ORIGINAL RESEARCH PAPER

AEROBIC AND ANAEROBIC CHARACTERISTICS IN FEMALE AMATEUR LACROSSE PLAYERS IN COMPARISON WITH UNTRAINED FEMALES

Aija Kursīte, Inese Pontaga

LASE, Riga, Latvia
Latvan Academy of Sport Education,
Brivibas street 333, Riga, LV-1006, Latvia
Phone: +371 67543444, Fax: +371 76543480
e-mail: aija.kursite@lspa.lv, inese.pontaga@lspa.lv

Abstract

To achieve good results in lacrosse, the player need high muscles power, good agility and sufficiently high aerobic endurance. The aim of our investigation is to determine female lacrosse players' aerobic and anaerobic physical characteristics and compare them with the same characteristics in women control group. Twelve LASE/taxi Lady female amateur lacrosse team players (20 – 25 year olds) and 12 the same age untrained control group of healthy women participated in the investigation. The maximal height and power of the squat jump and the legs' muscles strength endurance during 30 second series of jumps are measured by Fitro Jumper (Slovakia). The absolute and relative maximum oxygen consumption is determined by indirect method performing the step load test on the cycle ergometer (Ergoline, Germany). The heart rate recovery after the load test is estimated. The absolute and relative maximal oxygen consumption is higher, but the heart rate recovery from the maximal value to its value after four minutes of cooling – down period in lacrosse players is faster than in untrained women ($p<0.05$). The mean maximal vertical jump height and power are significantly greater in the group of players than in untrained women ($p<0.05$). The difference between the mean strength endurance in 30s jumps series in the groups of athletes and untrained persons is none significant ($p>0.05$). This can be explained by large variation of the results in both groups.

Key words: *oxygen uptake, heart rate, arterial blood pressure, jump height, strength endurance, lacrosse, female*

Introduction

Lacrosse is strenuous team sport game, an exhilarating mixture of basketball, soccer, and hockey (Gutowski & Rosene, 2011; Steinhagen, 1998). Therefore particularly relevant for athletes are rapid and variable intensity jogging, jump, powerful and accurate kick ball skills. To achieve good results, the player need high muscle power, good agility, and also sufficiently high aerobic endurance. Lacrosse is characterized by quick transitions, continuous physical activity, and bursts of high-intensity sprints (Enemark-Miller et al., 2009; Pistilli et al., 2008). It has been described as the fastest game on two feet and is one of the most strenuous team sports for women (Enemark-Miller et al., 2009; Steinhagen et al., 1998). Game play consists of long sprints up and down the field with abrupt starts and stops as well as precision passes and dodges, which is physically demanding for both the cardiovascular and musculoskeletal systems (Bruce et al, 1973; Enemark-Miller et al., 2009).Lacrosse athletes must have a high degree of hand-eye coordination, motor skill, agility, speed, strength, endurance, flexibility, and aerobic and anaerobic capacity (Steinhagen et al., 1998). From a physical fitness standpoint, lacrosse places a high demand on the oxidative capacity of participants; estimations have stated that 70% of energy consumption during lacrosse activity occurs through anaerobic pathways, while the remaining 30% occurs through aerobic pathways (Fox, 1984). Very large heart and slow heart rate at rest are not typical for sport games player, however aerobic endurance is necessary to maintain the performance during all the game. The high aerobic capacity of a player provides decrease of role of the anaerobic glycolysis in the energy supply of muscles and less amount of lactic acid accumulation in the body. It moves away onset of fatigue. Regular physical training causes a wide range of structural and morphological changes in the heart, which improves the blood ejection capabilities (Bovell et al. 1996). Ventricular myocardial hypertrophy, increase of heart cavities size and increased ventricular filling with blood during diastole determine the heart stroke volume increase at rest and during physical exercise, therefore maximum oxygen consumption increases.

