

Science and Football VIII

The Proceedings of the Eighth World
Congress on Science and Football

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First published 2017

ISBN: 978-1-138-94706-1 (hbk)

ISBN: 978-1-315-67030-0 (ebk)

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Prevention and treatment of
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Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2017
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

and by Routledge
711 Third Avenue, New York, NY 10017

Routledge is an imprint of the Taylor & Francis Group, an informa business

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British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data
Names: World Congress of Science and Football (8th : 2015 : Copenhagen, Denmark) | Bangsbo, J. (Jens), editor.

Title: Science and football VIII : [proceedings] / edited by Jens Bangsbo, Peter Krstrup, Peter Riis Hansen, Laila Ottesen, Gertrud Pfister, Anne-Marie Elb.

Other titles: Science and football 8 | Science and football eight

Description: Abingdon, Oxon ; New York, NY : Routledge, 2016. | Papers originally presented at the 8th World Congress on Science and Football held May 20–23, 2015, in Copenhagen, Denmark. | Includes bibliographical references.

Identifiers: LCCN 2016015217 | ISBN 9781138947061 (hardback) | ISBN 9781315670300 (e-book)

Subjects: LCSH: Football—Congresses. | Soccer—Congresses. | Rugby football—Congresses. | Football—Physiological aspects—Congresses. | Soccer—Physiological aspects—Congresses. | Rugby football—Physiological aspects—Congresses.

Classification: LCC GV940 .W674 2015 | DDC 796.334—dc23
LC record available at <https://lcn.loc.gov/2016015217>

ISBN: 978-1-138-94706-1 (hbk)

ISBN: 978-1-315-67030-0 (ebk)

Typeset in Times New Roman
by Apex CoVantage, LLC

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Introduction

It is now well established that physical activity is a cornerstone in the non-pharmacological prevention and treatment of lifestyle diseases (Pedersen and Saltin, 2006), and there is increasing evidence that sports participation has the potential to improve the health of nations (Khan et al., 2012). A very recent systematic review by Oja and colleagues investigating the available evidence on the health benefits of different sport disciplines for adults concluded that the “best evidence was found for soccer and running. These can especially improve cardiovascular and metabolic health” (Oja et al., 2015). This conclusion was based on more than 80 scientific articles published since 2009 describing the physiological demands of small-sided soccer training along with the fitness and health benefits of regular low-volume Soccer Fitness (football fitness) training for untrained individuals across the lifespan (Krstrup et al., 2009, 2010a, 2013, 2014; Bangsbo et al., 2015). The present chapter will provide an overview of the existing literature and a description of the relationship between the training elements of Soccer Fitness, the training-induced effects of Soccer Fitness on cardiovascular, metabolic and musculoskeletal fitness, and the potential of Soccer Fitness for the prevention and treatment of lifestyle diseases (see Figure 6.1).

Soccer fitness – cardiovascular demands and training effects

The average heart rate during Soccer Fitness training sessions lasting 45–60 min has been shown to be 80–90 percent of individual maximal heart rate (HR_{max}) in untrained women and men (Krstrup et al., 2009; Randers et al., 2010b; Bangsbo et al., 2015), which is actually similar to values obtained for elite soccer players during match play (Andersson et al., 2010). Such high average heart rates are elicited during Soccer Fitness irrespective of age, social status or skill level, with no influence of the number of players as long as the pitch size is adjusted (1v1 to 7v7 with ~80 m² per player) (Randers et al., 2012, 2014). It has also been observed that the heart rate fluctuates up and down between 70 and 100 percent HR_{max} during Soccer Fitness training, with 10–50 percent of the time in the highest HR zone above 90 percent HR_{max} both for untrained healthy women and men

