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SoccHealth: a health status examination of former professional football (soccer) players within the German National Cohort

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ABSTRACT

The long-term health effects of football (soccer) have received significant attention in recent years. While brain health is currently the focus of this interest, potential long-term risks or benefits related to cardiovascular and metabolic diseases and cancer are also of interest to sports medicine professionals. However, studies assessing the overall health risks for professional football players remain scarce. We introduce 'SoccHealth', a satellite project to the German National Cohort (NAKO), Germany's largest population-based cohort study. SoccHealth examined 348 former professional football players aged 40–69 using the infrastructure and comprehensive examination programme of NAKO. The German Statutory Accidental Insurance for Professional Athletes identified and invited male players, while female players were recruited among former national team members. Details of the examination programme and the sociodemographic and career-related characteristics of the participants are described. The identical examination programme for the NAKO participants provides the opportunity to draw general population controls according to various definitions and focus on the respective research question to be analysed. This report delineates one approach to evaluate the long-term health effects of football across a broad range of diseases.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The health effects of football have been studied using various study designs. Many of these studies focus on disorders and conditions of the brain after increased risks for dementia have been reported for other contact sports. The risks or benefits of professional football training and play on other health outcomes and disorders are rarely studied.

WHAT THIS STUDY ADDS

⇒ This study describes one approach to studying health outcomes after a professional football career using the framework of a large population-based study that provides the advantage of drawing controls appropriate for different research questions.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study outlines a comprehensive framework for data-based contributions to the controversial discussion on the football-related balance between health benefits and risks associated with a professional career.

INTRODUCTION

Over the past decades, many beneficial effects of regular physical exercise have been reported, for example, on mortality for different diseases as well as on surrogate parameters such as cardiovascular risk factors[1–4] and emotional[5] and cognitive functions.[6 7] Most study reports investigated endurance-dominated[8] or strength-dominated sports.[9] Some, however, did not differentiate between the two but quantified energy expenditure or used other measures to (semi)quantify physical exercise regardless of the employed sport.[10–12] However, the latter approach introduces a simplification for easier data analysis and for the sake of adequately sized samples. Still, most physically active individuals participate in more complex sports, like tennis, golf, or soccer, using specific combinations of endurance, strength, coordination and other skills.

Based on specific physiological requirements and the set of skills needed, adaptations to regular football (soccer) training and match play follow a sport-specific pattern. The same specificity is true for risks of adverse events (side effects) like injuries[13 14] and degenerative joint diseases,[15] sudden cardiac events or even neurodegenerative changes.[16]

The likelihood of specific adverse effects of regular football play is highest in those athletes who have undergone the highest sport-specific stress, that is, professionals. Adverse events in football receive particular attention if they occur during a game. However, this attention is usually short-lived. For several years now, the long-term health effects of football have been discussed more frequently among professionals in sports medicine and the bodies of organised football. Besides risks or benefits of cardiovascular and/or metabolic diseases or cancer, effects on long-term brain health are also under consideration. One approach to estimate the magnitude of risks or benefits of professional soccer play is to contrast them with control groups with different physical activity levels derived from the general population. This has already been done in a limited number of studies.[17 18]

Longitudinal ('training') studies with repeated examinations provide the best design to analyse the effects of regular training and competition[19] on health outcomes. However, they are difficult to conduct over decades of an entire football career, which typically starts in early childhood. This is even more problematic for disorders and dysfunctions that develop only after a lag time, such as degenerative diseases, which only become phenotypically detectable several years after the end of the career. Another example of methodological problems in such longitudinal investigations is the lack of measurement tools for children also to be applied to adults. This, however, would be necessary to address long-term changes properly.

This study addresses football-specific effects on various health-related outcomes, including cardiovascular, metabolic, musculoskeletal and neurological disorders among former professional football players in Germany. The framework and infrastructure of an existing mega-cohort in Germany have been used to achieve this goal. Here, we describe the study design and the examination programme, and we provide a summary of the characteristics of the participants of the 'SoccHealth Study' within the German National Cohort (NAKO).