The research topic was chosen based on the fact that preparation of sport game players often more emphasis is putted on sports specific or anaerobic capacity and technical preparation and little emphasis on aerobic capacity training. Coaches do not pay attention to the preparation stage of athletes' general physical fitness, but only on sports specific, which is representative for lower level teams. So we decided to compare anaerobic and aerobic characteristics in sport game athletes with at least two years training experience and untrained women. The lacrosse players' physical characteristics are not investigated in wide scale in the research of other authors. Research describing the fitness profile of intercollegiate lacrosse athletes is limited (Enemark-Miller et al., 2009).

The aim of our investigation was to determine female lacrosse players' physical characteristics: maximal vertical jump height and power, the strength endurance of vertical jump series and aerobic capacity (maximal oxygen consumption and the heart rate and arterial blood pressure recovery after physical load test) and compare them with the same characteristics in women control group.

Material and methods

Subjects Twelve LASE / taxi Lady female amateur lacrosse team players (20 – 25 year olds) and 12 the same age untrained control group of healthy women participated in the investigation voluntary. Lacrosse players are trained three times per week and regularly participate in games in weekends. They had at least two years training experience in lacrosse. The physical activity level in untrained females was estimated by questionnaire and did not exceeded four hours per week.

The difference between the mean anthropometric characteristics in both groups of females was not statistically significant (Table 1). The body mass index was in norm in all females: in the borders of 19 – 25kg/m^2 (Mathews & Wagner, 2008). This means that groups are equal.

Table 1

Comparison of anthropometric characteristics in female lacrosse players and untrained women

Characteristic	Lacrosse players	Untrained women	Significance of difference
Age, years	22.2 ± 2.0	21.6 ±2.0	None significant p = 0.455
Height in, cm	169.4 ± 3.0	169.7 ± 5.0	None significant p = 0. 914
Body weight, kg	62.6 ± 6.0	66.1 ± 13.0	None significant p = 0.517
Body mass index, kg/m^2	22.6 ± 2.0	23.11 ± 3.0	None significant p = 0.722

Methods

The absolute and relative maximal oxygen consumption is determined using the indirect method (Siconolfi et al., 1982: modified Astrand & Ryhming test, 1977) by performing of dosed step load test on the cycle ergometer (Ergoline, Germany) with the special arterial blood pressure measurement block (Ergoline, Germany). Astrand and Rodahl (1977) reported that the absolute maximal oxygen uptake estimated from the Astrand-Ryhming Nomogram (1954) underestimated the directly measured maximal oxygen uptake, when the values are low, but overestimated this value for well-trained athletes who have a high maximal oxygen uptake. Therefore the test can be useful for amateur level trained lacrosse players. The test load must be in the borders of heart rate from 120 to 170 beats per minute. This load intensity is aerobic. Therefore the relationships between the test load, heart rate and the oxygen uptake are linear. The rest heart rate must be determined in sitting athlete (measurement of pulsometer). If the rest heart rate exceeds 100 beats per minute, this athlete must be excluded from the test (the reasons of high heart rate may be increased body temperature, emotional stress etc.).

The athlete had to perform the load test on cycle ergometer, the test load increased step by step. This included three load steps. Duration of every step was six minutes. Test protocol for females: warming up load 49.0 W, duration two minutes; the first step load on the cycle ergometer was 73.5 W six minutes; the second step load 98.0 W six minutes; the third step load 122.5 W six minutes. Recovery (cooling-down) load was 25 W four minutes.

The athlete's heart rate must be determined in the end of every step load. Taking into account load intensity on cycle ergometer and the heart rate in the end of this load step, the maximal oxygen consumption (VO_{2max}) can be estimated from the nomogram. Three maximal oxygen uptake values (in the end of every load step) were obtained. The average value of the absolute maximal oxygen consumption was calculated. The average value of the absolute maximal oxygen consumption must be multiplied by the "age factor" to correct it in dependence on the age of athlete. This factor is 1.0 for young people (age 20 -30 years). The relative maximal oxygen uptake must be calculated dividing VO_{2max} by the body mass: Rel.VO_{2max} (ml / kg ▪ min.) = VO_{2max} (l/min.) ▪ 1000/ m (kg); where m- athlete's body mass in kilograms.

