Lecture Notes in Bioengineering

Mohd Hasnun Arif Hassan · Ahmad Munir Che Muhamed · Nur Fahriza Mohd Ali · Denise Koh Choon Lian · Kok Lian Yee · Nik Shanita Safii · Sarina Md Yusof · Nor Farah Mohamad Fauzi *Editors*

Enhancing Health and Sports Performance by Design

Proceedings of the 2019 Movement, Health & Exercise (MoHE) and International Sports Science Conference (ISSC)

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Editors
Mohd Hasnun Arif Hassan
Faculty of Mechanical and Automotive Engineering Technology
Universiti Malaysia Pahang
Pekan, Pahang, Malaysia

Nur Fahriza Mohd Ali
Malaysian Journal of Movement, Health & Exercise
Universiti Malaysia Pahang
Pekan, Pahang, Malaysia

Kok Lian Yee
Department of Sports Studies
Universiti Putra Malaysia
Selangor, Malaysia

Sarina Md Yusof
Faculty of Sports Science and Recreation
Universiti Teknologi MARA
Selangor, Malaysia

Ahmad Munir Che Muhamed
Advanced Medical and Dental Institute
Universiti Sains Malaysia
Kepala Batas, Pulau Pinang, Malaysia

Denise Koh Choon Lian
Centre for Community Education & Wellbeing, Faculty of Education
Universiti Kebangsaan Malaysia
Selangor, Malaysia

Nik Shanita Safii
School of Healthcare Sciences
Universiti Kebangsaan Malaysia
Kuala Lumpur, Malaysia

Nor Farah Mohamad Fauzi
Faculty of Health Sciences
Universiti Kebangsaan Malaysia
Kuala Lumpur, Malaysia

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Preface

Two of the most prestigious annual conference relating to Sport Science and Health in Malaysia was held in Kuching, Sarawak, from September 30, 2019, to October 2, 2019. This joint conference of the 6th International Conference on Movement, Health and Exercise and the 12th International Sports Science had attracted researchers and sports practitioners from various backgrounds to share and disseminate current research updates and evidence-based findings and translate them into winning practices through scholarly communication.

The theme chosen for this joint conference "Enhancing Health and Sports Performance by Design" is very relevant to the national agenda of producing world-class athletes via a systematic development program.

This peer-reviewed conference proceeding highlights high-quality research findings covering 8 areas of sports science and technology, which include Exercise Sciences, Human Performance, Physical Activity and Health, Sports Medicine, Sports Nutrition, Management and Sports Studies and Sports Engineering and Technology.

The publication of this proceedings in Lecture Notes in Bioengineering will assist in maximizing the accessibility of readers and the popularity of these papers.

Mohd Hasnun Arif Hassan
Ahmad Munir Che Muhamed
Nur Fahriza Mohd Ali
Denise Koh Choon Lian
Kok Lian Yee
Nik Shanita Safii
Sarina Md Yusof
Nor Farah Mohamad Fauzi

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Oleksandr K. Krasilshchikov	Exercise and Sport Science Program, School of Health Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia

Contents

Exercise Science

Determination of Cardiac Function Using Impedance Cardiography During Jogging With and Without Breast Support

Kunanya Masodsai[1,2](✉) and Rungchai Chaunchaiyakul[1]

[1] College of Sports Science and Technology, Mahidol University, Nakhon Pathom 73170, Thailand
kunanyamasodsai@gmail.com
[2] Faculty of Sports Science, Chulalongkorn University, Bangkok 10330, Thailand

Abstract. The goal of this study was to use a non-invasive method of impedance cardiography to investigate the consistency of cardiac variables, in parallel with metabolic function. Thirteen healthy females underwent two randomized jogging conditions: without breast support (NB) and with breast support (jogging bra, JB). Cardiorespiratory and metabolic functions were continuously recorded at rest, during exercise on the treadmill at a constant speed of 4 mph at 60, 70 and 80% of age-predicted maximum heart rate followed by a 5-min recovery. The results showed that there were no significant differences in resting cardiac variables, including cardiac output (CO), heart rate (HR), stroke volume (SV), end diastolic volume (EDV), end systolic volume (ESV) and cardiac index (CI). The parallel intensity-dependent characteristics of both cardiorespiratory and metabolic variables during jogging were also determined. The results showed normal cardiac functions during and after jogging with no significant differences of CO, HR, SV, EDV, ESV and CI between two conditions ($P > 0.05$). Metabolic variables showed no significant differences between the two conditions ($P > 0.05$) for oxygen consumption ($\dot{V}O_2$), carbon dioxide production ($\dot{V}CO_2$) and respiratory exchange ratio (RER). With narrow ranges of the standard errors of the mean and parallel alterations of metabolism at rest, during exercise and recovery from two conditions, this study concluded that a non-invasive impedance cardiography method can possibly reflect changes of both cardiorespiratory and metabolic functions. In addition, it is suggested that breast supports in females during treadmill running induce no limitations on both cardiorespiratory and metabolic functions.

