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Original article

Correlation between Lower Limb Power and Agility on Hand Grip Strength in three Different Positions in Young Fencers

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Abstract

Background: Fencing is an open skilled combat sport, which requires grip strength, core strength and lower limb strength. ***Aim:*** To determine the correlation between lower limb power, agility and core on hand grip strength in three different positions - On-guard, Lunge and Defence in young fencers. ***Methodology:*** A correlational study was carried out on 23 young fencers in the age group of 14-25 years of age as per the inclusion and exclusion criteria. The outcome measures recorded were - The Standing Broad Jump test, 7-5-5-7 Agility test, Side Plank test - Right and Left, Hand grip strength in On-guard, Lunge and Defence. ***Results:*** It showed significant positive excellent correlation between lower limb power on hand grip strength in three different positions, significant negative moderate correlation between agility and hand grip strength in three different positions and significant positive moderate correlation between core stability and hand grip strength in three different positions. ***Conclusion:*** There is a significant correlation between lower limb power, agility and core on hand grip strength in three different positions in young fencers.

Keywords: ***Physiotherapy, Fencing, Strength, Agility, Core, Grip strength.***

Introduction

Fencing is an open skilled combat sport first practiced indoors in Spain in the 16th century by both males and females in which two athletes fight indirectly through their weapons and physical contact is forbidden [1]. It has been modified and developed over the years and also features in Olympics since 2004 [2,3]. While playing the game, a player is required to wear particular costumes essential for safety measures. The fencing equipment includes - Uniform, Jackets, Underarm Protectors, Gloves - Electric/Non-Electric, Shoes and Socks, Weapon & Chest Protectors [4]. As Fencing is a very technically and strategically demanding sport, there are certain pre-requisites that are evaluated in the players to determine their level of fitness. These parameters include - Strength and Power, Flexibility, Agility, Core Strength, Balance, Reaction time, Hand grip Strength, Proprioception, anthropometric measures, psychological and other factors.

In this study the parameters to be assessed are - Hand Grip strength in three different positions- On-Guard, Lunge and Defence, lower limb power using - The Standing Broad Jump test, Agility using 7-5-5-7 Agility test and core strength using the Side Plank test. The 3 most frequently used positions in the game are - On-Guard, Lunge and Defence. In OnGuard position - the feet are shoulder width or more apart with the leading foot forward and trailing foot at right angles to it. Finally, the centre of gravity is kept midway between the heels as the knees are bent. This position offers the fencer a well-balanced position. This allows the fencer the ability to use his/her muscles to generate rapid bursts of speed and change of direction with comparative ease. This position decreases the vulnerable target area for the opponent, especially in 'foil' and 'epee'. Further, and more importantly, balance is maintained and the fencer can move with ease in different directions. Fencer "bounces" in preparation in the on-guard position for attack. This position enables the fencer to rapidly manipulate the base of support and therefore the centre of mass, where the fencer can quickly change the strategy from attack to defence and vide-versa. This ability is fundamental as to cope with an opponent's feint (or indeed attack), a fencer must be able to quickly change from a current or intended action to a new one that can accommodate this. Although perceptual and psychomotor skills highly modify these aspects, a fencer must have the physical requisites to capitalise on these aspects. Exercise protocol, strength and conditioning training which helps in force development and plyometric would be beneficial given the Bounce, semi-squat position, change of direction and speed [5].

International federation of fencing defines Lunge as - "the attack is the initial offensive action made by extending the arm and continuously threatening the opponent's target, preceding the launching of the lunge or fleche." Fencer starts the attack by extending the arm with the sword which is associated with extension of the knee of the rear leg after which the fencer moves forwards or backwards [6].

Fencer needs hits on the opponents in order to score and win a game in Fencing, but it also vital to defend against these hits and touches. Fencer deflects the opponent's blade in "Parry" which is the most frequently used with a retreat and riposte is where there is a quick responsive thrust forward. The fencer should take a few steps backwards in a retreat to save himself/herself when the opponent lunges forward to attack. The closet part of the blade is used to deflect the opponent's blade away from the target area [7]. Grips have been developed by master sword makers over the centuries to uniquely address different facets of fencing and was influenced by different styles adopted by fencers. In modern fencing there are two primary grips in Modern Fencing - Pistol grip and French grip. The description and the advantages and disadvantages of the grips are available in the other texts [8,9].

