Cardiorespiratory Responses to Recreational Small-Sided Walking Soccer in Community-Dwelling Middle-aged to Older Adults with Mild Metabolic Disorders

Makoto Ayabe*, Yoshiki Okita*, Yuya Higashino*, Kazuhiro Morimura, Hideaki Kumahara*** and Satoshi Ishizaki******

*Faculty of Computer Science and Systems Engineering, Okayama Prefectural University
111 Kuboki, Soja, Okayama 719-1197 Japan
ayabe@ss.oka-pu.ac.jp
**Faculty of Education, Shujitsu University
***Faculty of Nutritional Sciences, Nakamura Gakuen University
****Faculty of Engineering, Shibaura Institute of Technology
[Received January 27, 2020; Accepted April 23, 2020]

The current investigation aimed to examine the cardiorespiratory responses to recreational walking soccer (WS) in middle-aged to older adults with mild metabolic disorders. Twenty volunteers (aged 54-73 yr) played recreational WS that consists of five field players without a goalkeeper in one team, with movement limited to walking for 10 minutes of total playing time in an indoor standardized basketball court. The heart rate (HR) was 127 ± 20 beats/min (bpm; 82 ± 14% of the age-predicted maximum HR) in the 10-min game of WS, and it was significantly associated with the number of plays with a ball after adjusting for age ($p < 0.05$). The estimated metabolic cost was 8.0 ± 1.6 metabolic equivalents, showing a significant correlation with the maximal oxygen uptake, number of plays with a ball, and stepping rate ($p < 0.05$). These results indicated that the cardiorespiratory responses to a 10-min, 5 vs. 5 recreational WS would probably be above the desirable levels of the exercise prescribed in middle to old-aged adults with mild metabolic disorders. However, the chronic adaptability and health benefits of the recreational WS remain unclear.

Keywords: walking football, FIFA 11 for health, fitness, aerobic capacity, acceleration

[Football Science Vol.17, 11-15, 2020]

1. Introduction

An active lifestyle elicits numerous health benefits, and previous studies have demonstrated that physically active lifestyles are associated with lower risk of obesity, hypertensions, and diabetes (Miyachi et al., 2015; Piercy et al., 2018). Although exercise-based prevention programs have been recommended, an inactive lifestyle is still an important issue in public health. The Federation International Football Association plays a very active role in the implementation and promotion of football for health (Krustrup and Bangsbo, 2015). It is proved that football can induce desirable physical responses and physiological adaptations, because the basic physiological demand of soccer is not different from the exercise recommended for health benefits (Bangsbo, 1994; Piercy et al., 2018). Current evidence has linked recreational football training with favorable effects on the prevention and treatment of diseases, as well as on the resting blood pressure, resting heart rate (HR), and maximal oxygen uptake in adult men (Bangsbo et al., 2015).

However, there are several concerns related to recreational soccer being used as exercise therapy in individuals with chronic diseases. Based on the principle of exercise prescription, the exercise intensity has an important role in the safety and effectiveness of the exercise (Tanaka and Shindo, 1992). In recreational soccer, the average HR is around 80% of the maximal heart rate (HRmax) during training, with substantial time spent at 80-90% and >90% HRmax during a 1 h training session, irrespective of age, fitness status, and previous experience of football training (Bangsbo et al., 2015). The 50% of maximal oxygen uptake is a validated intensity in most individuals, including those with a chronic disease (Tanaka and Shindo, 1992), and moderate to vigorous intensity exercise has been widely recommended in the current guidelines (Miyachi et al., 2015; Piercy et al., 2018). Therefore, it is speculated that recreational soccer at lighter intensity could obtain health benefits, as well as improve the safety and practicality.

Walking football is a type of recreational soccer, where the movement is limited to walking. Additionally, the floating ball and physical contact are also restricted (Arnold et al., 2015). Thus, these features of walking football provide mild intensity exercise for individuals, and it would be enjoyable, moderately demanding, and a sustainable form of exercise in older adults (Reddy et al., 2017). A pilot study demonstrated that the 12-week walking football could reduce fat mass (Arnold et al., 2015). Although these studies have demonstrated the potentials of walking football in the field of health promotions, there are several limitations including the lack of controlled studies, health impact, and physiological intensity among the older adults with chronic diseases. Therefore, the primary purpose of this investigation was to examine the cardiorespiratory responses to recreational walking soccer (WS) in middle to old-aged adults having mild metabolic disorders. This study uses the term “walking soccer” instead of “walking football,” because the Japanese population would be more familiar with the term “soccer.” Additionally, the term “soccer” would be better in scientific use, because it expresses the actual elements of the exercise, whereas the term “football” may refer to the historical elements. Secondly, the contributor to the physiological stress was analyzed.

