Recreational football training improved health-related physical fitness in 9- to 10-year-old boys

Jin Wang[1], Liquan Cao[2], Pengfei Xie[2], Jianxiong Wang[3]*

[1] College of Sports Science, Tianjin Normal University, China.

[2] Tianjin Physical Fitness Research Center, Department of Health and Exercise Science, Tianjin University of Sport, China.

[3] School of Health and Wellbeing, University of Southern Queensland, Australia.

***Correspondence**:

Dr Jianxiong Wang

School of Health and Wellbeing

Faculty of Health, Engineering, and Sciences,

University of Southern Queensland,

Toowoomba QLD 4350, Australia

Fax: 61-7-46311530

Telephone: 61-7-46312363

E-mail: wangj@usq.edu.au

Running title: Recreational football training in children

Abstract

Background: Recreational football is an aerobic/anaerobic intermittent sport with altering exercise periods at high or low intensity. Various football drills and body movement in this exercise may easily attract children to take part in. The purpose of this study was to test the hypothesis that recreational football training would improve the health-related physical fitness in healthy 9- to 10-year-old boys, compared to the outcome from non-exercise boys.

Methods: Forty boys were randomly allocated into the football and control groups. Body composition, predicted maximal oxygen uptake, heart rate responses during submaximal exercise, running ability, muscle strengths, and body balance and flexibility were measured before and after the experimental period. No dietary modification was suggested to the boys in this study.

Results: Following 10 weeks of recreational football training, the football group achieved significant improvements in body fat% (-2.42%), fat mass (-0.93kg), abdominal fat (-0.06kg), 50-meter run (-0.9s), long jump (+7.6cm), core muscle strengths (front bridge increased 10.9s and side bridge increased 5.6s), and body balance (single-leg standing time increased 5.2s). The heart function during submaximal exercise and predicted maximal oxygen uptake were also significantly improved in the trained boys. There were no changes in these variables of the control group. There was no sport injury occurred during the training program. The daily energy intake was not changed for all boys before and after the interventions.

Conclusion: the 10-week recreational football training is an effective method to improve the health-related physical fitness in 9- to 10-year-old boys.

Key words: Recreational football, health-related physical fitness, running ability, core muscle strength, children

Introduction

Health-related physical fitness consists of body composition, cardiovascular function, muscle function, and body flexibility.[1] In children, poor physical fitness level would lead to childhood diseases, such as obesity,[2,3] elevate blood pressure,[4] insulin resistance and type 2 diabetes,[5] and skeletal and muscular disorders.[6] Regular physical activity and exercise training are important to achieve and maintain high health-related physical fitness.[7.8] According to children's natural characteristics, successful exercise program for children should be interesting and with various physical activities. Our research group has studied children's physical fitness and found that great effort was needed when we trained children using routine exercise for adults, for example, walking and running.[9,10]

Recreational football is an aerobic/anaerobic intermittent sport with altering exercise periods at high or low intensity and has about 900 various activity changes per hour, including multiple high-intensity runs, stops, turns, and jumps.[11,12] This exercise has been reported as a health promoting activity for adults.[13] Health-related physical fitness of untrained man was improved after 12 weeks of football training.[14] However, the research of effects of recreational football training on the health-related physical fitness in children is scarce. Previous studies of football training in children are focused on body mass or the heart structure and function.[15-17] The purpose of the present study was to investigate the changes in body composition, cardiovascular function, muscle strength, and flexibility in a group of healthy boys before and after a 10-week recreational football training program. We tested the hypothesis that the exercise training would improve important variables of health-related physical fitness of 9- to 10-year-old boys, compared to the outcome from non-exercise boys.

Methods

Subjects

Forty boys were recruited from a primary school in Tianjin city. The inclusion criteria were 9-10 years old, healthy, not overweight or obesity (BMI < the 85th age-specific percentile),[18] and not engaged in regular exercise training. The boys with heart diseases, pulmonary diseases, and any physical limitations to exercise were excluded. The exact details of the study were described to the boys and their parents before the baseline test, while a written informed consent to the study was signed by the parent of each boy. This study was approved by the Ethics Committee of Tianjin University of Sport, China.

Study design

Before the baseline data were collected, a third-party randomly assigned the enrolled subjects into a list. The boys with an odd number was allocated into the football training group; the boys with an even number into the control group, n=20 in each group. The baseline tests included body composition, predicted maximal oxygen uptake (VO_2max), cardiovascular fitness, and functional capacity. The football group participated in 10 weeks of recreational football training, three sessions per week, and one hour for each session. The control group was requested to maintain their normal physical activity habit during the experimental period. All tests at the baseline were repeated at the end of the experiments. The post-tests for the trained subjects were separated by 48 hours from the last training session. Under full supervision, all exercise tests were carried out in the Exercise Physiology Laboratory at Tianjin University of Sport, while all training sessions were run in the sports ground of the school. No dietary modification was suggested to the subjects in this study.