Standing Broad Jump test is a common test to measure the explosive lower limb power and is easy to administer [10]. The standing long jump was also once an event at the Olympic Games and in Sports Hall competitions in the UK. Analysis is done by comparing it with the athlete's previous results for this test. It is expected that with appropriate training between each test, the analysis indicates an improvement in the athlete's lower limb strength. Agility has been defined as the sudden movement of the whole body by changing speed or direction in response to a specific stimulus [11]. Agility is an important and valid parameter used in evaluation of sports performance measurement batteries [12]. The quality of agility requires the partnership of speed, balance power and coordination [13]. Fencing provides two main types of stimuli - tactile and visual, as evidenced by Borysiuk and Waskiewicz [4]. It therefore becomes essential to note that there are important factors affecting fencing performance. These parameters include - Inter-muscular co-ordination, technical level, Tactics, Physiological aspects [15]. The agility test used in this is 7-5-5-7 agility test. It uses the exact same footwork used by the fencers in the sport. It gives a precise information regarding the ability of the fencer to quickly change the direction in a smooth manner and the speed of the footwork [16-18].

The core is the centre of our body. The main functional significance during movement is to stabilize the trunk while the extremities move in different patterns. Studies have strongly suggested that strong core prevents injuries and allows a person to improve his/her performance. The side plank test is typically a measure of core endurance. In this position the participant braces themselves in a neutral and extended side lying position on the forearm, keeping the elbow directly below the shoulder. The top leg and trunk is raised and the participant tries to hold this position as long as possible without affecting the quality of position as shown in the figure. The other side is tested after a rest pause is given for 5 minutes rest [19,20]. There are many articles on the Physical characteristics determining the performance of fencers, speed of lunge, arm velocity, foot pressures and type of shoes and kinematics of various positions in fencing but there are no articles to our best knowledge studying about the influence of lower limb power, core strength and agility on hand grip strength in different positions acquired during fencing. This topic highlights the importance Kinematic Chain that includes the core strength and stability - which forms the centre and muscular box of kinematic chain and connects the lower limb to upper limb [21]. During explosive movements like, the most common attacking position in fencing - Lunge, the core forms a connection to transfer the lower limb power and strength to the upper limb which helps in the game. This study highlights the effect of agility - quick change of direction of movements frequently found during fencing competitions, Core strength and Lower limb power on Hand Grip Strength which has not been studied earlier. The study will give the coaches, researchers and fencers a practical application and inclusion of a comprehensive approach in their strength and conditioning protocol to improve their performance and hence there is a need to study the same.

Materials and Methods

A cross sectional, correlational study was conducted in a physiotherapy OPD of tertiary health care centre in Mumbai for a duration of 18 months after receiving institutional ethical clearance. We recruited 23 samples using the convenient sampling technique using the sample size formula of n= 〖((Z1+Z2)/Cr)〗^2 Where, r = 0.7357, and considering 15% non-response rate. We included fencing players in the age group of 14-25 years of any gender, having at least 2 years of experience of fencing. Those with a history of any neuromuscular or musculoskeletal injuries in the last 6 months were excluded. Upon screening and receiving informed consent the participants were asked to perform the standing broad jump test, 7-5-5- 7 agility test, side plank test in random order and hand grip was measured using hand dynamometer in three positions - on guard, lunge and defence position.