METHODS

Participants and recruitment

The 'German National Cohort (NAKO) is Germany's largest population-based prospective health study and has recruited more than 205 000 individuals between 2014 and 2019.[20] Participants aged 20–69 years were randomly drawn from the city registries of the 18 study centres across the country and subsequently invited to the local study centre. Registration with the community of living is mandatory in Germany. The comprehensive examination programme aimed at the assessment of a large number of health-related risk behaviours and diseases and lasted on average four (standard programme L1) or 6–7 hours (intensified programme L2 for a random 20% of the participants).[20] In five study centres, dedicated 3.0 Tesla Siemens MRI scanners were set up for a whole-body MRI of L2 study participants.[21]

SoccHealth is a satellite project of NAKO and uses the NAKO infrastructure and its intensified examination programme L2 during the first re-examination round (2019–2024) of the regular NAKO participants. SoccHealth aims to assess the health status of former professional football players after their professional career for many diseases and body functions, including imaging and biomarkers. Ex-professionals were qualified to participate in the project if they had played at least one season in the highest or second-highest (first or second Bundesliga) German soccer leagues or equivalent in neighbouring European countries. Since there is no list or registry of former soccer players in Germany, potential participants were identified at the 'German Statutory Accidental Insurance for Professional Athletes (VBG)', the mandatory insurance for all professional football, basketball, volleyball and ice-hockey players in Germany. Potential participants, aged 40–69 in 2021, were selected from the insurance database by insurance staff members who sent an information letter about SoccHealth plus an invitation to participate. Those interested filled out a brief contact sheet and mailed it to NAKO's central office in Heidelberg. In the sheet, they had to indicate their preference for 1 of the 18 study centres for the examination, ideally 1 of the 5 centres that included an MRI examination in their programme. The preferred study centre subsequently took over and organised an appointment for the examination and conducted the intensified NAKO L2 examination programme with the player.

For female ex-professionals, a slightly different recruitment approach was chosen. All former players in the German female national football team, aged 40–69 years in 2021, were invited to participate. This was done due to the very different structure of professional football between men and women during the active careers of these players. It was assumed that female players below the national team level did not train and compete on a comparably intense and collision-prone level as their male counterparts. A list of former national female players is kept at the central office of the German Football Association (Deutscher Fußball-Bund, DFB) in Frankfurt. Information about SoccHealth and an invitation to participate was sent from the DFB office to the former national players. If they decided to participate, the procedures would be the same for male players. Both male and female former professionals received one reminder letter in case of no response. Thus, while the German National Cohort is population-based and includes randomly selected participants from the general population with a baseline response of 17%, SoccHealth participants represent a convenience sample of former professional soccer players willing to participate in a large and comprehensive health study.

Examination programme

Each study centre's examination programme and procedures were standardised based on a list of more than 50 NAKO Standard Operation Procedures. Different

Table 1 Components and topics of the face-to-face interview and the self-report questionnaire, by component

Interview component	Topics
Socioeconomic/ sociodemographic status:	Nationality, ethnicity, native language, education, family status and education, living situation, occupational status, parental education
Lifetime/ current disease histories and treatment status for:	History of cardiovascular, metabolic, musculoskeletal, pulmonary, gastrointestinal, neurological, psychiatric, renal, eye and skin diseases, allergies, infections, cancer, list of rare disorders and operations
Medication:	Medication use in last 7 days (ATC coded)
Other:	Reproductive behaviour, hormone use
Self-report component	**Topics**
Health behaviours:	Smoking (history), alcohol consumption, drug consumption, physical activity, physical fitness, skin tattoos, solarium use
Healthcare utilisation:	Specialist type and contact frequency, hospitalisations, rehabilitations
Screening (last 5 years):	Participation in cancer screening programmes for colon, rectum, breast, cervix, prostate, skin
Job-related factors:	Occupational rewards and strains
Environment:	Exposure to traffic and animals
Quality of life (QoL):	SF-12, Instrumental Activities of Daily Living*
Weight history:	At ages 18/ 30/ 50 years
Early childhood:	Number of siblings, preterm birth, breast feeding, animal exposure, kindergarten visit, sunburns
Family history:	List of 9 diseases for father and mother
Pregnancy:	Number and details of pregnancies
Additional diseases: (question sets)	Chronic bronchitis, heart failure, headache (sub)types, sleep characteristics, infections, irritable bowel disease, restless legs syndrome, pain localisation/ characteristics (Mannequin)
Accidents and fractures†:	List of fractures and event types and event frequency
Emotional function:	Depressive (PHQ-9) and anxiety (GAD-7) symptoms, stress (PHQ), childhood trauma (CT-S), M.I.N.I. Neuropsychiatric Interview for MDD
Psychosocial function:	Personality Big-5, fatigue, social net and social support†
Senses:	Question sets for visus and hearing (aids)
Teeth health:	Tooth-related QoL, paradontitis
Soccer-specific questionnaire:	# of seasons played, league types, youth leagues, main play position, alternative position, injuries