The heart rate is monitored at rest, during the load test and four minutes during cooling – down exercises. The arterial blood pressure is measured every three minutes during all test and cooling – down period.

Research included the measurement of maximal height and power of the squat jump. The squat jump is performed from the standing position and before to jumping squat is performed until the knee is flexed approximately to 90˚ and hands on hips. The highest jump from five is taken into account.

The FiTRO Jumper (Fitro, Slovakia) consisting of a special contact switch mattress connected by means of a special interface to a computer is used for jump characteristics measurement (Zemkova & Hamar, 2005). The maximal jump's height in cm and the relative power of it in W/kg are estimated. The legs' muscles strength endurance is determined during 30sec series of jumps on the mattress by determining the jump height diminishing in percentages of the maximal jump height: expressed as a ratio of power decline (Pmax – Pmin/ Pmax) · 100 % are calculated.

The mean values and standard deviations are calculated for all determined characteristics in female lacrosse players and untrained women. The significance of differences between the mean values of two females groups is determined by *t - test* for non equal groups. The differences are considered to be statistically significant at $p<0.05$. The SPSS version 20 programs were used for statistical analysis of the data.

Results

The mean absolute and relative maximal oxygen consumption was significantly greater in the female lacrosse players in comparison with these characteristics in the untrained females, Table 2.

Table 2

Comparison of physical characteristics in female lacrosse players and untrained women

Aerobic and anaerobic characteristics	*Lacrosse players*	*Untrained women*	*Significance of difference*
Absolute maximal oxygen consumption, l/ min.	2.69 ± 0,42	2.21 ± 0,27	Significant p = 0.003
Relative maximal oxygen consumption, ml / kg·min	43 ± 4	34 ± 6	Significant p = 0.001
Maximal heart rate during the load test, beats per minute	165 ± 3	168 ± 2	None significant p = 0.310
Recovery of heart rate during four minutes cooling – down period after the load test in comparison with the maximal heart rate in the test,%	69 ± 3	73 ± 4	Significant p = 0.005
Maximal arterial blood pressure during the load test, mm Hg	164/ 89	178/ 98	Significant p = 0.019
Arterial blood pressure four minutes after exercise test, mm Hg	130/ 70	140/ 80	None significant p = 0.516
Maximal vertical jump height, cm	23.5 ± 4.0	19.1 ± 3.2	Significant p = 0.01
Maximal mean power developed in vertical jump test, W / kg	16 ± 5	11 ± 1	Significant p = 0.007
Fatigue index in strength endurance test of 30 s vertical jumps series, %	70 ± 13	63 ± 12	None significant p = 0.207

Recovery of the heart rate from its maximal value during the test to the cooling-down period of four minutes was faster in lacrosse players than in untrained persons. The mean arterial blood pressure after four minutes of recovery time returned to normal rest values in lacrosse players, as well as, untrained females.

The mean maximal vertical jump height and the mean jump power were significantly higher in lacrosse players in comparison with the control group females, Table 2. The mean fatigue index differences in the trained and untrained female groups were not significant, which can be explained by large variation of the results in both groups.

Discussion

The anthropometric characteristics of our female lacrosse players (the mean height 169.4 ± 3.0 cm, body mass - 62.6 ± 6.0 kg and the mean body mass index - 22.6 ± 2.0 kg/m^2) are similar with the data of other investigators. The participants in the study of Enemark-Miller et al. (2009) were 163.2 ± 25.6 cm tall and weighed 64.7 ± 9.6 kg. Descriptive statistics of Vescovi et al. (2007) showed the mean height of female lacrosse players - 168.3 ± 5.9 cm and body mass - 64.7 ± 6.9 kg. The Division I female players weighted more for approximately two kilograms in comparison with our players. This is possible to explain by increased muscle mass that is associated with improved athletic performance in Division I female players in comparison with our amateur level players.