Outcome Measures

1. The standing broad jump test:
   - A measure of lower body Power, Horizontal explosive power.
   - Instructions to patient "Stand behind the starting line and jump as far as possible while keeping the hands on the hip.
   - Landing should be stable - You should not fall forward and feet should not shuffle.
   - Measure the distance travelled from the back of the heel to the mark of jump.
2. **7-5-5-7 Agility test:**
   - A measure of Change of Direction of Speed using Fencing Footwork, tape Agility.
   - Instructions to the patients- Stand behind the starting line in On-Guard position. Start with the lead toe behind the start line and travel using high frequency footwork as rapidly as possible until you reach 7 meter mark. From here, rapidly change direction and travel back towards 2-meter line mark. Then rapidly change direction and travel forward towards 7 meter mark and end the test by traveling back towards the start line.
   - Measure the time taken by the participant to complete the test.
3. **Side Plank:**
   - A measure of Core stability.
   - Instructions - Athlete lies on his/her side with trainers. Maintain a good alignment with shoulders and between the legs and spine in a slide plank position on bent elbow, feet in touch with the top feet and bring the hips towards the ceiling.
   - Measure the time for which the participant could hold that position, each side
4. **Hand Grip Strength in Different Position:**
   - A measure of Hand grip strength in starting On-Guard position
   - **Instructions:** The athlete maintains an OnGuard, Lunge (Attack) and Defence position with the feet making 90-degree angle with each other, knees slightly flexed, elbows soft a and a Hand Dynamometer is used to measure the hand grip strength of the dominant hand in these three positions.

Data Analysis

Mean and Standard Deviations for the quantitative variables were calculated. Normality of the data was assessed using Kolmogorov-Smirnov test. Since the data did not pass the normality test Spearman Rho's Correlation tests were used. p- Value of 0.01 were considered statistically significant and 95% confidence interval. For the strength of correlation, the following criteria is used: ±0.00 to 0.25 (Little or no relationship), ±0.25 to 0.50 (Fair relationship), ±0.50 to 0.75

(Moderate to Good relationship), Above 0.75 (Good to Excellent relationship)

Results And Discussion

A total of 23 fencers participated in the study based on the inclusion exclusion criteria they had a mean age of 21.7 years ± 1.87years, mean height of 176.04cms ± 5.97cms, mean weight of 70.78kgs ± 9.67 kgs, and a BMI of 22.64kg/m^2 ± 2.43 kg/m^2. Out of 23 players, 18 were male and 5 were females, with 16 having a right hand dominant. 7 players used FOIL and EPEE sword and 9 used sabre. Majority of them had experience 2-3 years (69%). Mean and standard deviation of the hand grips in different positions and also the scores of the various outcome measures are recorded in table 1.

Table 1: Shows the mean and standard deviation of various tests performed by study participants.

Test	Mean	Standard Deviation
Standing Broad Jump- Test	1.70	0.13
Hand Grip Strength - On-Guard	32.60	7.20
Hand Grip Strength - Lunge	31.74	6.97
Hand Grip Strength - Defence	30.91	7.90
7-5-5-7 Agility Test	32.83	5.28
Side Plank Right	31.65	7.45
Side Plank Left	31.35	7.77

Table 2: shows the correlations between The Standing Broad Jump test, 7-5-5-7Agility test, Side plank - Right and Left with Hand Grip Strength in On-Guard, Lunge and Defence.

Variables	Hand grip strength - on- Guard	Hand grip strength -Lunge	Hand grip strength -Defence
STANDING BROAD JUMP TEST	0.861	0.860	0.841
7-5-5-7 AGILITY TEST	-0.650	-0.684	-0.700
SIDE PLANK (RIGTH)	0.852	0.859	0.762
SIDE PLANK (LEFT)	0.725	0.748	0.689

Discussion

The findings of the study were:

1. There is a significant positive excellent correlation between Standing Broad Jump Test and Hand grip strength in On-Guard, Lunge and Defence.
2. There is a significant negative moderate correlation between 7-5-5-7 Agility Test and Hand grip strength in On-Guard, Lunge and Defence
3. There is a significant positive moderate correlation between Side Plank (Right) Test and Hand grip strength in On-Guard, Lunge and Defence.
4. There is a significant positive moderate correlation between Side Plank (Left) Test and Hand grip strength in On-Guard, Lunge and Defence.

Hand grip strength is an indicator of performance and success in athletes [22]. Grip strength is important in various sports - Fencing, Archery, Golf, Hockey, Rock climbing, etc. where hand grip is considered as an informative factor of successfulness and sportsmanship [23,24]. Hence it becomes an important factor in Fencing as a pre-requisite in athletes indicating the upper limb strength as the majority of the game depends on the strategies used by the Fencer with the Sword.