Keywords: Running bra · Breast support · Gas exchange · Cardiac impedance · Metabolism

1 Introduction

Hemodynamic determination is usually conducted via invasive hemodynamic measurement such as the Swan-Ganz catheter, with unsure results [1]. Invasive Swan-Ganz catheter method can only be done at rest and not during physical activity [2]. Another

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non-invasive method, echocardiography, can be done only at pre- and immediate post-exercise [3]. Clinical and exercise specialists have looked at alternative methods to measure cardiac functions during physical activity under certain stresses such as during physical activity.

Impedance cardiography (ICG), a non-invasive method for the estimation of hemodynamic variables, is based on the assumption that the thorax is a homogeneous fluid cylinder, composed of blood, tissues, air and organs. Therefore, these tissues contain a fixed resistance. So, to measure ICG a low steady current amplitude (1.5 mA, 86 kHz) generated by external electrodes (located in the thoracic and cervical skin regions) can be captured as instantaneous voltage changes around the thoracic cavity according to Ohm's law [4]. When a steady minimal electric current is applied to the thorax, the voltage changes are directly proportional to the impedance changes. Baseline thoracic impedance (Z_0) is the sum of the impedance of all constant thoracic components. The alteration of dynamic Z (dZ/dt) is, therefore, derived solely from fluid changes, and then converted to stroke volume and cardiac output values using mathematical algorithms [5]. Validations of non-invasive cardiac impedance has been shown during constant cycling exercise in healthy fit subjects [6], in patients with lung problems [7] and in children [8]. It has been reported that this method could also give relevant cardiac information during non-steady motion such as running.

Active females have been shown to be at high risk of breast pain from repeated excessive breast swinging motions [9]. However, only 13% of adolescent females [10] and 41% of women use jogging bra during physical activity [11] because they report discomfort from tightness, mastalgia and dyspnea [11, 12] and the belief that a jogging bra will diminish lung functions and deviated respiratory pattern toward rapid and shallow breathing [13]. It has been reported that the numbers of females involved with physical activity has been increasing [14]. Few studies have focused on in-depth cardiac variables in females jogging without breast support [15, 16]. The purpose of this study was to use this non-invasive ICG method to investigate the characteristics of changes in cardiorespiratory system during different metabolic demands in female subjects during treadmill running by comparing cardiorespiratory and metabolic functions with and without breast support.

2 Materials and Methods

2.1 Participants

Thirteen healthy active females (ages 20–25 yrs), with B and C breast cup sizes, voluntarily participated in this study. Inclusion criteria consisted of those who were free from cardiorespiratory and musculoskeletal disorders, had regular menstrual cycle within 6 months prior to participating in the study, not using hormone replacement therapy, non-pregnant, non-smoking and non-alcoholism. Objectives, experimental procedures, risks and benefits of the study were explained to potential study participants before completing the informed consent forms. Individual bra size was identified [10], then an appropriate jogging bra was provided for each individual. Subjects' instructions were provided to remind them to keep their normal diets and consume enough water to ensure euhydration status. Each subject was informed to avoid coffee, tea, tobacco or alcohol, and strenuous physical activity on the day prior to testing. This study was conducted under the Human Research Ethics Committee of Mahidol University, Thailand (MU-IRB 2013/159.1112).

2.2 Experimental Procedures

For confidential, only female investigators were allowed to conduct the tests in the closed room within the laboratory. Prior to exercise testing, each subject's anthropometric data was collected as well as estimated physical activity level using a questionnaire. The treadmill running tests were conducted on two separate occasions. Each visit was randomized with subjects either not wearing a bra (NB) or wearing a jogging bra (JB). The tests were performed at the same phase of their menstrual cycle. Prior to the treadmill test each subject performed a callisthenic warm up, then the treadmill exercise was started at 2 mph, for 3 min. A constant speed of 4 mph was continuously kept up to 80% of age-predicted maximum heart rate (MHR). Various parameters were collected at rest, 60%, 70%, and 80% of MHR, and 5 min of recovery. Gas analyzer (Oxycon Mobile, German) had been utilized to determine respiratory functions, including respiratory rate (RR), tidal volume (V_T), minute ventilation ($\dot{V}_E$) and metabolic functions, including oxygen consumption ($\dot{V}O_2$), carbon dioxide production ($\dot{V}CO_2$) and respiratory exchange ratio (RER). Cardiac functions, including cardiac output (CO), heart rate (HR), stroke volume (SV), end diastolic volume (EDV), end systolic volume (ESV), cardiac index (CI), were continuously monitored by using non-invasive impedance cardiography method (Physioflow®, France).

2.3 Statistical Analysis

All data were presented as mean ± standard error of mean (SEM). Two-ways ANOVA-repeated measure was used for significant difference analysis with Tukey's *post hoc* test. Significant level was accepted at *P*-value less than 0.05.

3 Results

3.1 General Characteristics

Subjects age and height were 22.85 ± 2.69 years and 163.1 ± 1.42 cm respectively. General characteristics (Table 1) revealed the normal ranges of their anthropometric variables within this age [17]. No significant differences of the above variables within three months of this crossover design experiment.