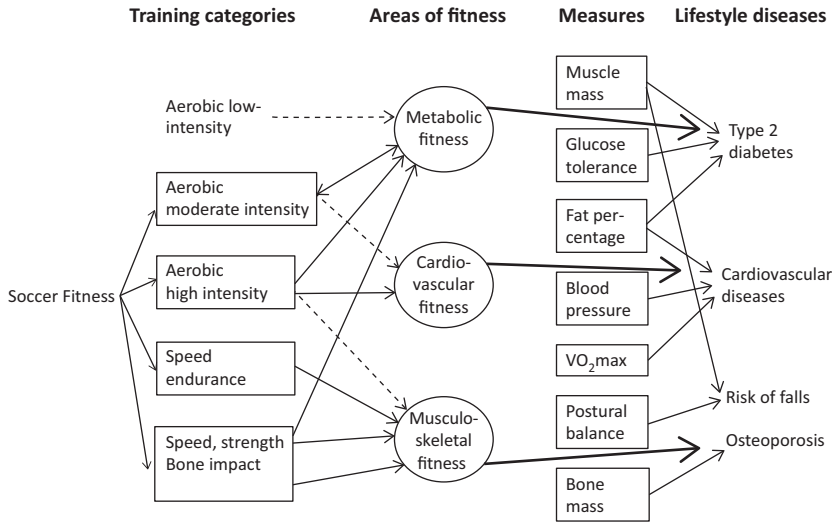


Figure 6.1 Holistic model describing that Soccer Fitness is a form of training that combines aerobic moderate and high intensity aerobic training with elements of speed endurance, speed, strength and bone impact training, and it is therefore an effective form of training for improving cardiovascular fitness, metabolic fitness and musculoskeletal fitness. These broad-spectrum favorable fitness effects make Soccer Fitness a powerful tool for broad-spectrum prevention and treatment of lifestyle diseases

Source: modified from Krustrup et al. (2010).

aged 18–80 (Krustrup et al., 2009; Randers et al., 2010b, 2014; De Sousa et al., 2014; Andersen et al., 2014a) and also for patient groups with hypertension, type 2 diabetes mellitus and prostate cancer (Krustrup et al., 2013; Andersen et al., 2014b; Uth et al., 2014). These observations make it clear that Soccer Fitness is a combination of endurance training and high-intensity interval training (HIIT) for basically everyone who takes to the soccer pitch (see Figure 6.1).

It is well established that HIIT training is an effective training type for elevating maximal oxygen uptake and improve cardiovascular function (Helgerud et al. 2007; Aspenes et al., 2011), and multiple randomized controlled trials (RCTs) have shown that this is also the case for Soccer Fitness. A recent systematic review and meta-analysis concluded that the average increase in VO_{2max} after a short-term Soccer Fitness training intervention was 3.51 ml/min/kg, with three- to four-month effects ranging from 5 to 20 percent, and that there were greater effects from Soccer Fitness than from interventions involving jogging or strength training (Milanović et al., 2015a, 2015b). In accordance with this finding, an RCT with 68 weeks of Soccer Fitness and jogging training revealed considerable cardiac adaptations after 16 and 68 weeks of training with greater effects from Soccer

Fitness than from continuous moderate-intensity training (Krustrup et al., 2010b). Interestingly, Soccer Fitness has also been shown to result in large and systematic reductions of blood pressure in hypertensive men and women that compare favorably with effects of beta-blockers and other commonly used antihypertensive medications (Hayashino et al., 2012). Thus, 12–16 weeks of Soccer Fitness training sessions of 2x1 hour/week lowered systolic and diastolic blood pressure by 12/8, 8/8 and 11/9 mmHg in three training studies with hypertensive and type 2 diabetic men (Knoepfli-Lenzin et al., 2010; Krustrup et al., 2013; Schmidt et al., 2013), while 15 weeks of Soccer Fitness training sessions of 3x1 hour/week resulted in a 12/6 mmHg drop in blood pressure in hypertensive women (Mohr et al., 2014).