Analysing the biomechanical aspect of these positions, the fencer is the most stable in the On-Guard followed by Lunge and then Defence. According to our study the Hand grip strength is highest in On-Guard position (32.9±7.19), Lunge position (31.73±6.96) and least in the Defence position (30.91±7.9). This study suggests that it will be easier for a fencer with stronger lower limb power to maintain the position and hold the sword firmly to save the point. A fencer cannot afford to deflect even slightly in any position as the opponent can take advantage of that as the fencer's attention is divided to hold the position in saving the target area and the grip on the sword reduces.

Many studies have proved that the values of hand grip strength and standing broad jump test values are higher in athletes than the normal population in the same age group. The strength and conditioning training given to the players helps in building the muscle strength and endurance and thus helps these athletes to enhance their performance [25]. Our study has shown that Lower Limb Power has strong positive correlated to the hand grip strength in different positions. The different positions acquired by the fencers during the game changes the position of the limbs, forces acting on the joint segments, centre of mass and the base of support. In a study done B. N. Davies, performance by young adults in Standing Broad Jump test and strength of Handgrip was linearly related to the lean volume of the limbs involved in performing each of these tests. The study found that there was a significant linear relationship between Strength of handgrip, the lean volume of the forearm and performance in Standing Broad Jump and lean volume of the lower limbs in normal, young, adult men and women which supports the results of this study [26]. A study supporting the results of this study was done by Wang M et al. In his study he concluded that there is a significant correlation between grip strength, back strength and quadriceps strength in healthy females [27]. Frickle et al in his study has also concluded that there is a significant correlation between grip strength and jumping which supports the findings of our study [28]. Hence, this helps us understanding the correlation of the lower limb strength with grip strength in various positions.

In fencing a bout/game, the work to rest ratio is 1:1 and 2:1 in men's and women's epee, respectively, and 1:3 in men's foil. It has also been noted that there is a significantly greater number of directional change while comparing female fencers of high and low technical ability [29]. The number of times a fencer changes the direction also indicates the tactical level. So, in young novice fencers it becomes an important factor in determining the level of sport and it can be used to enhance performance. The most physically demanding aspects of the bout are incurred on changing the direction and attacking on performing a lunge, which makes sit very important as it occurs very frequently. Indeed, the ability to quickly and efficiently use the lunge may be indicative of success. Therefore, regarding the program design, there is a clear need to develop change-of direction speed (CODS), lunge speed, and ability to use

these over a possible 3 rounds of 3 minutes [29]. The results of this study suggests that Agility has a significant moderate negative correlation with hand grip strength in three different positions in younger fencers. The strong correlation between strength, power tasks (r =0.77-0.94) and Agility in fencers which is executed more times compared to other sports motor skills [30]. Tsolakis et al reported that continuous fencing steps with rhythmic changes in direction are activated by Short Stretch Cycles, which in turn influences the subsequent propulsive concentric muscle contraction of the following lunge [31]. These studies supports the results of our study indicating that a fencer with a higher tactical level, faster in change in change of direction has a better performance during the game. It highlights the importance of agility training in fencers to improve their strategies and enhance their performance.

Several authors have proposed that Core is the Fundamental foundation for most of the Kinetic Chain in the Human Body and that it facilitates the torque and momentum between the extremities [32]. Core stability determines the capability of a person to maintain pelvic in a neutral position which is ideal for force production and transfer of forces to the upper and lower limb during dynamic functional activities [33]. Core assists in transferring the load from the centre to the extremities [32,34]. The results of this study has shown a significant positive moderate correlation between core strength and hand grip strength in three different positions and there are various studies done to support this. Athletic performance is built stringer by core providing as very strong base of support - bridge to the entire body. Sports performance will be negatively impacted if the core muscles producing maximal power, but the generated power cannot be transferred. Oliver et al in his study have suggested that shoulder and elbow mobility have become more efficient with gluteal muscle activation.

