RESEARCH ARTICLE

Physiological Profile versus Fencing Performance in Elite Indian Male Fencers.

Authors
Madhu Bhatt, MB:BS, MD, Email: madhubhtt@gmail.com
Ex Head, Department of Sports Medicine, Armed Forces Medical College, Pune, India.
Anup Krishnan, MB;BS, DSM, PhD, Email: faujidoc@rediffmail.com
Ex Head, Sports Sciences Faculty, Army Sports Institute, Pune, India.
Vishal Sharma, MB;BS, MD, Email: vishalderma@gmail.com
Military Hospital, Garhi Cantt, Dehradun – 248007, UK, India.
Chandrasekhara Guru, MB:BS, MD, Assistant Professor, Department of Sports Medicine, Armed Forces Medical College, Old Solapur Road, Pune, India. Email: drscsguru@gmail.com
Deep Sharma, MB:BS, MD, Email: deepsharma33@rediffmail.com
Head, Department of Sports Medicine, Armed Forces Medical College, Pune, India.
Sunil Jhajharia, MB:BS, MD, Senior Resident, Department of Sports Medicine, Armed Forces Medical College, Old Solapur Road, Pune, India. Email: jhajhariadr@gmail.com
Krishan Singh, MB:BS, MD, Email: krishansingh14@gmail.com
Command Hospital (Southern Command), Pune, India.
Corresponding author: -
Col (Dr) Anup Krishnan
Military Hospital, Garhi Cantt, Dehradun – 248007, UK, India.
Mobile- 9158999169
Email- faujidoc@rediffmail.com
Study conducted at:- Army Sports Institute, Pune, India.

Abstract

Background: Fencing is a combat sport influenced by psychomotor abilities, explosive power and physical endurance. It requires anaerobic performance in bouts and aerobic performance to reach the tournament finals. The study was conducted to analyse the physiological profile of elite Indian male fencers in terms of anthropometry, aerobic fitness, anaerobic fitness and Fencing scores.

Methods: 37 elite male fencers of a Sports institute volunteered to be part of the study.

Results: Fencing score was significantly positively correlated with sports age (r=0.510, p=0.001) and Standing broad jump (SBJ) (r=0.408, p=0.012). Further, sports age and fencing scores were significantly positively correlated with national medals (r=0.610, p<0.0001), (r=0.659, p<0.0001) and international medals (r=0.532, p=0.001), (r=0.500, p=0.002) respectively. On Multiple Regression analysis, Sports age (β=1.300, 95% CI=0.437, 2.162), VO_2max (β=0.753, 95% CI=0.266, 1.240) and fencing score (β=10.488, 95% CI=3.919, 17.058) were significant predictors of national medals. Height (β=0.069, 95% CI=0.025, 0.113), standing broad jump (β= -3.519, 95% CI= -5.731,-1.308), shuttle speed (β= -1.257, 95% CI= -5.731, -1.308) and fencing performance (β=1.235, 95% CI=0.410, 2.060) were significant predictors of international medals.

Conclusion: Sports age and SBJ can predict fencing performance. VO_2 max can predict national medals and height was a significant predictor of international medals won.

Key words: Physiological profile, Performance, Elite fencers

1. Introduction

Fencing is a physically and mentally challenging sport which involves offensive and defensive movements with a sword. The fencers' ability to act and react to opponent's sudden and unexpected movements is an important factor in success. In Fencing, a powerful lunge is key to a successful touch that counts towards the score. Power and velocity of Fencing lunge, opponents timing and actions, distance between fencers, strategy / intent of the opponent are other factors also affecting overall performance score[1,2,3].