2. Methods

2.1 Participants

This study included middle to old-aged individuals recruited from the exercise-based health-up class (n = 20) (Okayama Prefectural University Medical Fitness Class). Briefly, the program targeted to improve the metabolic disorders in middle to old-aged adults. All participants completed the medical examination and agreed to participate in the standard exercise before starting the program. Additionally, they participated in the weekly program for ≥3 months during the present investigation. The mean characteristics of the included participants were age, 65.4 ± 5.3 years; height, 156.3 ± 5.7 cm; body weight, 56.6 ± 9.2 kg; and body mass index, 23.1 ± 2.7 kg/m^2. Among these participants, 15 females, 13 elderly (>65 yr of age), 5 obese individuals (above 25 kg/m^2 of body mass index), 2 diabetes mellitus patients (undergoing treatment for diabetes), 9 hypertension patients (above 85 mmHg of diastolic blood pressure and/or above 130 mmHg of systolic blood pressure), 8 hyperlipidemia patients (above 150 mg/dl of triglyceride and/or above 40 mg/dl of high-density lipoprotein cholesterol) were included in the study. All procedures were performed according to the ethical standards of sports and exercise science research (Harriss and Atkinson, 2015). The study protocol was approved by the Ethical Committee, and all participants signed an informed consent statement after the experiment was explained to them.

2.2 Walking soccer

After the standardized warm-up and walking, all participants played WS for two sets of 5-min, with resting period (running time) in between. The participants were instructed thoroughly about the rules of WS, and the exercise intensity was controlled by the players themselves. Since all participants were playing WS for the first time, they were made to play it a few times before the measurement day to be familiarized with it. The WS was conducted in an indoor basketball court. As per the desirable court size (Reddy et al., 2017), this investigation used a basketball court (28 ×15 m dimensions) for generalization and diffusion. In Japan, basketball has been one of the major sports in the physical education in primary and/or the junior high schools, and all general gymnasiums have a basketball court. The goal used was a recreational soccer goal (180 cm width and 120 cm height). Furthermore, it is expected that the number of unused gyms will increase in the future due to the decrease in the number of children. WS includes five field-players. The players were randomly assigned, and then changed after the first 5 min. The officially recognized futsal ball was used. The participants were prohibited from running and jogging, and movement was limited to walking only, and the physical contact and lifting the ball were prohibited. The violations were visually confirmed by the players, and when a rule violation occurred, the match was restarted with a free kick by the opposing team.

2.3 Measurement

During this investigation, the HR, stepping rate, and number of plays with the ball were evaluated. The HR was measured by an armband type of portable HR monitor (OH1, Polar, Kempele, Finland), which showed a high-level of agreement with the HR measured by electrocardiogram (Hettiarachchi et al., 2019). The HR was monitored during experiments to avoid the measurement error, and the average HR and peak HR were evaluated after the experimental period. The number of steps was measured using a pedometer with an accelerometer (Lifecorder- 4sec, Kenz, Nagoya, Japan) having high accuracy and reliability (Ayabe et al., 2010), and the stepping rate was also validated in the field studies (Ayabe et al., 2011). The Lifecorder was placed on the left anterior mid-line of the thigh along the waistband of the participant's clothing. After the data collection period, the number of the minutes-by-minutes steps was obtained. In order to analyze the number of the plays with a ball, the video was recorded by a portable handy camera at 30 fps. The present investigation evaluated the number of plays with a ball, regardless of the play-duration and continuity. For example, 10 seconds of continuous dribble, 5 seconds of dribble, direct pass, and pass cut were equally defined as one play; additionally, the continuous play, such as pass after the dribble, was also defined as one play. Furthermore, the plays associated with "set play," "restart," and apparent unintentional contact with a ball were not included. The two independent researchers evaluated the video to guarantee the measurement accuracy, and the coding was repeated if there were any differences between the two evaluators. Maximal oxygen uptake was estimated using a previously validated procedure (Ayabe et al., 2015). Briefly, all participants performed a sub-maximal graded step test, and the metabolic equivalents (METs) corresponding to the age-predicted HRmax (220 - age) were extrapolated using the relationship between the METs value and HR responses. Furthermore, the METs corresponding to the average HR was evaluated as the metabolic cost of the WS using the HR-METs relationship from the graded exercise test. Because of the miss measurement of HR responses during the graded step test in one subject, the maximal oxygen uptake and METs value were obtained in remining 19 subjects.