Also, the lumbopelvic-hip complex plays a major role in instability and energy production and transfer to the upper limb [35]. When grip and locomotion take place simultaneously, it requires co-ordination. Also, a set of impedance components - Effective mass, inertia, damping and stiffness are important in determining the performance like, in upper limb it's responsible for transmission and attenuation of impact forces in tasks of repulsive loading. These factors specifically are relevant to upper limb, lower limb, joint performance and trunk stability seating under dynamic conditions. This impedance is of great interest because of tasks involved like "GRIP" [36]. This study helps us understanding the integration of various physical factors - power, agility and core stability, grip strength in different positions during the Fencing game which can be incorporated into the training protocol to enhance performance and reduce injures. Fencing is a very dynamic sport which requires a player to be strong, quick and effective in his/her moves in order to excel in the game. This study helps us to get a better understanding on the correlation between factors affecting the players grip in different positions. At any point in the game a fencer cannot afford to lose a point during attack or fail to save himself/herself from an attack. This study highlights the correlation between lower limb power, agility and core strength on grip strength in various positions which will help the players to train accordingly to improve their game and enhance their tactics and strategies.

Conclusion

The study shows a significant correlation between lower limb power, agility and core strength with Hand grip strength in three different positions - On-guard, Lunge and Defence in young fencers. The findings in the study shows multiple factors like lower limb explosive power, agility and core strength are important and can affect the grip strength during the various postures attained by a fencer during the game. Hence all these factors should be incorporated in the training protocol to enhance the performance of players and prevent injuries of any kind.

Ethics approval and consent to participate

Ethical approval was taken from the Institutional ethical committee of K J Somaiya College of Physiotherapy, Sion, India. Written informed consent was taking from participants of the study.

Data Availability

Readers can access extra data by contacting the institutional ethical committee or the corresponding author.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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Authors' contributions

PS collected, analysed and interpreted the patient data. AP was guiding at all stages. PS was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

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References

[1] Roi G, Bianchedi D. The science of Fencing. Sports Medicine. 2008;38(6):465-481.
[2] Murgu A. Fencing. Physical Medicine and Rehabilitation Clinic of North America. 2006;17(3):725-736.
[3] World athletics technical rules, official document. In force from 1 november 2019 & amended on 31 January 2020. (https://worldathletics.org)
[4] Barth B. The complete guide to Fencing. Myer & Myer Verlag; 2006.
[5] Turner A, James N, Dimitriou L, et al. Determinants of Olympiv Fencing Performance and implications of Strength and Conditioning Training. J Strength Cond Res. 2014;28: 3001-3011.
[6] Ismail M.F., ASHA M.H., Syahrul R.M., Muscle Activity during lunge for fencers, Man in India, Jan 2017, 97(13):153-158.
[7] Carmen Gutierrez-Cruz C, Rojas J and Davila M. Effect of defence response time during lunge in foil fencing. Journal of Sports Sciences. 2015;34(7): 651-657.
[8] El-gohary T, Abd Elkader S, Al-shenqiti A, Ibrahim M. Assessment of hand-grip and key-pinch strength at three arm positions among healthy college students: Dominant versus non-dominant hand. Journal of Taibah University Medical Sciences. 2019;14(6):566-571.
[9] Shetty M, Balasundaran S, Mullerpatan R. Grip and pinch strength: Reference values for children and adolescents from India. Journal of Pediatric Rehabilitation Medicine. 2019;12(3):255-262.
[10] Wu WF, Porter JM, Brown LE. Effect of attentional focus strategies on peak force and performance in the standing long jump. J Strength Cond Res. 2012;26(5): 1226- 1231.