Fencing is an intermittent sport characterized by high intensity but short duration of bursts of activity. It is an anaerobic sport that demands aerobic fitness to sustain the number of bouts required to be performed to reach the finals in the tournament. Since the tournaments are spread over the day consisting of multiple bouts, hence the relevance of assessing fencers for their endurance levels and including the same in their training schedules is important. Studies have reported that although the aerobic capacity of fencers (52.9ml/Kg/min) is greater than sedentary population (42ml/Kg/min), it is lower than that of aerobic endurance athletes, therefore concluding that high VO2max has a relatively small role in Fencing [4]. Contrary to this, Stewart et al concluded that a high degree of cardiorespiratory fitness is a prerequisite for successful Fencing [5]. They found that VO2 max, VE max & 2 Km run accounted for more of the explained variance in their fencing subjects. Anthony turner and his coworkers in their review article on Fencers have reiterated the importance of strength and conditioning training in Fencers [6].

Explosive power of lower limbs is important during attacks and counterattacks in a fencing event [7]. Hence assessment of anaerobic test parameters and their monitoring is relevant for fencers. Researchers in the past have examined the usefulness of biomechanical and physiological indices recorded for estimation of adaptation levels [8, 5]. There is scarcity of data available on physiological profile of Indian elite fencers. Hence the present study endeavors to assess fitness profile of Indian elite fencers. The objectives of the present study were to study aerobic fitness, anaerobic fitness, other physiological profile parameters and their correlation with performance score. The data so obtained can serve as a baseline to be used by exercise physiologists, coaches, training academies to set targets/predict medal tally / podium positions for their trainee fencers.

2. Material and Methods

2.1 Study Design and Subjects: This Cross-sectional study was conducted in an elite training institute with residential facility for sportsmen, participating at national or higher level. Ethical clearance and approval was obtained from the institute's ethical committee. The fencers, their coaches and trainers were informed about the study and its implications. Inclusion criteria for subject participation were: Elite Male fencers who were involved in fencing for a minimum of 06 months of regular training and had participated in national (equivalent) or higher level of fencing competition were included in the study. Exclusion criteria for subject participation were: Fencers with history of hospitalization or not having participated for more than 02 weeks in last three months due to any reason were excluded from the study. In addition any fencer not found fit to undergo the test on the test days was also excluded from the study. Informed consent was obtained from 37 male fencers who volunteered to be part of the study and also fulfilled our exclusion and inclusion criteria. Sample size calculation was not done with a view of including as many Elite fencers as possible as multiple variables were being studied and to reduce selection bias.

2.2 Data Collection and variables measured: All data was collected over one week for each subject. Anaerobic fitness was assessed using 30 sec Wingate test [8, 9, 10, 11] and Standing broad Jump (SBJ) [12]. Aerobic fitness was estimated using Canadian shuttle test [13, 14] and also measured by Astrand test [15, 16]. On day 1 anthropometry, SBJ and Wingate test were performed. Canadian shuttle test for VO2max was performed on day 2. Astrand test for VO2 max was performed on day 3. Fencing score was assessed on day 4. The order of testing was randomized to negate the practice effects and enough time was given for recovery.

Anthropometric parameters included height (cm), weight (kg), lean body mass (%) and body fat (%). Anaerobic performance was measured through Wingate test (lower limbs) performed in a sports science lab. Data was measured in terms of peak power (Watt/kg) and mean power (Watt/kg). Relevant motor qualities were measured through various physical tests namely shuttle speed test (30 m S/S; m/sec), SBJ (cm) , sit and reach test (cm), push-ups and squat in numbers per unit time. Aerobic capacity was measured as VO2max (ml/min/kg) using Canadian shuttle test and VO2 (ml/min/kg) using Astrand test. Fencing performance was measured as fencing score, which was calculated as the ratio of touches served and touches received. The fencing score greater than one indicated that the touches served were more than the touches received by the fencer. Number of medals won in national and international games was considered as another measure of performance.

3. Test Procedures

3.1 Wingate Test Protocol: Lower body Wingate test was performed using Monark 894e Lower body cycle ergometer. The protocol consisted of warm up, test procedure and cool down. The warm up was done on a Monark 894e Lower body cycle ergometer to promote more specific physiological and motor adaptation. After the warm up, 3 minutes of rest was given to eliminate fatigue. With the command "START," subjects had to pedal as fast as possible against a low resistance to overcome the inertial and frictional resistance of the flywheel. A predetermined load of 75 gm/Kg was applied and the subjects were asked to maintain maximal speed throughout the 30s period. As soon as resistance was applied, the counting of revolution began automatically and lasted exactly 30s. Verbal encouragement was given throughout the test, especially during the last 10 to 15s when discomfort is maximum and more willpower is needed. To cool down, 2-3 min of pedaling against a light resistance immediately following the test was done.