Table 1. Baseline characteristics of female subjects during the study.

Variables	No bra (n = 13)	Jogging bra (n = 13)
Weight (kg)	56.45 ± 5.79	56.29 ± 5.60
BMI (kg.m^{-2})	21.70 ± 1.77	21.78 ± 1.68
Body fat (%)	22.91 ± 2.75	22.93 ± 2.70
Lean body mass (%)	28.03 ± 1.67	28.15 ± 1.69
Waist circumference (cm)	74.38 ± 6.40	74.66 ± 6.83
Hip circumference (cm)	94.88 ± 5.02	94.34 ± 5.19

BMI, body mass index.

3.2 Resting Cardiac Variables

Most of the resting cardiac variables in the present study (Table 2) were in the ranges of other references. While HR, EDV and ESV fell in the ranges covered by other methods, CO, and CI showed slightly lower values. Even though different methods were used from other studies, it was quite confident to conclude that impedance cardiography reflected the reliable resting cardiac variables.

Table 2. Resting cardiac variables including HR, SV, CO, CI, EDV and ESV measured from the present study with additional value of $\dot{V}O_2$max. Methods of determinations and references are defined.

Variables	This study	Ranges/Methods/References
Heart rate (bpm)	72.39 ± 2.38	68.9 ± 0.8/myocardial perfusion imaging/ [18]
Stroke volume (ml/beat)	51.36 ± 3.25	49-112/echo magnetic resonance imaging/ [19]
Cardiac output (L/min)	3.76 ± 0.25	5-7/Dye dilution/ [20]
Cardiac index (L/min/m^2)	2.38 ± 0.15	3-5/Dye dilution/ [20]
End diastolic volume (ml)	111.19 ± 5.57	76-161/echo magnetic resonance imaging/ [19]
End systolic volume (ml)	59.83 ± 3.95	17-63/echo magnetic resonance imaging/ [19]
$\dot{V}O_2$max (ml/min/kg)	36.82 ± 1.14	22.6 ± 4.3, Quantitative Radionucleotide Angiography/ [21] 34.0-41.8/in-direct methods/ [17]

$\dot{V}O_2$max, maximal oxygen consumption.

3.3 Changes in Metabolic Variables During Exercise

During jogging, changes in $\dot{V}O_2$ and $\dot{V}CO_2$ (Fig. 1A and B) significantly increased from resting values in both conditions. In NB, $\dot{V}O_2$ and $\dot{V}CO_2$ values declined immediately as jogging was ceased. But $\dot{V}O_2$ in JB recovered after the first minute ($P < 0.05$) while $\dot{V}CO_2$ recovered after 3 min ($P < 0.05$). Increasing in RER of both conditions was shown after 70%MHR intensity throughout the study period ($P < 0.05$). No significant differences between conditions were found.

3.4 Changes in Cardiac Variables During Exercise

Most of cardiac variables showed the intensity-dependent characteristics (Fig. 2) with narrow SEM ranges for both conditions. During jogging, there were increasing of EDV, SV, HR, CO and CI (Fig. 2A, C, D, E and F). During recovery, there were increasing of HR, CO and CI (Fig. 2D, E and F). ESV showed steady values throughout the study (Fig. 2B). No significant differences between conditions were found.

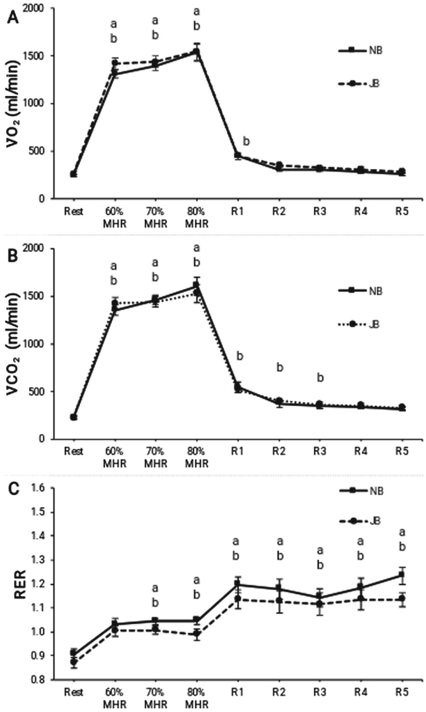

Fig. 1. Changes in metabolic variables, $\dot{V}O_2$, $\dot{V}CO_2$ and RER during and after jogging. Symbols a and b represent significant different from resting values of NB and JB respectively.

3.5 Changes in Respiratory Variables During Exercise

Most of respiratory variables increased as intensity-dependent characteristics where RR, V_T and VE significantly increased from resting values during jogging but immediately recover as exercise was ceased (Fig. 3A, B and C). No significant differences between conditions were found.