[11] Hazir T, Mahir O. F, and Acikada C. Sports performance and agility tests. Journal of Human Sciences. 2010;10(1): 1693-1704.
[12] Comuk N and Erden Z. The examination of the effect of games and agility exercises on 10-11-year-old children's processing speed and reaction times. Turkish International Journal of Special Education and Guidance & Counceling. 2010;3(1): 1300-7432.
[13] Chelladurai P. Manifestations of Agility. Journal of the Canadian Association of Health, Physical Education and Recreation. 1976;42(3): 36-41.
[14] Borysiuk Z & Waskiewicz Z. Information processes, stimulation and perceptual training in fencing. Journal of Human Kinetics. 2008;19: 63-82.
[15] Balko S, Rous M, Balko I, Hnizdil J, et al. Influence of a 9-week training intervention on the reaction time of fencers aged 15 to 18 years. Physical Activity Review. 2017;5: 146-154.
[16] Borysiuk Z. The significance of sensorimotor response components on EMG signals depending on the stimuli type fencing. Acta Uni Palacki Olomuc Gymn. 2008;38(1): 43-51.
[17] Gracz J & Tomczak M. Slelected Temporomental Properties and Achievement Motivation of Fencers. Studies in Physical Culyure and Tourism.2008;15(2): 109-118.
[18] Harmenberg J, Ceci R, Baevestad P, et al. Comparison of different tests of fencing performance. International Journal of Sports Medicine. 1991;12(6): 573-576.
[19] Elliott BC, Marshal RN, Noffal GJ. Contributions of upper limb segment during power serve in tennis. J Appl Biomech. 1995;11:433-42.]
[20] Fleisig GS, Barrentine SW, Escamilla RF, Andrews JR. Biomechanics of overhand throwing with implications for injuries. Sports Med. 1996;21:421-37]
[21] Anderson D, Barthelemy L, Gmach R, Posey B, Core Strength Testing: Developing Normative Data for Three Clinical Tests (2013), Doctor of Physical Therapy Research Papers, Paper 21; 1-68.
[22] Williams LR, Walmsley A. Response Amendment in fencing differences between elute and novice subjects. Percept Mot Skills. 2000;91(1): 131-142.
[23] Iermakov S, Podrigalo LW and Jagiello W. Hand Grip strength as an indicator for predicting the success in martial arts athletes. Original Article. 2016;12: 179-186.
[24] Limonta E, Ce E, Gobbo M et al. Motor Unit activation strategy during sustained isometric contraction of finger flexor muscles in elite climbers. J Sports Sci. 2016;34(2): 133-142.
[25] MacKenzie SJ, Boucher DE. The influence of golf shaft stiffness on grip strength and clubhead kinematics. J Sports Sci. 2016;11: 140-148.
[26] Davies B. N. The relationship of lean limb volume to performance in the handgrip and standing long jump test in boys and girls, aged 11.6-13.2 years. Eur J Appl Physiol. 1990. 60: 139-143.
[27] Wang M, Leger AB, Dumas GA. Prediction of back strength using Anthropometric and Strength measurements in healthy females. Clin Biomech (Bristol, Avon). 2005;20(7): 685-692.
[28] Frickle O, Schoenau E. Examining the Developing skeletal muscle: why, what and how? J Musculoskeletal Neuronal Interact. 2005;5(3): 225-231.
[29] Roi, G and Pittaluga, I. Time-motion analysis in women's sword fencing. In: Proceedings of the fourth IOC Congress on Sport Sciences, Monaco, 66, 1997. pp. 22-25.
[30] Asci, A and Acikada, C. Power production among different sports with similar maximum strength. J Strength Cond Res 2007;21(1): 10-16.
[31] Tsolakis, C and Vagenas, G. Anthropometric, physiological and performance characteristics of elite and sub-elite fencers. J Hum Kinetics 23: 89-95, 2010.
[32] Gutierrez-Davila, M. Response timing in the lunge and target change in elite versus medium-level fencers. Eur J Sport Sci 13:364-371,2013.
[33] Anne E, Takken W T, Paul J, at al. Is grip strength a predictor for total muscle strength in healthy children, adolescents and young adults? Eur J Pediatr. 2010;169: 281-287.
[34] D. G. Robertson & D. Fleming. Kinetics of Standing Broad and Vertical Jumping. Canadian Journal of applied sports science. 1987: 19-23.
[35] Oliver GD, Sola M, Dougherty SH. Quantitative examination of upper and lower extremity muscle activation during common shoulder rehabilitation exercises using the body blade. J Stren. 2013;27;2509-17.]
[36] Northrip J. W, Logan G. And McKinney W. C. Introduction to Biomechanical Analysis of Sport, Analysing Human Movement Patterns. 2nd Edition. London: Routele;2007.