*Age group 60+ years only.
†Age group 50+ years only.
ATC, anatomical therapeutic chemical; CT-S, childhood trauma screener; GAD-7, patient health questionnaire (general anxiety disorder part); M.I.N.I., mini international neuropsychiatric interview vs. 5.0.0; PHQ-9, patient health questionnaire (depression part); SF-12, short form-12 (quality of life questionnaire).

measurements, scales, question sets and instruments were used for each of the eight major disease groups. Study nurses conducted the face-to-face interviews, all examinations and guided the participants during the study centre visit. They were trained and certified for each examination. Tables 1 and 2 describe the components of the interview and the examination programme in more detail.

In addition, participants provided self-reports on touch screens that included many different scales and question sets, more closely described in table 1. The topics addressed in these self-reports covered, among others, family history of several diseases, childhood experiences and aspects, healthcare utilisation patterns and quality of life. These self-reports also included questions on additional diseases and self-report scales, for example, for stress, depressive and anxiety symptoms, as shown in the Patient Health Questionnaire.[22 23]

Some examinations were done in a subset of participants only, for example, 7-day accelerometry or 24-hour 1-channel ECG since they were based on the willingness to wear a mobile device for some time at home and, therefore, outside the study centre. Other measurements were conducted in some centres only due to restrictions in the availability of technical equipment and the duration of the overall examination programme. Dedicated

Table 2 Components and detailed measurements of the physical examination programme by disease group and measurements

Examination	Measurements	
Anthropometry:	► Body weight/ height	► Body impedance (BIA)
	► Waist circumference	► Ultrasound abdominal fat
Cardiovascular system:	► Blood pressure (2×)	► Heart rate
	► 10 s ECG (12 leads)	► 3-D-Echocardiography (abbrev.)
	► Ankle Brachial Index	► Pulse wave velocity
	► 24 hours 1-channel ECG*	► Bicycle ergometry†
Diabetes-related:	► Oral glucose tolerance test	► Skin autofluorescence
Musculoskeletal system:	► Medical exam finger†	
Oral health:	► Tooth count	► Detailed oral examination†
Sensory system:	► Retinal funduscopy	► Visus measurement
	► Hearing test	► Olfactory test (Sniffin Sticks-12)
3T MRI for body region (specific sequences):	► Brain + Central Nervous System: T1w 3D MPRAGE, 2D FLAIR, DTI, SWI ► Body trunk: T1w 3D VIBE two-point DIXON, T2w HASTE, T2w HASTE, Multiecho 3D VIBE ► Cardiovascular System: Cine LAX/Cine SAX, Cardio Molli, MR angio 3D SPACE Musculoskeletal System: PD FS 3D SPACE, T2w 2D fast spin-echo	
Biosamples:	► Serum/plasma	► Urine
Lung function:	► Spirometry	► Nitric oxide measurement
Cognitive function:	► Semantic/ episodic memory	► Executive function
(Six tests)	► Fluid intelligence	► Perdue-Peg-board
Physical activity/fitness:	► Hand grip strength	► 7-day actigraphy*

*Optionally only.
†Only in some study centres.
BIA, body impedance measurement.

MRI was available in 5 of the 18 study centres, and identical scanners and sequences were implemented only for NAKO. Ex-players were invited to primarily come to these study centres, depending on the distance to their place of living and potential contraindications for the 'whole body' MRI that included the body sections from the head to the hips.

The only difference in the examination programme between SoccHealth and regular NAKO participants was a football-specific questionnaire. It assessed career details, such as the number of seasons played in youth, adult age and after the career, and the different league levels. In addition, the latter career details were also collected from three official and publicly available data sources (www.kicker.de and www.transfermarkt.de for men and www.dfb.de for women), allowing a more detailed quantification of number of games and minutes played per season in most instances. For the description, we report medians and means (SD) for continuous variables and absolute and relative frequencies for categorical variables.