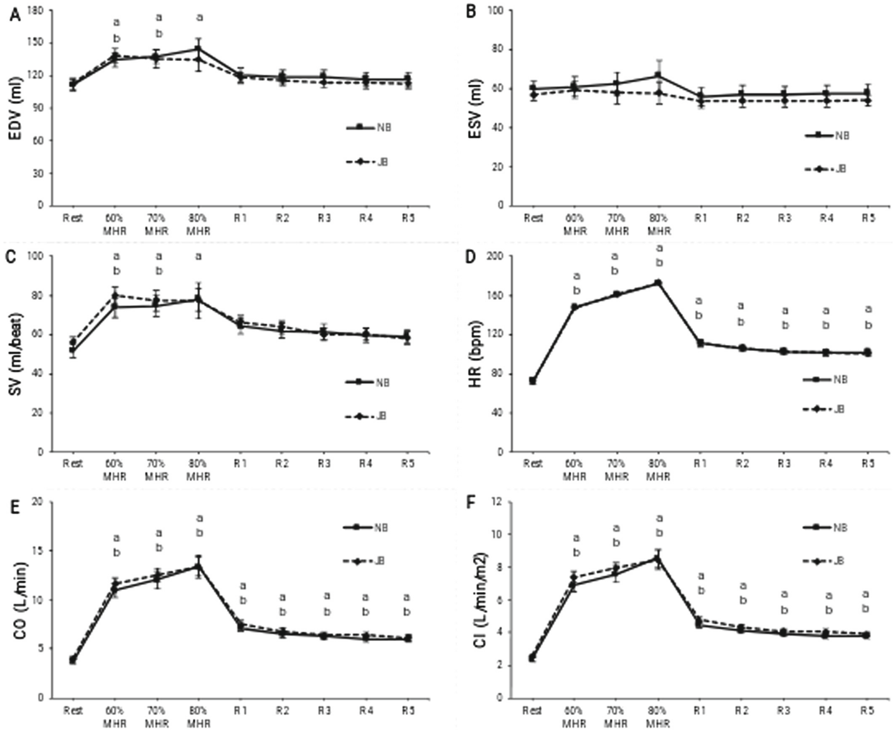

Fig. 2. Changes of cardiac variables at rest, during jogging and recovery. Symbols a and b represent significant different from resting values of NB and JB respectively.

4 Discussion

There are parallel alterations of metabolism at rest, during exercise, and recovery from two jogging conditions of without and with breast support. In addition, with narrow ranges of the standard errors of the mean from both metabolic and cardiorespiratory variables, this non-invasive impedance cardiography method reflects changes of both cardiorespiratory functions. It is suggested that breast supports in females during physical activity induce no limitations on both cardiorespiratory and metabolic functions. With post-jogging discomfort, jogging without breast support is not recommended.

The durations when subjects in NB condition approached 60, 70 and 80%MHR were 7.06 ± 1.66, 12.08 ± 2.82 and 14.88 ± 1.95 min, whereas in JB were 8.50 ± 1.80, 14.82 ± 2.80 and 23.05 ± 3.23 min (means ± SEM) respectively. There was significant different jogging duration between NB and JB only at 80% MHR ($P < 0.05$). In addition, subjects in NB complained breast discomfort by the end of jogging. The steeper heart rate responses at 80%MHR of NB condition from this study imply that jogging exercise without breast support is not recommended [16, 22].

This study shows the coexistent changes of cardiorespiratory and metabolism functions. No changes in $\dot{V}O_2$, of either NB or JB reveal no limitation of metabolism generated from sports bra during exercise. Metabolism during exercise shows an intensity-dependent pattern for both NB and JB. However, JB induced higher metabolic demand during first few minutes of recovery. It was determined that $\dot{V}O_2$ and $\dot{V}CO_2$ at rest was approximately about 250 and 200 ml/min respectively [23]. This causes the ratio between $\dot{V}CO_2/\dot{V}O_2$ (RER) to be 0.8. During higher metabolic demand, like exercise, increasing in $\dot{V}O_2$ and $\dot{V}CO_2$ is known to be intensity-dependent [24]. This will cause deviations of RER from 0.8 towards nearly or above 1.00 which reflects carbohydrate aerobic combustion. If exercise intensity is prolonged, RER may deviate toward 0.7 for fat metabolism [23–26]. The deviations of RER remain even though exercise had been stopped. This reflects that the existing and continuing of high metabolism. Higher RER > 1.00 during recovery in jogging bra condition likely indicates the involvement of anaerobic processes [27]. Thus, 5 min recovery period in the present study was not appropriate for exercise at moderate to high intensity of >80% MHR.