Body composition

Each subject's body mass and height were measured to calculate body mass index (BMI) through dividing body mass (kg) by height in meters squared (m^2). After an overnight fast, the total body composition was measured using a dual-energy X-ray absorptiometry (DXA) (Prodigy Advance, GE Healthcare Lunar, Madison, WI, USA). By means of the standard soft tissue analysis provided by that company, the non-bone fat-free soft tissue, fat tissue, and abdominal fat mass were measured. The body fat (%) was determined as a portion of the total amount of fat in the entire body mass. Fat mass and fat-free mass (FFM) were also calculated.

Cardiovascular fitness

The VO_2max of each boy was estimated from the performance of 20-meter shuttle run test.[19] The heart rate response to a certain exercise workload, 30 squats in 30 seconds, was used as the cardiovascular fitness index.[9] Briefly, the subject rested for 10 minutes before the resting HR was measured. The squats exercise test was conducted followed the sound rhythm of one beep per second. HRs at the end of exercise and one minute after exercise were recorded. The cardiovascular fitness index was calculated as (resting HR + end exercise HR + recovery HR at one minute - 200) ÷ 10. HR was monitored using a PE-4000 HR monitor (Polar Electro, Kempele, Finland) in this test.

Functional capacity tests

After 10 minutes of warm-up (whole body movement and stretches), 50-meter run, standing long jump, hand grip, 1-minute sit up, sit-and-reach, and single-leg standing (close eyes) were measured by the researchers. Each test was repeated twice and the better result was used in the data analyses. Two exercises, front bridge and side bridge, were used to assess core muscle function.[20] After an introduction of the correct body positions, subjects were timed whilst holding front bridge and side bridge positions and these times were used as an indicator of core muscle function.

Exercise training program

The football group undertook 10 weeks of recreational football training, three sessions per week, and one hour per session. There were 30 training sessions in total for each trained boy. All of these training sessions were supervised by the researchers. There was no change in exercise duration of each training session during the 10-week training period, however, exercise intensity and workload were increased gradually as the boys improved their football skills and physical fitness, for example, they could move at faster speeds and cover longer distance in the 3-minute dribbling activity as their skill improved.

A training session consisted of

1) 10 minutes of warm-up period, which included walking and jogging, as well as muscle stretches.
2) 30 minutes of football activity. In detail, there were 10 minutes of dribbling (10-meter equilateral triangle, a flag was set on each of the three corners, the boy dribbled a ball around the flags for 3 minutes x 3 times, and took about 1 minute of rest in between); 10 minutes of dribbling and shooting (3 flags were put in line with 1 meter apart, the boy dribbled a ball, passed the flags, shot to the goal at 5 meters away, then dribbled the ball back to the start point. Continued for 3 minutes x 3 times and took about 1 minute of rest in between); and 10 minutes of passing activity (two boys stood five meters apart, passed a ball continually for 3 minutes x 3 times, and took about 1 minute of rest in between).
3) 10 minutes of running activity, the boys dashed 150-meter shuttle run x 2 times (placed 2 flags 25 meters apart, performed 3 go and back repetitions for a total of 150 meters and took about 2 minute of rest in between). They also run a 300-meter shuttle (six flags were placed in line with 10 meters apart, the boy run 10 meters and back to start, run 20 meters and back, 30 meters back, 40 meters back, and 50 meters back, totally run 300 meters).

4) 10 minutes of cool-down period by walking slowly and stretching the muscles.

Dietary records

There was no diet control introduced during the experimental period for all boys. The parents were asked to record a five-weekday dietary diary for their sons at the beginning and the end of the experimental period. The weight of food and the percentages of carbohydrate, fat, and protein in the food were estimated from the records. Daily energy intake was then calculated by multiplying the weight of carbohydrate, fat, and protein consumed with their energy values (carbohydrate provides 16.74kJ/g of energy, fat 37.66kJ/g, and protein 16.74kJ/g). Following removal of the highest and the lowest data, the average of other three days was reported as the daily energy intake.

Data analyses

All the values were presented as means ± SD. Effects of exercise training on the measured variables were detected using 2 times (before and after experiment) × 2 groups (exercise and control) factorial design, split-plot ANOVA (SPANOVA). The effect size (ES) of measured variables following exercise training was calculated.[21] A $p < 0.05$ was regarded to be statistically significant. All analyses were performed using the IBM SPSS Statistics for Windows, version 21.0.

Results

Eighteen boys of the football group completed the training program (attendance > 95%); two boys dropped out because they took part in other after-school activities. All boys of the control group completed the program. Therefore, by the end of the experiment, there were 18 boys in the football groups, while 20 boys were in the control groups. There was no significant difference in measured variables between the groups at baseline. There was no physical injury caused by the recreational football training in this study. The dietary records did not show any changes in daily energy intake, as well as daily macronutrient intake before and after the experimental period for all boys. They had an average energy intake of 8410 ± 176 kJ/day at baseline and 8460 ± 188 kJ/day at the end of study ($p>0.05$). The daily macronutrient intakes were 33% carbohydrate, 39% fat, and 28% protein. These percentages were not changed before and after the experiment.