3.2 Standing Broad Jump Protocol: The athlete stood behind a line marked on the ground with feet slightly apart. A two foot take-off and landing was used, with swinging of the arms and bending of the knees to provide forward drive. The subject was instructed to jump forwards and land on both feet without falling backwards. The measurement was taken from take-off line to the nearest point of contact on the landing (back of the heels). The longest distance jumped i.e. the best of the three attempts were recorded.

3.3 Canadian Shuttle test: This test involves continuous running between two lines 20m apart in time to recorded beeps. For this reason the test is also often called the 'beep' or 'bleep' test. The time between recorded beeps decreases each minute (level).

A record was kept of the level attained by the athlete before they were unable to keep up with the audio recording. This score is converted to a VO_2max equivalent score using the normogram. Logistics required include flat, non-slip surface, marking cones, 20m measuring tape, shuttle run CD, CD player and recording sheets.

3.4 Astrand Test: The test was performed using MONARK Bicycle Ergometer with software, Metronome, Polar Heart Rate Monitor, Weight scale and Stop watch. Personal details of the subject including weight, height, blood pressure, pulse rate were entered in the software. The subjects were asked to pedal the bicycle ergometer for 6 min at 60 rpm against the work load keeping heart rate between 120 to 170 bpm. Astrand- Ryhming normogram was used for calculation of VO2 max.

3.5 Fencing scoring: Fencing performance was measured as fencing score, which was calculated as the ratio of touches served and touches received Points are scored by touching or 'hitting' opponents with the tip or blade of the sword, which is wired to a buzzer that sounds to indicate contact on a valid target area i.e. the trunk of the body (Foil), everything above the waist excluding hands (Sabre), and the entire body (Epee).

4. Statistical analysis

All statistical analysis was done in SPSS version 20.0 for Windows (SPSS Inc., Chicago, IL). Statistical significance was set at $p \leq 0.05$. Summary statistics including mean and standard deviation were calculated for anthropometric parameters, anaerobic capacity, lower body strength parameters. Pearson's correlation was used to assess correlation of various variables measured among fencers.

Multiple regression analysis was done to identify relative importance of various variables in explaining the variance in fencers' i.e their role in predicting fencing performance in national and international games. Three different Multiple regression models were developed; fencing score was considered as an outcome or dependent variable in the first model. In second model, medals won in national games was dependent variable and in third model, dependent variable was medals won in international games. In all three models, anthropometric parameters, aerobic capacity, lower body strength were considered as predictor variables.

5. Results

Mean age of male fencers was 22.7 ± 4.65 yrs (SD=), height was 174.1 ± 6.98 cm, weight was 68.3 ± 8.93 kg and sports age was 6.9 ± 3.01 years. Fencing score was significantly positively correlated with sports age (r=0.510, p=0.001) , standing broad jump (r=0.408, p=0.012) but it was negatively correlated with agility (r= - 0.386, p=0.018) . Further, sports age and fencing scores were significantly positively correlated with the number of medals won in national (r=0.610, p<0.0001), (r=0.659, p<0.0001) and international games (r=0.532, p=0.001), (r=0.500, p=0.002) respectively.

Fencing score was found to have weak and statistically insignificant positive correlation with relative peak power (r=0.249, p=0.137). Pearsons correlation between VO2max (Canadian shuttle test) or VO2 (Astrand Test) and Fencing score was found to be weakly positive but statistically insignificant (r = 0.095; p=0.577, r = 0.085; p=0.616) respectively. Correlations between other variables measured were not statistically significant as shown in Table 1.