Results of other authors (Enemark-Miller et al., 2009; Vescovi et al., 2007) showed that lacrosse players were above average for most tests when compared to normative data. For a population of women ages 18 - 25, the relative maximal oxygen consumption's score between 38 and 41 ml/ kg • min. is considered "average" aerobic fitness (Wood, 2012). The mean relative oxygen consumption in our females control group (34.0 ± 6.0 ml/ kg • min.) is slightly lower in comparison with these score values.

Fitness characteristics of lacrosse players are found to be similar to those previously found in women's basketball and soccer players. For example, the mean relative oxygen consumption in female soccer players from data of different researchers varies from 38.6 to 57.6 ml/ kg · min (Stolen et al., 2005). The mean relative oxygen consumption in our amateur female lacrosse players (43.0 ± 4.0 ml/ kg · min) is in this range. Our data are in good agreement with this characteristic in lacrosse athletes included Division I female players 45.7 ± 4.9 ml/ kg · min. (Enemark-Miller, Seegmiller, & Rana, 2009) and 46.8 ± 4.4 ml/ kg · min. (Vescovi, Brown, & Murray, 2007).

Anaerobic vertical power can be measured effectively with the vertical jump test (Gutowski & Rosene, 2011). Muscular power and explosiveness rely on both - the force produced and the magnitude, or speed, of the movement (Peterson et al., 2006). Peterson et al. (2006) found a positive correlation between lower body strength and measures of lower body muscular power, such as the vertical jump. Lacrosse players in the other authors study (Enemark-Miller et al., 2009) exhibited significantly higher countermovement jump scores of 44.0 ± 6.2cm, measured by the distance between the height of the highest vane touched and standing vertical touch in comparison with normal vertical jump results for college-aged females based on activity level: 20 – 36cm for sedentary individuals and 38 - 39cm for recreational athletes. Using a countermovement jump, Vescovi et al. (2007) estimated the vertical jump scores of female lacrosse players to be 0.0 ± 5.6cm. Maryland females intercollegiate lacrosse team average countermovement jump height was 39.6 ± 6.4cm (Schmidt M.N. et al., 1981). The maximal vertical squat jump with the hands on the hips in our amateur lacrosse players (23.5 ± 4.0 cm) is significantly higher than in untrained females (19.1 ± 3.2cm). Due to different methods of measurement and kinds of jumps these results are not comparable with the data of Enemark-Miller et al. (2009). Nevertheless to this, seems that vertical explosive power of our players is low in comparison with the female lacrosse players from Division I because the mean squat jump height of our players is twice lower than the countermovement jump height in the USA and Australian Division I teams' athletes. Lacrosse does not directly involve extensive jumping, such as is seen in basketball, but because the vertical jump test has been shown to be a reliable measure of explosiveness, it is expected that similar scores will be measured due to the explosive movements required in lacrosse. Our data can be used to create and improve strength and power training programs of female lacrosse players.

Conclusions

1. The absolute and relative maximal oxygen consumption, as well as, the heart rate recovery from the maximal value to its value after four minutes of cooling – down period in lacrosse players is significantly higher in comparison with untrained women ($p<0.05$). These data confirm that training in lacrosse during two years period reliably increases players' aerobic capacity.
2. The mean maximal vertical jump height and power are also significantly greater in the group of players than in untrained women

($p<0.05$). This means that training in lacrosse reliably increases players' power characteristics.

3. The difference between the mean strength endurance in 30 s jumps series in the groups of athletes and untrained persons is none significant ($p>0.05$). This can be explained by large variation of the results in both groups. The recommendation for the coach of LASE/ taxi Lady female amateur lacrosse team is to emphasize the strength and power exercises in this training program.