RESULTS

In the computer-assisted face-to-face medical interview (table 1), the lifetime histories of eight different disorder groups with varying numbers of disease entities per group were assessed. In the cardiovascular disorder group, for example, histories of myocardial infarction, heart failure and cardiac arrhythmia were assessed, whereas in the group of neurological disorders, stroke, migraine, Parkinson's disease and epilepsy were covered. In case of a positive disease report by a participant, additional questions on treatment during the last 12 months and the time (year or age) of diagnosis of the specific disorder were asked. Current medication taken during the last 7 days was also assessed in the interview and directly coded into the 'Anatomical Therapeutic Chemical' classification provided by the WHO Collaborating Centre for Drug Statistics Methodology (https://atcddd.fhi.no/).

All examinations are listed in table 2 by relevant disorder groups. This workup allows the detection of subclinical changes in various systems, such as the vascular system, below the threshold of a clinical diagnosis. The assessments of, for example, pulse wave velocity or spirometry, provided endpoints in a continuous format that can be analysed as a continuous variable or based on different thresholds. The applied neuropsychological test battery included different tests to address the domains of memory and executive functions and tests for fine motor movements, attention and numerical reasoning. Other examinations, especially in anthropometry, provided

Table 3 Sociodemographic and lifestyle characteristics of SoccHealth participants, according to sex

	Men N=296	Women N=52
Age, mean (SD), years	54.5 (8.0)	46.9 (7.6)
Age group 60+ years, N (%)	76 (25.7)	5 (12.8)
Education:		
ISCED-97 level high, %	34.0	40.4
ISCED-97 education-years, median	13.0	15.0
Full-/part-time current work, %	79.3	92.3
Subjective general health status*		
Excellent/very good, %	33.8	55.8
Fair/poor, %	11.6	5.8
Measured current weight, kg median	87.1	65.7
Self-reported weight history†		
At age 18 years (N=286), kg median	73.0	58.0
At age 30 years (N=307), kg median	78.5	62.0
At age 50 years (N=204), kg median	85.0	65.0
Smoking status		
Current smoker, %	12.9	11.5
Ex-smoker, %	20.1	28.9
Self-reported alcohol consumption		
Former/never alcohol consumers, %	6.5	9.6
Gram alcohol/day‡ in current consumers, median	8.0	4.5
Positive self-report for any tattoo, %	19.9	40.7

*Question 1 of the SF-12 German version.
†Missing data excluded.
‡Based on a detailed assessment of beverage type and amount (glass number and size) for the last 7 days.
ISCED-97, international standard classification of education 1997; SF-12, short form-12 quality of life questionnaire.

Table 4 Career-related characteristics of SoccHealth participants, according to sex

	Men N=296	Women N=52
Age at first organised training+play, median years	6.0	7.0
Highest German leagues played:		
Only in first League (Bundesliga 1), %	13.1	65.4
Only in second League (Bundesliga 2), %	23.1	0.0
League 1+2 (Bundesliga 1+2), %	63.7	25.0
Number of seasons played in first Bundesliga		
Self-report, median (mean)	3.0 (4.9)	8.5 (9.1)
According to an internet source, median (mean)	4.0 (5.6)	10.0 (9.8)
Number of seasons played in second Bundesliga Self-report, median (mean)	3.0 (3.6)	0.0 (0.8)
According to an internet source, median (mean)	3.0 (3.5)	3.0 (2.4)
Main game position:		
Goalkeeper, %	8.8	21.2
Defence, %	40.1	23.1
Midfield, %	33,7	36.5
Forward, %	17.4	19.2
Percentage with an injury-related break of >28 days during adult (18–39 years) career, %	92.4	82.7
Additional play in amateur football after the end of professional soccer play, %	53.1	38.0
Time in years played as an amateur after end of professional soccer play, median (years)	5.0	5.5
Time in years since the end of professional soccer play, median	21.2	13.5

parameters important for different disease and risk factor profiles and for scaling variables dependent on body dimensions. An example is the body impedance measurement, which calculates the distribution of body fat, body water and body muscle mass. The MRI examination was done in 65% of the SoccHealth participants (66% in men and 62% in women). 35% were examined in a study centre without MRI or had known contraindications assessed in detail before the appointment. The MRI included 2–4 specific sequences (table 2) for each included body section or system, respectively.