Table 1 : **Pearsons Correlation Coefficient between the measured variables.**

		National medals won	International medals won	Fencing score (Touches served/ touches received)
National medals won	Pearson Correlation	1	.611**	.659**
	Sig. (2-tailed)		.000	.000
	N	37	37	37
International medals won	Pearson Correlation	.611**	1	.500**
	Sig. (2-tailed)	.000		.002
	N	37	37	37
Age (Years)	Pearson Correlation	-.055	.110	.189
	Sig. (2-tailed)	.747	.516	.263
	N	37	37	37
Sports Age (Years)	Pearson Correlation	.549**	.429**	.510**
	Sig. (2-tailed)	.000	.008	.001
	N	37	37	37
Height (cm)	Pearson Correlation	-.047	.316	.112
	Sig. (2-tailed)	.780	.056	.511
	N	37	37	37
Weight (kg)	Pearson Correlation	.096	.280	.316
	Sig. (2-tailed)	.573	.093	.057
	N	37	37	37
Lean body mass (%)	Pearson Correlation	-.046	-.019	-.139
	Sig. (2-tailed)	.785	.911	.413
	N	37	37	37
Fat (%)	Pearson Correlation	.056	.024	.148
	Sig. (2-tailed)	.741	.890	.381
	N	37	37	37
Agility	Pearson Correlation	-.150	-.211	-.386*
	Sig. (2-tailed)	.375	.211	.018
	N	37	37	37
30 m S/S	Pearson Correlation	-.106	-.238	-.194
	Sig. (2-tailed)	.531	.157	.249
	N	37	37	37
Standing Broad Jump (SBJ) (m)	Pearson Correlation	.089	.073	.408*
	Sig. (2-tailed)	.601	.669	.012
	N	37	37	37
Flexibility	Pearson Correlation	.011	-.035	.107
	Sig. (2-tailed)	.950	.835	.528
	N	37	37	37
Push Up 10"	Pearson Correlation	-.069	.019	.190
	Sig. (2-tailed)	.684	.913	.260
	N	37	37	37
Squat 10"	Pearson Correlation	.101	-.276	.113
	Sig. (2-tailed)	.553	.099	.505
	N	37	37	37
VO2 Max (ml/min/kg) (Canadian)	Pearson Correlation	.320	.073	.095
	Sig. (2-tailed)	.053	.668	.577
	N	37	37	37
VO2 (ml/min/Kg) (Astrand)	Pearson Correlation	.275	.161	.085
	Sig. (2-tailed)	.100	.341	.616
	N	37	37	37
Relative peak power (Watt/kg)	Pearson Correlation	.226	.156	.249
	Sig. (2-tailed)	.178	.357	.137
	N	37	37	37
Relative Mean power (Watt/kg)	Pearson Correlation	.168	.104	.231
	Sig. (2-tailed)	.321	.538	.170
	N	37	37	37

In first multivariate regression model, as shown in Table 2, sports age (β=0.060, 95% CI=0.024, 0.096) and standing broad jump (β=0.854, 95% CI=0.160, 1.548) were significant predictors of fencing score. For every one year increase in sports age, a 0.06 unit increase in fencing score is predicted, holding all other variables constant. For every meter increase in standing broad jump, a 0.854 unit increase in fencing score is predicted, holding all other variables constant.

Table 2 : First Model ; Dependent variable - Fencing score (R=0.612, Adjusted R2=0.338)

Predictor Variables	Unstandardized Coefficients β	Standardized Beta Coefficients	p-value	95% CI for β
Constant	-1.604		0.071	-3.353, 0.145
Sports Age (years)	0.060	0.461	0.002	0.024, 0.096
Standing Broad Jump (SBJ) (m)	0.854	0.343	0.017	0.160, 1.548

In the second model, as shown in Table 3, sports age (β=1.300, 95% CI=0.437, 2.162), VO2max (β=0.753, 95% CI=0.266, 1.240) and fencing score (β=10.488, 95% CI=3.919, 17.058) were significant predictors of the medals won in the national games. For every one year increase in sports age, a 1.3 unit; every 1 ml/min/kg increase in VO_2max, a unit 0.753; and every unit increase in fencing score, a 10.488 unit increase in fencing score is predicted, holding all other variables constant.