2.4 Statistical analysis

The data were expressed as the mean and standard deviation. The potential differences in age, height, body weight, body mass index, and maximal oxygen uptake by obesity, diabetes, hypertension, and hyperlipidemia were analyzed using the *Mann-Whitney U*-test. The relationship between two variables was analyzed using the *Pearson correlation coefficient (r)*. As age was associated with some variables, the partial correlation adjusted by age was also performed. P-values < 0.05 were considered statistically significant, and all statistical analyses were performed using the Statistical Package for the Social Sciences software (SPSS software program; IBM, New York, USA).

3. Results

The characteristics of subjects (age, height, body weight, body mass index) did not differ significantly by obesity, diabetes, hypertension, and hyperlipidemia except for the significant difference in the body mass index in the obesity category ($p < 0.05$). The estimated maximal oxygen up take was 36.7 ± 7.4 ml/kg/min, showing significant differences in the categories of obesity ($p < 0.05$).

For WS, the average HR and peak HR were 127.0 ± 20.5 beats/min (bpm) and 142.8 ± 21.8 bpm, respectively, and corresponded to 82.3 ± 13.9 % and 92.2 ± 13.0% of the age-predicted HRmax, respectively. The estimate metabolic cost was 8.0 ± 1.6 METs, stepping rate was 84.8 ± 17.7 steps/min at an average and 103.6 ± 13.7 steps/min at peak, and number of play with a ball was 12.2 ± 4.3 numbers/game. There was no significant difference in HR, stepping rate, and number of plays with a ball among the potential characteristics.

The *Pearson correlation coefficient* shows that the maximal oxygen uptake was significantly associated with the metabolic cost ($r = 0.822$, $p < 0.001$), stepping rate ($r = 0.496$, $p = 0.031$), and number of plays with a ball ($r = 0.459$, $p = 0.048$) (**Figure 1**). The relationship between the maximal oxygen uptake and the metabolic cost remained significant in the partial correlation adjusted for age ($r = 0.811$, $p < 0.001$).

The HR correlated with the stepping rate and number of plays with a ball ($p < 0.05$) (**Figure 2**). Furthermore, the partial correlation adjusted by age showed a significant relationship between the number of plays with a ball and the relative HR ($r = 0.422$, $p < 0.048$). The relationship between the HR and stepping rate just fell short of reaching statistical significance ($p < 0.10$).

4. Discussion

The present investigation examined the cardiorespiratory responses to the recreational WS

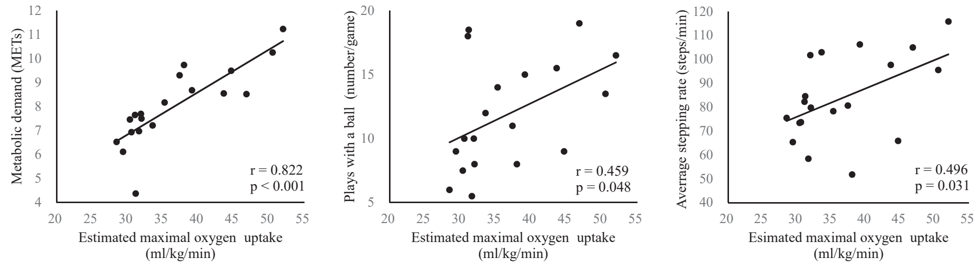

Figure 1 Relationship between estimated maximal oxygen uptake with metabolic demand, number of plays with ball, and stepping rate during recreational walking soccer