Soccer fitness – metabolic demands and training effects

The metabolic demands and energy utilization are very high during Soccer Fitness, with a constantly high aerobic energy turnover amounting to an average of 70 percent VO_{2max} and periods with high anaerobic energy turnover (Castagna et al., 2007; Krustrup et al., 2009; Randers et al., 2010b). Actually, it has been estimated that the average energy turnover is 750 and 600 kcal per hour of training for untrained men and women, respectively (Krustrup et al., 2009, 2010b, 2010c). It is characteristic that all the metabolic energy systems are used during Soccer Fitness for participant groups across the lifespan, including carbohydrate and fat oxidation as well as lactate production and creatine phosphate utilization (Krustrup et al., 2010c; Randers et al., 2010b; Andersen et al., 2014a). It is also evident that most muscle groups are active during Soccer Fitness due to the very diverse movement pattern (see section below) and that all striated muscle fiber types are recruited during Soccer Fitness as well as during elite soccer, as revealed by high glycogen utilization in red slow-twitch fibers (Type I) and white fast-twitch fibers (Type IIa and IIx) (Krustrup et al., 2010c; Mujika et al., 2013).

Soccer fitness's combination of HIIT and endurance training, along with utilization of all energy systems and fiber types, has been shown to have marked and broad-spectrum effects on metabolic fitness (see Figure 6.1). Many training studies have shown that Soccer Fitness results in positive changes in body composition in healthy untrained men and women, with 1–3 kg less fat and 1–2.5 kg more muscle mass after just 12–16 weeks of training (Krustrup et al., 2009; Randers et al., 2012; Connolly et al. 2014). Similar reductions in fat mass have been observed in middle-aged men with T2DM (Andersen et al., 2014b) and women with hypertension (Mohr et al., 2014), and the fat loss was as high as 3.4 kg for 48–68-year-old Brazilian women and men with type 2 diabetes when using a 12-week intervention combining Soccer Fitness and a calorie-restricted diet (De Sousa et al., 2014). In several studies, but not all, short-term Soccer Fitness training has also resulted in positive alterations in blood lipid profile exemplified by 0.2–0.5 mM reductions in LDL cholesterol values in untrained young men, homeless men, hypertensive women and type 2 diabetics along with 0.2–0.4 mM reductions in triglycerides in the two latter studies (Krustrup et al., 2009; Randers et al., 2012; Mohr et al.,

2014; De Sousa et al., 2014). It has also been evidenced that Soccer Fitness training over 12–24 weeks for healthy untrained as well as patient groups results in a 7–24 percent increase in the number of capillaries around the type I and type 2 fibers (Krustrup et al., 2009, 2010b; Andersen et al., 2014b), a 10–14 percent increase in oxidative enzyme activity (Krustrup et al., 2010b) and improved fat oxidation during everyday activities (Krustrup et al., 2009). Furthermore, there is clear evidence that a combination of Soccer Fitness and diet manipulation can result in marked benefits in glucose tolerance after only 12 weeks (De Sousa et al., 2014, 2016) and also preliminary results indicate lower resting blood glucose levels in middle-aged men with type 2 diabetes after 24 weeks of Soccer Fitness (Andersen et al., 2014b), but further studies are required to elucidate the effects of Soccer Fitness per se (unaltered diet) on glucose tolerance and insulin sensitivity.