Table 3 : Second Model; Dependent variable - Medals won in national games (R=0.782, Adjusted R2=0.577)

Predictor Variables	Unstandardized Coefficients β	Standardized Beta Coefficients	p-value	95% CI for β
Constant	-51.308		0.001	-79.241, -23.374
Sports Age (years)	1.300	0.402	0.004	0.437, 2.162
VO2 Max (ml/min/kg)	0.753	0.357	0.004	0.266, 1.240
Fencing score	10.488	0.420	0.003	3.919, 17.058

In the third model, as shown in Table 4, height (β=0.069, 95% CI=0.025, 0.113), standing broad jump (β= -3.519, 95% CI= -5.731,-1.308), shuttle speed (β= -1.257, 95% CI= -5.731, -1.308) and fencing skill (β=1.235, 95% CI=0.410, 2.060) were significant predictors of the medals won in the international games. However, sports age (β=0.081, 95% CI= -0.190, 0.180) was not significant, still included in the model as it gave the highest correlation (R=0.732) between observed and predicted values of the medals won in the international games.

Table 4 : Third Model; Dependent variable - Medals won in national games (R=0.782, Adjusted R2=0.577)

Predictor Variables	Unstandardized Coefficients β	Standardized Beta Coefficients	p-value	95% CI for β
Constant	0.946		0.839	-8.486, 10.378
Sports Age (years)	0.081	0.248	0.108	-0.019, 0.180
Height (cm)	0.069	0.492	0.003	0.025, 0.113
Standing Broad Jump (SBJ) (m)	-3.519	-0.562	0.003	-5.731, -1.308
Shuttle speed	-1.257	-0.287	0.048	-2.502, -0.013
Fencing score	1.235	0.492	0.005	0.410, 2.060

6. Discussion

In the present study, significant positive value of Pearsons correlation is found between sports age and fencing score (0.510; p=0.001) and also between Standing Broad Jump and Fencing score (r=0.408, p=0.012). This shows that fencing score increased with an increase in sports age and standing broad jump. An increase in fencing skill yielded in winning more national and international medals. Agility was negatively correlated with the fencing score indicating that if agility was more, then touches received were more. Tsolaski C and Vagenas A in their project found no statistically significant differences in anthropometric parameters of their elite and sub elite fencers [17] but found significant differences in time for lunge and shuttle which are dependent on maximum strength and power of lower limbs. This corroborates our finding of significant positive correlation between SBJ (a measure of lower limb strength) and fencing score in our subjects.

The present study did not find significant positive correlation between aerobic fitness variables i.e. VO2max and VO2 though some of the studies in the past have found that cardio respiratory fitness variables of VO2max and VEmax accounted for the greatest variance in Fencers [5]. In fact their values for VO2max and VO2 were as high as is found in Wrestlers.

On the contrary, other researchers have reported aerobic capacity of their fencers higher than sedentary population but much lower than that of aerobic endurance athletes [4, 18]. These differences could be due to different training schedules followed by the respective sports centers and also due to inadequacy of conventional tests in mimicking the actual load during the fencing bout. Weichenberger et al found very significant positive correlation between fencing specific endurance tests (FET) and fencing bouts variables [19].

They found very weak correlation between fencing bouts variables measured during conventional cycle ergometry and treadmill testing. This is possibly because FET allows better assessment of physical demands during bouts than when tested by ergometry or treadmill testing.

Physical demands of fencing and performance are subject to challenges from opponent side. Hence it is difficult to establish significant relationship between physiological characteristics and performance singularly.

7. Conclusion

Fencing skill can be predicted from sports age and standing broad jump. VO_2max was significant predictor of the number of medals won at national level games and height was significant predictor of medals won at international level and not national level games. Fencing performance is determined not by single factor alone but by a multitude of factors. The results of this study may be used in talent identification and performance predictions. Further research with larger sample sizes and mixed population is needed to further corroborate/negate our findings.