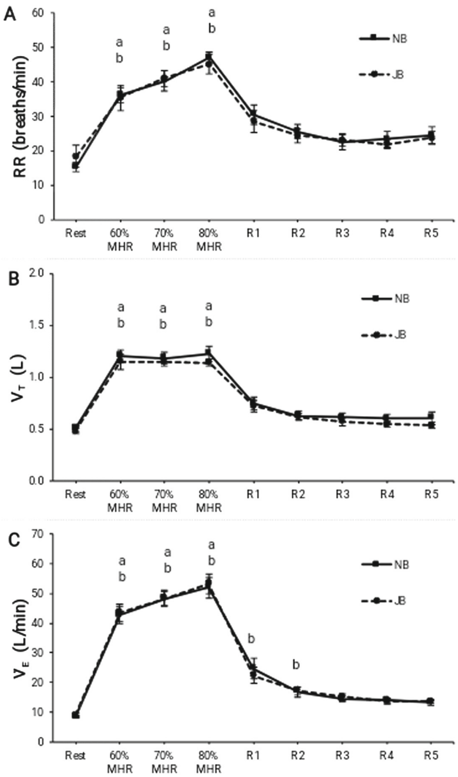

Fig. 3. Changes of respiratory variables at rest, during jogging and recovery. Symbols a and b represent significant different from resting values of NB and JB respectively.

The feeling of chest wall restriction will change breathing pattern from unsatisfied sensation [13]. If this really exists, we might find differences in resting respiratory variables in JB but not in NB. With no significant different between resting respiratory variables between NB and JB (Fig. 3), we conclude that putting on jogging bra will not induce any changes in breathing pattern as previously believed. At very high pressure models, this will cause skin furrows [27], and alters respiratory pattern [28, 29]. An immediate ventilator responses to exercise is proposedly derived from neural drives and later from blood-borne mediators from exercising muscles [30]. During low to moderate exercise, increasing in V_T and RR are in the proportion to intensity [31]. Increasing too fast breathing frequency will induce higher airways resistance even in normal healthy subjects [32]. The present study found effective respiratory adjustments during recovery.

Physical activity induces higher ventricular contraction. Thus, cardiac contractility and rhythm are activated [33]. Increasing of HR and SV resulted in higher cardiac output [34]. These compensatory conditions remain similarly with NB and chest wall strapping (JB). In contrast to a previous study, lung volumes were diminished to 35% from extremely high chest wall restriction [34]. In our model, low elastic recoil of elastic bra's garment may not affect hemodynamic within the thorax. Increasing in SV and CO in both NB and JB during jogging is most likely associated with higher RR [35], which possibly affect cardiac function and will bring about higher SV [34]. With constant body surface area, increasing in CI is mainly due to increasing in CO. This means that suitable hemodynamic to all body parts is maintained [36]. In parallel to metabolic variables, it was shown that cardiac variables in sedentary females (ages 23–26 yrs) during treadmill exercise increased in parallel to metabolic variables [37]. These characteristics were found in moderately trained females (18–30 yrs) [38].

5 Conclusion

The parallel concomitant changes of metabolism and cardiorespiratory systems under the same stress reveal that non-invasive impedance cardiography method can be used to determine changes in cardiorespiratory system. This study also indicates no limitation of jogging bra on metabolic and cardiovascular profiles during constant speed jogging. In addition, jogging bra is recommended for safety and effectively for breast support without functional limitation.

References

1. Robin, E.D.: The cult of the Swan-Ganz catheter. Overuse and abuse of pulmonary flow catheters. Ann. Intern. Med. **103**(3), 445–449 (1985)
2. Fields, C., Trotsky, A., Fernandez, N., Smith, B.A.: Mobility and ambulation for patients with pulmonary artery catheters: a retrospective descriptive study. J. Acute Care Phys. Ther. **6**(2), 64–70 (2015)
3. Grazioli, G., Sanz, M., Montserrat, S., Vidal, B., Sitges, M.: Echocardiography in the evaluation of athletes. F1000Res. **4**, 151 (2015)