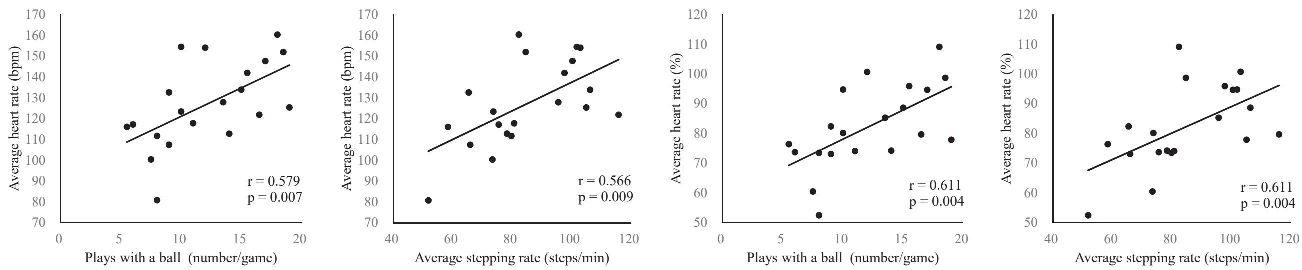

Figure 2 Relationship between average heart rate with number of plays with ball and stepping rate during recreational walking soccer

in middle to old-aged adults having mild metabolic disorders. The present investigation measured stepping rate during the WS, which was 84.8 ± 17.7 steps/min at an average and 103.6 ± 13.7 steps/min at peak. The stepping rate reflects the exercise intensity and locomotion speed, and previous findings showed that <100 steps/min would correspond to a brisk walking (Ayabe et al., 2011). Therefore, the present investigation successfully limited the locomotion to the walking, thereafter, it is evident that the results of the present investigation show the physiological responses to the WS.

As per the results, the average HR exceeded 80% of the age-predicted HRmax, and the peak HR was achieved at 90%. These results consistent with the previous findings where the HR responses to recreational soccer were almost 80% independent of the participant's health status (Bangsbo et al., 2015). Additionally, the present investigation demonstrated that the METs value achieved to 8.0 ± 1.6 METs corresponding to the 80% of maximal oxygen uptake (36.7 ± 7.4 ml/kg/min). These results clearly demonstrated that the cardiorespiratory responses to WS were above the intensity recommended by the current guidelines for physical activity (Miyachi et al., 2015; Piercy et al., 2018; Tanaka and Shindo, 1992).

There are several reasons for the severe cardiorespiratory stress with the WS. Interestingly the average stepping rate corresponded to the 3METs or less, whereas the average HR was achieved to the 82.3±13.9 %, and estimated metabolic cost was 8.0±1.6 METs. Regarding WS, it is speculated that steps were accumulated through short-distance walking with a turn rather than through walking in a straight line continuously. The previous investigation demonstrated that the walking with turn significantly increased energy expenditure compared with that in the straight walking (Araki et al., 2015). Furthermore, the changes of the direction and the accelerations associated with the increases in energy expenditure (Higashino et al., 2018; Piras et al., 2017). As results, the WS demonstrated the higher METs value at fixed stepping rate compared with that in the straight walking. It is not surprising that the exercise intensity during WS corresponded to that during running, aerobic dancing, and other vigorous physical activities (Ainsworth et al., 2011), since intermittent movements in WS such as acceleration, changes of direction, and movements with the ball contribute to additional physical demands (Higashino et al., 2018; Piras et al., 2017).

There were several limitations in the present investigation. First, as the present investigation was a pilot design, the participants were limited. Second, the participants of this investigation were not familiar with WS, and physiological stress could change with experience. Finally, the court size and the number of players would also be significant factors affecting physiologic responses. The use of a basketball court instead of outdoor grounds may improve WS features, and advantages include easy access, presence of existing facilities, and safety from weather changes. Additionally, this study used “5 vs 5” situations because of the rules of the basketball, the maintenance of the play with a ball, game availability. Thus, future research should further investigate the physiologic demands of WS under different conditions.

To summarize, the present investigation confirmed that the cardiovascular demand of the WS was 8 METs and the HR responses achieved 80% of the age-predicted HRmax in community-dwelling middle to old-aged adults with mild metabolic disorders. Future research should examine the safety and physiological adaptability of heterogeneous individuals to WS, and further evaluate specific regulation of the WS.

Acknowledgements

The part of the present investigation was supported by KAKENHI (19K11493).

References

Ainsworth, B.E., Haskell, W.L., Herrmann, S.D., Meckes, N., Bassett, D.R., Jr., Tudor-Locke, C., Greer, J.L., Vezina, J., Whitt-Glover, M.C., and Leon, A.S. (2011). 2011 compendium of physical activities: A second update of codes and met values. Med. Sci. Sports Exerc., 43: 1575-1581.