Acknowledgements

Col PS Cheema, SM, VSM,
Commandant, Army Sports Institute, Pune, India.

Mrs Uma Mahajan,
Consultant Biostatistician, Army Sports Institute, Pune, India.

Conflict of Interests

The authors have none to declare.

References

1. Zhang BM, Chu DPK, Hong Y. Biomechanical analysis of the lunge technique in elite female fencers. Abstracts from ISBS symposium XVII. 1999. http://www.education.ed.ac.uk/isbs. arc99/2.html.
2. Fiegel CNG, House PD, Zupan MF.The effect of nonleading foot placement on power and velocity in the fencing lunge. J Strength Cond Res. 2013; 27(1): 57-63.
3. Bottoms L, Greenhalgh A, Sinclair J. Kinematic determinants of weapon velocity during the fencing lunge in experienced epee fencers. Acta of Bioengineering and Biomechanics. 2013; 15(4): 109-113.
4. Roi G, Bianchedi D. The science of fencing. Implications for performance and injury prevention. Sports Med. 2008; 38: 465 – 481.
5. Stewart KJ, Peredo AR, Williams CM. Physiological and morphological factors associated with successful fencing performance. J Human Ergol. 1977; 6: 53-60.
6. Turner A, Miller S, Stewart P, Cree J, Ingram R, Dimitriou L, Moody J, Kilduff L. Strength and conditioning for fencing. Strength Cond J. 2013; 35(1): 1-9.
7. Obminski Z, Ladyga M, Czapowska JS, Borkowski L. Physiological and biomechanical symptoms of physical adaptation to anaerobic and endurance exercises after 3 month period of increased sport activity in female fencers. Journal of combat sports and martial arts 2011; 1(2):13-18.
8. Inbar O, Bar-Or O, Skinner JS. The Wingate Anaerobic Test. Human Kinetics; 1996.
9. Hubner-Wozniak E, Kosmol A, Błachnio D. Anaerobic capacity of upper and lower limbs muscles in combat sports contestants. J Combat Sport Martial Arts. 2011; 2(2): 91–94.
10. Gierczuk D, Hübner-Wozniak E, Długołêcka B. Influence of training on anaerobic power and capacity of upper and lower limbs in young greco-roman wrestlers. Biol Sport. 2012;29(3):235–239.
11. Inbar O, Bar-Or O. Anaerobic characteristics in male children and adolescents. Med Sci Sports Ex. 1986; 18(3): 264-269.
12. Pinero JC, Ortega FB, ArteroEG, Rejoin MJG, Mora J, Sjostrom M, Rutz JR. Assessing muscular strength in youth: usefulness of standing long jump as ageneral index of muscular fitness. J Strength Cond. Res 2010; 24(7): 1810-1817.
13. Ramsbottom R, Brewer J, Williams C. A progressive shuttle run test to estimate maximal oxygen uptake. Br J Sports Med. 1988; 22(4): 141-144.
14. Leger LA, Lambert J. A maximal multistage 20m shuttle run test to predict VO_{2max}. Euro J Appl Physiol. 1982; 49: 1-5.
15. ASTRAND PO, RYHMING I. A nomogram for calculation of aerobic capacity (physical fitness) from pulse rate during submaximal work. J Appl Physiol. 1954: 7: 218-221.
16. Mackenzie B. (2007) Astrand 6 minute Cycle Test [WWW] Available from: https://www.brianmac.co.uk/cycle6min.htm accessed 30/5/2017].
17. Tsolakis C, Vagenas. A. Anthropometric, Physiological and Performance Characteristics of Elite and Sub-elite Fencers. Journal of Human Kinetics. 2010; 23: 89-95.
18. Vander LB, Franklin BA, Wrisley D, Scherf J, Kogler AA, Rubenfire M. Physiological Profile of National-Class

National Collegiate Athletic Association Fencers. JAMA. 1984;252(4):500-503.
19. Weichenberger M, Liu Y , Steinacker JM. A test for determining endurance capacity in fencers. Int J Sports Med. 2012; 33: 48 – 52.