4. Silva, L.D.S., Reis, F.F., Silva, M.E.S., Lima, D.V.M.D.: Accuracy of impedance cardiography in acute myocardial infarction: a literature review. Int. J. Cardiovasc. Sci. **31**(3), 282–289 (2018)
5. Mehta, Y., Arora, D.: Newer methods of cardiac output monitoring. World J. Cardiol. **6**(9), 1022–1029 (2014)
6. Tordi, N., Mourot, L., Matusheski, B., Hughson, R.L.: Measurements of cardiac output during constant exercises: comparison of two non-invasive techniques. Int. J. Sports Med. **25**(2), 145–149 (2004)
7. Bougault, V., Lonsdorfer-Wolf, E., Charloux, A., Richard, R., Geny, B., Oswald-Mammosser, M.: Does thoracic bioimpedance accurately determine cardiac output in COPD patients during maximal or intermittent exercise? Chest **127**(4), 1122–1131 (2005)
8. Welsman, J., Bywater, K., Farr, C., Welford, D., Armstrong, N.: Reliability of peak VO(2) and maximal cardiac output assessed using thoracic bioimpedance in children. Eur. J. Appl. Physiol. **94**(3), 228–234 (2005)
9. Brown, N., White, J., Brasher, A., Scurr, J.: The experience of breast pain (mastalgia) in female runners of the 2012 London Marathon and its effect on exercise behaviour. Br. J. Sports Med. **48**(4), 320–325 (2014)
10. McGhee, D.E., Steele, J.R.: Optimising breast support in female patients through correct bra fit. A cross-sectional study. J. Sci. Med. Sport. **13**(6), 568–572 (2010)
11. Bowles, K.A., Steele, J.R., Munro, B.: What are the breast support choices of Australian women during physical activity? Br. J. Sports Med. **42**(8), 670–673 (2008)
12. Bowles, K.A., Steele, J.R., Chaunchaiyakul, R.: Do current sports brassiere designs impede respiratory function? Med. Sci. Sports Exerc. **37**(9), 1633–1640 (2005)
13. O'Donnell, D.E., Hong, H.H., Webb, K.A.: Respiratory sensation during chest wall restriction and dead space loading in exercising men. J. Appl. Physiol. **88**(5), 1859–1869 (2000)
14. Sherar, L.B., Gyurcsik, N.C., Humbert, M.L., Dyck, R.F., Fowler-Kerry, S., Baxter-Jones, A.D.: Activity and barriers in girls (8–16 yr) based on grade and maturity status. Med. Sci. Sports Exerc. **41**(1), 87–95 (2009)
15. Mills, C., Risius, D., Scurr, J.: Breast motion asymmetry during running. J. Sports Sci. **33**(7), 746–753 (2015)
16. Scurr, J.C., White, J.L., Hedger, W.: The effect of breast support on the kinematics of the breast during the running gait cycle. J. Sports Sci. **28**(10), 1103–1109 (2010)
17. Sport Authority of Thailand: Physical fitness norms of Thai population. Sports Science Sector, Sports Science Department, Sport Authority of Thailand, Bangkok 2002
18. Yamada, A.T., Campos Neto Gde, C., Soares Jr, J., Giorgi M.C., Araujo F., Meneghetti J.C., et al.: Gender differences in ventricular volumes and left ventricle ejection fraction estimated by myocardial perfusion imaging: comparison of Quantitative Gated SPECT (QGS) and Segami software programs. Arq. Bras. Cardiol. **88**(3), 285–290 (2007)
19. Cain, P.A., Ahl, R., Hedstrom, E., Ugander, M., Allansdotter-Johnsson, A., Friberg, P., et al.: Age and gender specific normal values of left ventricular mass, volume and function for gradient echo magnetic resonance imaging: a cross sectional study. BMC Med. Imag. **9**, 2 (2009)
20. Katori, R.: Normal cardiac output in relation to age and body size. Tohoku J. Exp. Med. **128**(4), 377–387 (1979)
21. Higginbotham, M.B., Morris, K.G., Coleman, R.E., Cobb, F.R.: Sex-related differences in the normal cardiac response to upright exercise. Circulation **70**(3), 357–366 (1984)
22. Haake, S., Scurr, J.: A dynamic model of the breast during exercise. Sports Eng. **12**(4), 189–197 (2010)

23. Sedlock, D.A., Lee, M.G., Flynn, M.G., Park, K.S., Kamimori, G.H.: Excess postexercise oxygen consumption after aerobic exercise training. Int. J. Sport Nutr. Exerc. Metab. **20**(4), 336–349 (2010)
24. Gore, C.J., Withers, R.T.: Effect of exercise intensity and duration on postexercise metabolism. J. Appl. Physiol. **68**(6), 2362–2368 (1990)
25. Hagberg, J.M., Mullin, J.P., Nagle, F.J.: Effect of work intensity and duration on recovery O2. J. Appl. Physiol. Respir. Environ. Exerc. Physiol. **48**(3), 540–544 (1980)
26. Sperlich, B., Born, D.P., Kaskinoro, K., Kalliokoski, K.K., Laaksonen, M.S.: Squeezing the muscle: compression clothing and muscle metabolism during recovery from high intensity exercise. PLoS ONE One **8**(4), e60923 (2013)
27. Guenette, J.A., Witt, J.D., McKenzie, D.C., Road, J.D., Sheel, A.W.: Respiratory mechanics during exercise in endurance-trained men and women. J. Physiol. **581**(Pt 3), 1309–1322 (2007)
28. Casaburi, R., Storer, T.W., Wasserman, K.: Mediation of reduced ventilatory response to exercise after endurance training. J. Appl. Physiol. **63**(4), 1533–1538 (1987)
29. Coast, J.R., Cline, C.C.: The effect of chest wall restriction on exercise capacity. Respirology **9**(2), 197–203 (2004)
30. Casaburi, R.: The mechanism of the exercise hyperpnea: the ultrasecret revisited. Am. J. Respir. Crit. Care Med. **186**(7), 578–579 (2012)
31. Carey, D., Pliego, G., Raymond, R.L.: How endurance athletes breathe during incremental exercise to fatigue: interaction of tidal volume and frequency. J. Exerc. Physiol. **11**(4), 44–51 (2008)
32. Chaunchaiyakul, R., Groeller, H., Clarke, J.R., Taylor, N.A.: The impact of aging and habitual physical activity on static respiratory work at rest and during exercise. Am. J. Physiol. Lung Cell. Mol. Physiol. **287**(6), L1098–L1106 (2004)
33. Dyakova, E.Y., Kapilevich, L.V., Shylko, V.G., Popov, S.V., Anfinogenova, Y.: Physical exercise associated with NO production: signaling pathways and significance in health and disease. Front. Cell Dev. Biol. **3**, 19 (2015)
34. Miller, J.D., Beck, K.C., Joyner, M.J., Brice, A.G., Johnson, B.D.: Cardiorespiratory effects of inelastic chest wall restriction. J. Appl. Physiol. **92**(6), 2419–2428 (2002)
35. Mendonca, C.T., Schaeffer, M.R., Riley, P., Jensen, D.: Physiological mechanisms of dyspnea during exercise with external thoracic restriction: role of increased neural respiratory drive. J. Appl. Physiol. **116**(5), 570–581 (2014)
36. Klabunde, R.E.: Cardiovascular Physiology Concepts, 2nd edn. Lippincott Williams & Wilkins, Philadelphia (2012)
37. Ogawa, T., Spina, R.J., Martin 3rd, W.H., Kohrt, W.M., Schechtman, K.B., Holloszy, J.O., et al.: Effects of aging, sex, and physical training on cardiovascular responses to exercise. Circulation **86**(2), 494–503 (1992)
38. Ferguson, S., Gledhill, N., Jamnik, V.K., Wiebe, C., Payne, N.: Cardiac performance in endurance-trained and moderately active young women. Med. Sci. Sports Exerc. **33**(7), 1114–1119 (2001)