Soccer fitness – musculoskeletal demands and training effects

Movement analyses by GPS tracking and video recordings have clearly show that Soccer Fitness constitutes intense, versatile interval training with multiple repetitions of orthodox and unorthodox movements, altogether providing a high and multifaceted stimulus to muscles and bones (Krustrup et al., 2010a, 2010b; Randers et al., 2010a, 2010b; Helge et al., 2014a, 2014b; Krustrup and Bangsbo, 2015) (see Figure 6.1). A one-hour Soccer Fitness 7v7 session for untrained men involved 886 locomotor activities at various speeds, of which 98 were high-intensity runs, 16 were sprints and 59 were backwards and sideways runs (Krustrup et al., 2010b), with corresponding values for untrained women with no prior soccer experience of 954, 101, 15 and 46, respectively (Randers et al., 2010b). Additionally, it has been observed that Soccer Fitness involves multiple so-called specific intense actions, totaling an average of 192 for the untrained women during a 1-h 7v7 session, with 66 turns, 28 stops, 40 shots and passes, 17 dribbles, 21 shoulder contacts and 17 foot tackles (Pedersen et al., 2009). Interestingly, the same movement pattern was seen for 1-h Soccer Fitness sessions with 2, 4, 6 and 8 untrained women and men (Randers et al., 2010b), for homeless men playing 4v4 asphalt soccer (Helge et al., 2014b) and untrained young men playing 5v5 on sand, asphalt and artificial turf (Brito et al., 2012), with the only difference that 1v1, 2v2, 3v3 and 4v4 sessions involve even more sideways/backwards running bouts and more short high-intensity runs. A recent study using GPS tracking of a 45-min Soccer Fitness session for elderly men with prostate cancer has also shown that, despite the total distance of about half that observed in young men (2.65 km), the players performed as many as 194 accelerations, 296 decelerations and 100 running bouts (Uth et al., 2015a). Altogether, these findings emphasize that it is easy to organize Soccer Fitness sessions for participants across the lifespan with high player involvement and high and multifaceted musculoskeletal demands.

A number of recent investigations have shown that Soccer Fitness provides a marked osteogenic response, as evidenced by training-induced increases in circulating levels of the bone formation marker osteocalcin in untrained young women (37 percent, 16 weeks, Jackman et al., 2013), 25–65-year-old female hospital

workers (21 percent, 12 weeks, Barene et al., 2014), hypertensive women (37 percent, 15 weeks, Mohr et al., 2015), homeless men (27 percent, 12 weeks, Helge et al., 2014a), elderly untrained men (45 percent, 16 weeks, Helge et al., 2014b) and elderly prostate cancer patients undergoing anti-androgen treatment (34 percent, 12 weeks, Uth et al., 2015a). Accordingly, Soccer Fitness interventions have caused improvements in bone mineral content (BMC) and bone mineral density (BMD) in young, middle-aged and elderly participants, with greater effects from Soccer Fitness than from swimming, continuous running and interval running (Helge et al., 2010; Krstrup et al., 2010a; Mohr et al., 2015). Thus, tibia BMD and leg BMC increased by 2–3 percent in untrained healthy women and men as well as hypertensive women after 12–16 weeks with 2–3 1-h Soccer Fitness sessions (Helge et al., 2010; Krstrup et al., 2010a; Mohr et al., 2015), and several studies have shown that BMD increases in clinically important sites such as the femoral shaft, femoral neck and hip, by 1–2 percent over 12–16 weeks in hypertensive women and elderly men (Mohr et al., 2015; Helge et al., 2014b; Uth et al., 2015a), but even more with medium-term and long-term Soccer Fitness interventions, with increases of 2–5 percent in elderly healthy men (52 weeks, Helge et al., 2014a) and elderly prostate cancer patients (32 weeks, Uth et al., 2015b). Interestingly, the study by Uth et al. (2015a) revealed a significant correlation ($r=0.65$) between the number of decelerations during training and the 12-week increase in leg BMC, supporting a link between the movement pattern and the training-induced skeletal effects (see Figure 6.1). Studies on Soccer Fitness have also shown marked effects on muscular function, including postural balance, muscle strength and functional capacity. Improvements in postural balance after 12–16 weeks of Soccer Fitness have been observed in untrained young men (Krstrup et al., 2009; Jakobsen et al., 2011), untrained young women (Krstrup et al., 2010b) and homeless men (Helge et al., 2014b), but not in elderly healthy men and elderly prostate cancer patients over 12–52-week intervention periods (Andersen et al., 2014a; Uth et al., 2015a, 2015b), which may be due to lack of sensitivity of the applied balance test, as the elderly men had several other measureable improvements in functional capacity. Thus, despite the lack of testosterone due to the antiandrogen treatment, the elderly men with prostate cancer had an increase in muscle mass of 0.7 kg and an increase in leg muscle strength of 15 percent compared to controls after 12 weeks of Soccer Fitness and 8–15 percent improvements in jump performance, sit-to-stand performance and stair climbing after 32 weeks, and the healthy elderly men had a 29 percent increase in sit-to-stand performance after 16 weeks of Soccer Fitness (Andersen et al., 2014a). To sum up, Soccer Fitness is an effective form of training for improving musculoskeletal fitness and, due to the combined favorable effects on bone mineralization, postural balance and muscle function, appears to be a relevant tool for the prevention of falls and bone fractures.