Araki, M., Hatamoto, Y., Matsuda, T., Higaki, Y., Kiyonaga, A., and Tanaka, H. (2015). Examination of home exercise "slow walking & turn" for heart failure. Journal of Japanese Association of Cardiac Rehabilitation., 20: 242-246. (in japanese)

Arnold, J.T., Bruce-Low, S., and Sammut, L. (2015). The impact of 12 weeks walking football on health and fitness in males over 50 years of age. BMJ Open Sport Exerc. Med., 1: e000048.

Ayabe, M., Aoki, J., Kumahara, H., and Tanaka, H. (2011). Assessment of minute-by-minute stepping rate of physical activity under free-living conditions in female adults. Gai. Pos., 2: 292-294.

Ayabe, M., Ishii, K., Takayama, K., Aoki, J., and Tanaka, H. (2010). Comparison of interdevice measurement difference of pedometers in younger and older adults. Br. J. Sports Med., 44: 95-99.

Ayabe, M., Kumahara, H., Morimura, K., and Tanaka, H. (2015). Effects of exercise intervention on habitual physical activity above lactate threshold under free-living conditions: A randomized controlled trial. Int. J. Sports Med., 36: 1106-1111.

Bangsbo, J. (1994). Energy demands in competitive soccer. J. Sports Sci., 12 Spec No: S5-12.

Bangsbo, J., Hansen, P.R., Dvorak, J., and Krustrup, P. (2015). Recreational football for disease prevention and treatment in untrained men: A narrative review examining cardiovascular health, lipid profile, body composition, muscle strength and functional capacity. Br. J. Sports Med., 49: 568-576.

Harriss, D.J., and Atkinson, G. (2015). Ethical standards in sport and exercise science research: 2016 update. Int. J. Sports Med., 36: 1121-1124.

Hettiarachchi, I.T., Hanoun, S., Nahavandi, D., and Nahavandi, S. (2019). Validation of polar oh1 optical heart rate sensor for moderate and high intensity physical activities. PLOS ONE., 14: e0217288.

Higashino, Y., Ayabe, M., Okita, Y., Hijikata, T., Morimura, K., and Ishizaki, S. (2018). Contribution of acceleration by location tracking system to energy expenditure during soccer -based intermittent exercise. Jap. J. Phys. Fitness Sports Med., 67: 411-421. (in japanese)

Krustrup, P., and Bangsbo, J. (2015). Recreational football is effective in the treatment of non-communicable diseases. Br. J. Sports Med., 49: 1426-1427.

Miyachi, M., Tripette, J., Kawakami, R., and Murakami, H. (2015). "+10 min of physical activity per day": Japan is looking for efficient but feasible recommendations for its population. J. Nutr. Sci. Vitaminol. (Tokyo)., 61 Suppl: S7-9.

Piercy, K.L., Troiano, R.P., Ballard, R.M., Carlson, S.A., Fulton, J.E., Galuska, D.A., George, S.M., and Olson, R.D. (2018). The physical activity guidelines for americans. JAMA, 320: 2020-2028.

Piras, A., Raffi, M., Atmatzidis, C., Merni, F., and Di Michele, R. (2017). The energy cost of running with the ball in soccer. Int. J. Sports Med., 38: 877-822.

Reddy, P., Dias, I., Holland, C., Campbell, N., Nagar, I., Connolly, L., Krustrup, P., and Hubball, H. (2017). Walking football as sustainable exercise for older adults - a pilot investigation. Eur. J. Sport Sci., 17: 638-645.

Tanaka, H., and Shindo, M. (1992). The benefits of the low intensity training. Ann. Physiol. Anthropol., 11: 365-368.

Name:
Makoto Ayabe

Affiliation:
Faculty of Computer Science and Systems Engineering, Okayama Prefectural University

Address:
111 Kuboki, Soja, Okayama 719-1197 Japan

Brief Biographical History:
Juntendo University (BS)
Fukuoka University (MS)
Hokkaido University (PhD)

Main Works:
- Narrative review: GPS-based Tracking system in football. The Journal of Japanese Society of Science and Football (2020)

Membership in Learned Societies:
- Japanese Society of Science and Football
- Japanese Society of Physical Fitness and Sports Medicine
- International Society for the Measurement of Physical Behavior