Changes in Immune Response to Moderate Exercise in Active Trainees

Aparup Konar[1(✉)], Sridip Chatterjee[2], and Samiran Mondal[3]

[1] Office of the Director of Physical Instruction, Sports Board, Jadavpur University, Kolkata 700032, West Bengal, India
kaparup@gmail.com

[2] Department of Physical Education, Jadavpur University, Kolkata 700032, West Bengal, India

[3] Department of Physical Education, Visva Bharati University, Santiniketan 731235, West Bengal, India

Abstract. Many questions are still reaming about the mechanism by which regular moderate training to the magnitude of the specific immune response. The purpose of this study was to investigate the influence of regular moderate training on specific immune response in human body.

A less air polluted zone of Burdwan, West Bengal, India was selected for this study. Total 32 male subjects chosen out of which 18 subjects (mean age 25 ± 2.06 years) treated as regular habit of Moderately Trained (MT) group and 14 subjects (mean age 22.5 ± 1.79 years) were act as Sedentary Control (SC) group from the same area. Specific immune variables such as Immunoglobulin G (IgG), CD4 (Helper T cells) percentage, CD4/CD8 ratio, Albumin and Albumin Globulin ratio were examined. Mean, SD and independent 't' test were used for statistical analysis by using IBM SPSS 20.0 version software.

The higher mean were observed in MT group compared to SC group in all specific immune variables although there was no significant difference found between both groups.

Regular moderate training habit may be increased in modulating the specific Immune response which is a possible biologic efficiency to foster the defense against disease on human health.

Keywords: Moderate training · Immune response & physical education students

1 Introduction

The immune system is the vital body system that improves one's sense of wellbeing & general health and does a remarkable job of defending against disease causing micro-organism. Exercise and training habit may be the most effective defense mechanism to produce strong functioning of immune system on human health. Regular physical exercise &training can have a positive effect and appears to improve functioning of the specific immunological response on human body. The effect of regular exercise on the

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specific immune response has been received very little evidence to suggest clinical significance and many questions are still reaming. Several reports have indicated that, exercise and training produce significant increase in specific immune components (Cordova et al. 2010; Grazzi et al. 1993; Karpinski et al. 2001; Krebs 1992; Miles et al. 2003; Kendall et al. 1990; Malm et al. 2004). Though there are also evidences that regular physical activity had negative effect on specific immune parameters in response to exercise (Ramel et al. 2003; Wu et al. 2004; Nehlsen-Cannarella et al. 1991; Weiss et al. 1995; Brown et al. 2015). Research findings also showed that no changes in the specific immune variables over the exercise training (Shimizu et al. 2011; Buyukyazi et al. 2004; Barriga et al. 1993; Bachi et al. 2015; Gleeson et al. 2000; Karacabey et al. 2005). With this brief background the specific objective of the present study was to observe the effect of regular moderate exercise on selected specific immune variables in active trainees.

2 Materials and Methods

2.1 Study Area and Subjects

The city of Burdwan (Latitude 22° 56′-23° 53′ North, Longitude 86° 48′-88° 25′ East) West Bengal, India was selected as study location which is a less air polluted area in India. Total thirty two (32) male subjects were selected out of which 18 postgraduate students (Mean Age: 25 ± 2.06 yrs) from the Department of Physical Education, Burdwan University participated in this study, pursuing regular curriculum of Physical Education classes during the two previous years treated as Moderately Trained (MT) group and 14 residential students (Mean Age: 22.525 ± 1.79 yrs) from other stream such as Zoology, Chemistry, Physics, History, Bengali & Political Science were chosen as Sedentary Control (SC) group. None of the subjects had the history of smoking, drink alcohol, or were taking medication may alter the measureable variables and affect the hormonal response.

