mortality: findings from the population-based EPIC_Norfolk cohort. *BMJ Open* 2013; 3:e003797. Published online 14 November 2013. doi: 10.1136/bmjopen.2013.003797.
- [21] Chase NL, Sui X, Blair SN. Comparison of the health aspects of swimming with other types of physical activity and sedentary lifestyle habits. *Int J Aquat Res Educ* 2008;2:151-161.
- [22] Farahmand B, Broman G, de Faire U et al. Golf: a game of life and death – reduced mortality in Swedish golf players. *Scand J Med Sci Sports* 2009;19:419-424.
- [23] Knoepfli-Lenzin C, Sennhauser C, Toigo M et al. Effects of a 12-week intervention period with football and running for habitually active men with mild hypertension. *Scand J Med Sci Sports* 2010;20 Suppl 1:72-9.
- [24] Krstrup P. Recreational soccer is an effective health-promoting activity for untrained men. *Br J Sports Med* 2009;43:825-31.
- [25] Krstrup P, Hansen PR, Randers MB et al. Beneficial effects of recreational football on the cardiovascular risk profile in untrained premenopausal women. *Scand J Med Sci Sports* 2010a;20:40-49.
- [26] Krstrup P, Hansen PR, Andersen LJ et al. Long-term musculoskeletal and cardiac health effects of recreational football and running for premenopausal women. *Scand J Med Sci Sports* 2010b;20:58-71.
- [27] Randers MB, Petersen J, Andersen LJ et al. Short-term street soccer improves fitness and cardiovascular health status of homeless men. *Eur J Appl Physiol* 2012;112:2097-2106.
- [28] Krstrup P, Christensen JF, Randers MB et al. Muscle adaptations and performance enhancements of soccer training for untrained men. *Eur J Appl Physiol* 2010c;108:1247-1258.
- [29] Randers MB, Nielsen JJ, Krstrup BR et al. Positive performance and health effects of a football training program over 12 weeks can be maintained over a 1-year period with reduced training frequency. *Scand J Med Sci Sports* 2010;20:80-89.
- [30] Bangsbo J, Nielsen JJ, Mohr M et al. Performance enhancements and muscular adaptations of a 16-week recreational football interventions for untrained women. *Scand J Med Sci Sports* 2010;20:24-30.

- [31] Andersen LJ, Hansen PR, Sögaard P et al. Improvement of systolic and diastolic heart function after physical training in sedentary women. *Scand J Med Sci Sports* 2010;20:50-57.
- [32] Helge EW, Aagard P, Jacobsen MD et al. Recreational football training decreases risk factors for bone fractures in untrained premenopausal women. *Scand J Med Sci Sports* 2010;20:31-39.
- [33] Carrasco M, Vaquero M. Water training in postmenopausal women: Effect on muscular strength. *Eur J Sport Sci* 2012;12:193-200.
- [34] Meyers MC. Effect of equitation training on health and physical fitness of college females. *Eur J Appl Physiol* 2006;98:177-84.
- [35] Fine NM, Pellikka PA, Scott CG et al. Characteristics and outcomes of patients who achieve high workload (≥ 10 Metabolic Equivalents) during treadmill exercise echocardiography. *Mayo Clin Proc* 2013;88:1408-1419.
- [36] Saxena A, Minton D, Lee D-C et al. Protective role of resting heart rate on all-cause and cardiovascular disease mortality. *Mayo Clin Proc* 2013;88:1420-1426.
- [37] Nybo L, Sundstrup E, Jakobsen MD et al. High-intensity training versus traditional exercise interventions for promoting health. *Med Sci Sports Exerc* 2010;42:1951-1958.
- [38] Mendham AE, Duffield R, Marino F et al. Small-sided games training reduces CRP, IL-6 and leptin in sedentary, middle-aged men. *Eur J Appl Physiol* 2014. Published online 22 July 2014: doi 10.1007/s00421-014-2953-3.
- [39] Scandinavian Journal of Medicine & Science in Sports. Special Issue: Football for Health - Prevention and Treatment of Non-Communicable Diseases across the Lifespan through Football. Guest Editors: Bangsbo J, Krstrup P, Dvořák J. August 2014, Volume 24, Issue Supplement S1, Pages 1–150.
- [40] Bangsbo J, Junge A, Dvorak J et al. Executive summary: Football for health – prevention and treatment of non-communicable diseases across the lifespan through football. *Scand J Med Sci Sports* 2014;24 (Suppl 1):147-150. Published online August 2014. doi:10.1111/sms.12271.
- [41] Leppänen M, Aaltonen S, Parkkari J et al. Interventions to prevent sports related injuries: A systematic review and meta-analysis of randomized controlled trials. *Sports Med* 2014;44:473-86. doi: 10.1007/s40279-013-0136-8.
- [42] Verhagen E, van Mechelen W. Health issues as primary reasons for choosing sport for all programs. In: Brown WJ, Havas E, Komi PV, eds. Promoting Sport for All. Benefits and Strategies for the 21st Century. Proceedings of the XIII World Sport for All Congress. 14-17 June 2010, Jyväskylä Finland. Keuruskopio OY, Keuruu, Finland, 2010:43-47.

Figure legends:

Figure 1. Flow chart of the data search.

Figure 2. Meta-analysis of the effects of recreational football on aerobic fitness (VO_2max ml/kg/min), resting heart rate (beats/min) and fat mass (kg).