References

1. Astrand, P.O., & Rodalh, K. (1977). *Textbook of Work Physiology. Physiologic Bases of Exercise*, 2nd Edition. (pp.349 – 353). New York: MsGraw-Hill Book Co., USA.
2. Bovell, D., Nimmo, M. & Wood, L. (1996). Exercise. In: D. L. Bowell (Ed.) *Principles of Physiology. A Scientific Foundation of Physiotherapy* (pp.185-223). WB Saunders Company Ltd, United Kingdom.
3. Bruce, R.A., Kusumi, F., & Hosmer, D. (1973). Maximal Oxygen Intake and Nomographic Assessment of Functional Aerobic Impairment in Cardiovascular Disease. *American Heart Journal*, *85*, 545–572. DOI: org/10.1016/0002-8703 (73)90502-4
4. Enemark-Miller, E. A., Seegmiller, J. G., & Rana, S. R. (2009). Physiological Profile of Women's Lacrosse Players. *The Journal of Strength and Conditioning Research*, *23* (1), 39-43. DOI: 10.1519/JSC.0b013e318185f07c
5. Fox, E. L. (1984). *Sports Physiology*. Philadelphia: Saunders.
6. Gutowski, A. E. & Rosene, J. M. (2011). Preseason Performance Testing Battery for Men's Lacrosse. *Strength and Conditioning Journal*, *33* (2), 16-22. DOI: 10.1519/SSC.0b013e318208cb04
7. Mathews, E.M., & Wagner, D.R. (2008). Prevalence of Overweight and Obesity in Collegiate American Football Players by Position, *Journal of American College of Health*, *57* (1), 33–38. DOI: 10.3200/JACH.57.1.33-38
8. Peterson, M. D., Alvar, B. A., & Rhea, M. R. (2006). The Contribution of Maximal Force Production to Explosive Movement Among Young Collegiate Athletes. *Journal of Strength and Conditioning Research*, *20* (4), 867-873. PMID: 17194245
9. Pistilli, E. E., Ginther, G. & Larsen, J. (2008). Sport-specific Strength-training Exercises for the Sport of Lacrosse. *Strength and Conditioning Journal*, *30* (4), 31-38. DOI: 10.1519/SSC.0b013e31817d1cf7

10. Schmidt, M. N., Gray, P., & Tyler, S. (1981). Selected Fitness Parameters of College Female Lacrosse Players. *Journal of Sports Medicine, 21*, 282–290. PMID: 7321560
11. Siconolfi, S. F., Cullinane, E. M., Carleton, R. A., & Thompson, P. D. (1982). Assessing VO2max in Epidemiologic Studies: Modification of the Astrand Rhyming test. *Medicine and Science in Sports and Exercise, 14* (5), 335 – 338. PMID: 7154887
12. Steinhagen, M. R., Meyers, M. C., Howard, H. E., Noble, L. & Richardson, M. T. (1998). Physiological Profile of College Club-sport Lacrosse Athletes. *Journal of Strength and Conditioning Research*, *12* (4), 226-231.
13. Stolen, T., Chamari, K., Castagna, C., & Wisloff, U. (2005). Physiology of Soccer. An Update. *Sports Medicine, 35* (6), 501-536. DOI: 0112-1642/05/0006-0501/$34.95/0
14. Vescovi, J. D., Brown, T. D., & Murray, T. M. (2007). Descriptive Characteristics of NCAA Division I Women Lacrosse Players. *Journal of Science and Medicine in Sport, 10* (5), 334-340. PMID: 16962826
15. Wood, R. (2012). VO2 max norms. Retrieved April 12, 2012, from Topend Sports: http://www.topendsports.com/testing/vo2norms.htm
16. Zemkova, E., & Hamar, D. (2005). Jump Ergometer in Sport Performance Testing. *Acta Universitatis Palacki., Olomuc., Gymn., 35* (1), 7 – 16.

Submitted: April 2, 2013
Accepted: November 27, 2013