2.2 Physical Activity Programme

Moderately trained group subject trained daily in two sessions, a morning session that consisted of a 2 h practical workout of major games & sports with conditioning and an afternoon session consisting of a 2 h game practice. Cardio-respiratory fitness efficiency were assessed to maintain the homogeneity of the subjects. Resting heart rate varied 57 ± 4.80 beats/minute and exercise heart rate varied 142 ± 9.10 beats/minute. The range of resting respiratory rate was 16 ± 3.84 breaths/minute and exercise respiratory rate was 26 ± 5.56 breaths/minute. All subjects followed a similar and controlled diet throughout the session and they belong to families with very similar background of demographic status like socioeconomic, sociocultural, nutritional, psycho physiological and educational. The details of the training protocol in presented in the Table 1.

Table 1. Detail programme of physical activity followed by the training

Days	Morning Session Practical Class (6.30 am to 8.30 pm)	Afternoon Session Practical Class 3.30 pm to 5.30 pm
Monday	General conditioning (30 min) Athletic class on running (45 min) Mass demonstration class (45 min)	Major game practice (football/volleyball/kabaddi)
Tuesday	General conditioning (30 min) Gymnastic class (45 min) Mass demonstration class (45 min)	Major game practice (basketball/handball/kho kho)
Wednesday	General conditioning (30 min) Athletic class on running (45 min) Mass demonstration class (45 min)	Major game practice (football/volleyball/kabaddi)
Thursday	General conditioning (30 min) Gymnastic class (45 min) Yoga class (45 min)	Major game practice (basketball/handball/kho kho)
Friday	General conditioning (30 min) Aerobics class (45 min) Yoga class (45 min)	Formal and mass demonstration activities

2.3 Experimental Design

For selection of the subjects, simple random sampling was adopted. The subjects were part of a demographic comparative study design with moderately trained and sedentary control groups to determine the influence of regular moderately training and recreational activities on specific immune response. The study design is presented in the Fig. 1.

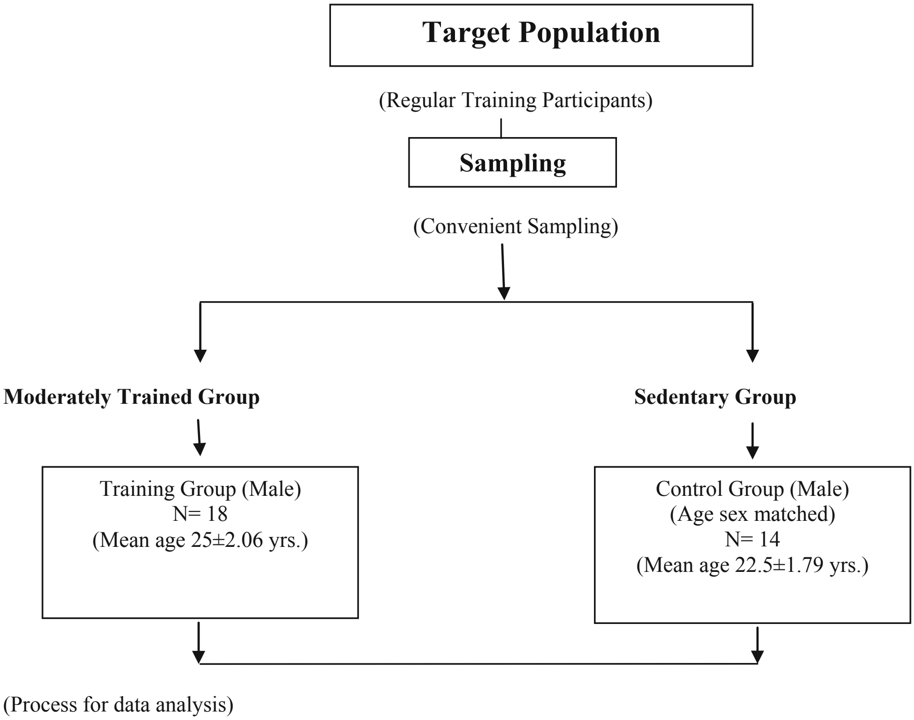

Fig. 1. Flow chart of the study design

Subjects were selected according to the formulation of objectives of the study. The experiments were done only in the regular moderate training group and compared it with the regular recreational activity group as sedentary control to draw final findings.

The researcher had collected blood samples and measured all the specific immunological health variables in a standard laboratory (namely Future Health Care, Kolkata, India) which is licensed under the West Bengal Clinical Establishment Act 1950. Before collecting the measurements, all the testing procedure was duly calibrated on time. Since the test of all the above specific immunological health variables were conducted in a reputed pathological research laboratory, reliability of data was established automatically. The test procedures are all valid since the methods adopted were from standard literature.

2.4 Variables Studied

To fulfill the objective of the study, two types of variables i.e. immunological and biochemical variables were assessed.