Table 3 shows the sociodemographic and lifestyle characteristics of the SoccHealth participants. On average, the 52 female ex-professionals among the 348 players were 7.5 years younger than the men. More than three-quarters of male players and more than 90% of female players reported that they are currently working. A higher proportion of women perceived their health status as excellent or very good, and a lower proportion as poor compared with men. Based on the self-reported weight history, men had an average weight increase of 12 kg between 18 and 50 years compared with 7 kg among women. Interestingly, a higher proportion of women reported a current or former smoking history and having one or more tattoos.

Table 4 summarises the professional career details of the players. About two-thirds of male professionals had played in Germany's first and second highest leagues (Bundesliga). However, the same proportion of female players had played only in the highest first female Bundesliga. This is most likely because professional soccer leagues for women in Germany were established no earlier than 1990. In that year, the women's Bundesliga started with two sections. In 1997, they were merged into a single-track league. A second Bundesliga for female professional football only started in 2004. Men had played a median of 3 years in Bundesliga 1 and 3 years in Bundesliga 2. Female ex-professionals had a higher median number of seasons in the first (8.5) but a lower number in the second Bundesliga, most likely due to the different time points of league establishment. Interestingly, the average number of years played in the different leagues was very similar when assessed by self-report questionnaires during the study centre visit versus the assessment from open-access internet resources. The most frequent game position among male ex-professional players was defender, followed by midfield, while it was the other way around among women. The proportion of injury-related breaks (time loss) of more than 1 month during their career was expectedly very high and similar among both groups. Men ended their professional careers on average at 33 years, while it was 34 years for women. 53% of men continued playing amateur football for an average of 5.0 years, while 38% of women did so for a median of 5.5 years. Interestingly, for both men and women, the total time spent in active football summed up to an average of 32 years in training and playing in amateur and professional leagues, based on their average football start and stop ages.

DISCUSSION

The problem of potential adverse effects of professional collision sports, including football, has received considerable attention in recent years. The question of risks for brain health and the potential to develop dementia have been central to these discussions. The long-term consequences with respect to other health outcomes, including metabolic and cardiovascular diseases or cancer, are less well studied. However, the controversial debate overshines the more general question of the benefits and adverse effects of different types of professional sports on later health outcomes. In the case of football, the question is about the risks and benefits of long-term professional training and match play for the onset of different disorders and body functions in midlife and higher ages.

The established and highly standardised setting of one of the few so-called mega-cohorts worldwide, that is, longitudinal studies with more than one hundred thousand participants, offered a unique opportunity to study these risks and benefits among ex-professional soccer players. Given the comprehensive NAKO examination programme that allows detailed phenotyping of different functions, diseases, risk factors and subclinical outcomes, potential risks and benefits can be meticulously analysed in this special group. In addition, the German National Cohort offers the possibility of drawing comparison groups from many individuals who have received the same examinations. These comparison groups can be targeted, for example, based on different levels of physical activity, enabling contrasts between the extreme sports group and others relevant to the research question of interest. The availability of blood samples and whole-body MRI scans allows for future analyses of biomarkers and imaging markers, which help to understand the development of diseases or (patho)physiological changes in the body due to long-term professional football exposure. Preliminary career details indicate that the total football exposure of the SoccHealth participants was high and not considerably different between men and women. The higher number of male players reflects the reality of professional football during their main exposure. The sex-related differences in age, smoking status and alcohol consumption must be taken into account when interpreting disease-related information. The next step involves the construction of a detailed exposure index to explain health-related phenomena by the number of individual ways of football play and training.

In summary, SoccHealth provides a comprehensive study framework to shed new light on the football-related balance between health benefits and risks associated with a decades-long football career.

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Competing interests Senior author TM is chairman of the DFB's and the European Football Confederation's (UEFA's) medical committee as well as DFL's working group 'Medicine in Professional Football'. All other authors have nothing to declare.

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Patient consent for publication Not applicable.

Ethics approval This study involves human participants and the 18 ethics committees of the 18 NAKO study centres across Germany approved the study using their own reference number (eg, study centre Münster #2013-134-b-S). Participants gave informed consent to participate in the study before taking part.

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Data availability statement Data are available on reasonable request. Access to the SoccHealth data will be available on reasonable request. Access and use of NAKO data can be obtained via an electronic application portal (https://transfer.nako.de) that provides details about the application process.

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