The football training program decreased body fat% (ES = 0.67), fat mass (ES = 0.54), and abdominal fat (ES = 0.55) of the trained boys ($p<0.05$), but there was no change in these variables in the control boys. Body mass, BMI, and fat-free mass were not changed after 10 weeks of experiments in both exercise and control groups (Table 1).

Recreational football training improved the performances of 50-meter run ($p<0.05$, ES = 1.35), standing long jump ($p<0.05$, ES = 0.32), and 1-min sit-up ($p<0.01$, ES = 0.56). Core muscle function, measured by the front and side bridges, was improved significantly ($p<0.01$, ES = 1.29 and $p<0.05$, ES = 1.04). The trained boys improved their body balance in the single-leg-standing test ($p<0.05$, ES = 0.48). There were no changes in hand grip and sit-and-reach test following football training. Predicted VO_2max of the football group obtained a significant increase ($p<0.05$, ES = 0.84). Recreational football training also decreased heart rate index ($p<0.01$, ES = 1.56), which meant an improved heart function of the trained group. No changes were found in the measured variables in the control group (Table 2).

Discussion

The main finding of this study was that 10 weeks of recreational football training improved body composition, predicted VO_2max, cardiovascular fitness, skeletal muscle function, and body balance of the trained boys. Daily energy intake and the percentages of energy contribution from the macronutrients for all subjects were not changed before and after the experimental period. These results support our hypothesis that recreational football training is effective in improving health-related physical fitness of 9-10 years old healthy boys.

In the present study, 10 weeks of recreational football training did not change body mass and BMI, but decreased body fat%, fat mass, and abdominal fat mass of trained boys. The moderate effect size of 0.54-0.67 indicate that the recreational football is an effective training program on improving body composition in children. Decreased body fat suggested that the football training is an effective physical activity to prevent childhood obesity; while the decreased abdominal fat may have more beneficial effects for the boys, as this part of body fat has been reported more active to lead to the development of metabolic diseases in children.[22,23] A cross-sectional study of young footballers and controls supported our result of decreased body fat in trained boys,[17] in which 9-year-old children with normal body mass had a significantly lower body fat% after one year football training, compared with that of the control children. The non-changed body mass and BMI in our study agreed to another study in 9-10-year-old healthy children,[24] as well as the similar aged overweight children.[16,25,26] However, all of these studies did not measure the change in body composition. This result highlighted the importance of measuring body composition, but not just body mass and BMI in children's exercise training study.

We found that the predicted VO_2max was increased significantly after the football training with a large ES of 0.84. A study of 10-year-old overweight children reported that six months of football training did not change VO_2max, compared to that of the control group.[25] Small group size would be one the reasons for that unchanged VO_2max. A system review in general population reported that recreational football training produces large improvement in VO_2max, compared to strength training or non-exercise control.[27] In addition to the improved VO_2max, in our study, a fixed workload of exercise test, 30 squats in 30 seconds, was run to evaluate heart function responded to exercise. The trained boys significantly decreased their heart rate index following 10 weeks of the training (ES =1.56). This result suggested that their heart function was improved and could handle the submaximal workload more effectively. Therefore, the current training program has beneficial effects on cardiovascular function of children. The evidences of football training improved heart structure and function in children's have also been presented in the previous studies,[16,24] which agreed with the results of our study.

Football training includes running, turning, dribbling, passing, and shooting, these physical activities mostly utilise skeletal muscles from lower limbs and trunk. As expected, we found significantly improved performance in 50-meter running, standing long jump, and 1-min sit-and-up test. We also found the improved core muscle strength, measured by front and side bridges time. Core muscle strength is important for children to learn new motor skills and keep body balance.[28] This improved core muscle function would be one reasons of improved body balance, tested by the single-led standing time. Hand grip force was not changed in our study. It can be explained as little upper limbs activities were done during the football training.

There are limitations in this study. More accurate data would be obtained if advanced equipment were used. For example, measure VO_2max directly using a gas analyzer but not predict from a shuttle run test; measure leg muscle strength by keen extension on an isokinetic dynamometer. As our subjects were boys without football training experience before, we did not introduce small-sided game into the program of this study. Small-sided football game would make the program more attractive if the boys could control and play ball much skillful. Longer duration of football training would achieve much better results in the measured variables. Only boys were recruited in this study. The effects of recreational football training on girl's physical fitness should be studied in the future.

In conclusion, the 10-week recreational football training achieved improvements in body composition, cardiorespiratory fitness, muscle function, and body balance in this group of subjects. This result indicates that the recreational football training is an effective exercise program for improving health-related physical fitness in 9-10 years old healthy boys.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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