Implementation of soccer fitness

Soccer is by far the most popular sport in the world, with an estimated 400 million people playing regularly in sports clubs or on an unorganized basis, but there is a

potential for even higher global participation. Soccer Fitness is a new type of soccer that can attract new participant groups, as it focuses on soccer training among friends in small groups rather than on competition (Bennike et al., 2014). Apart from its broad-spectrum fitness and health effects, investigations of Soccer Fitness have also shown that it is considered fun, enjoyable and motivating, and that it develops social capital, networking and general well-being (Ottesen et al., 2010; Bruun et al., 2014; Nielsen et al., 2014). The focus on team-mates, opponents and on the small-sided soccer game itself has also been shown to increase flow and to lower perceived exertion during Soccer Fitness, despite the high physical demands (Elbe et al., 2010; Krustrup et al., 2010a). These elements – including flow during training, motivational factors and the development of social capital – are very important for regular participation in and long-term adherence to sport (Elbe et al., 2016).

The concept of Soccer Fitness was developed in collaboration between researchers at Copenhagen University and the Danish FA in 2007–2010 and introduced in 2011. The concept has now been implemented in as many as 250 Danish soccer clubs (~15 percent) and the vision is to reach a total of 600 clubs (35 percent) over the next five-year period. A majority of the participants are untrained women aged 30–50, but also middle-aged and elderly men and women, along with different types of teams, including patient groups with hypertension and prostate cancer and teams of unemployed men and women in job training programs (Bennike et al., 2014). In spring 2015, the Soccer Fitness concept was introduced nationwide in the small country of the Faroe Islands with great success. Indeed, as many as 1.5 percent of the population started up before the summer, including 6 percent of all Faroese women aged 30–50, with the number of female members of the Faroese FA doubling in 9 months. In 2015, the FC Prostate study was expanded into the FC Prostate Community project, where patients are recruited from six hospitals across Denmark to play soccer in soccer clubs in close proximity to the hospitals (Bruun et al., 2014), and there is also an ongoing project in the Prevention Centers in the Municipality of Copenhagen, where ball games are now used as part of a 12-week training regime offered to 40–80-year-old patients with lifestyle diseases and many of these participants are encouraged to continue physical activity by playing Soccer Fitness in local soccer clubs. Without doubt, there is great potential in this project, and it will be interesting to monitor the extent to which this concept is implemented in the Nordic countries as well as in the rest of the world.

Conclusions

Soccer fitness is a new type of soccer developed for untrained individuals across the lifespan aiming at improving fitness and health of all participants, irrespective of gender, socioeconomic status, skills and prior experience. The Soccer Fitness concept involves regular small-sided outdoor or indoor soccer training among friends, using warm-up and 3v3 to 7v7 drills and no competitive games. Soccer fitness is a form of training that combines aerobic moderate and high intensity aerobic training with elements of speed endurance, speed, strength and bone

impact training, and it is therefore an effective form of training for improving cardiovascular fitness, metabolic fitness and musculoskeletal fitness. It is now evident that these broad-spectrum fitness effects make Soccer Fitness a strong tool for the prevention and treatment of lifestyle diseases. Altogether, the available scientific publications provide evidence that Soccer Fitness is an intense, versatile, enjoyable and social all-in-one training type that combines high-intensity cardio, endurance and strength training and has great potential for preventing and treating lifestyle diseases as well as rehabilitating cancer patients undergoing anti-hormone treatment.

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