

CORRELATION BETWEEN TRUNK STABILITY AND REACTION TIME IN WHEELCHAIR FENCERS: A CROSS- SECTIONAL STUDY

by

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Master of Physiotherapy

in

SPORTS

Under the guidance of

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**Abhinav Bindra Sports Medicine and Research Institute,
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2022-2024

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation/thesis entitled “**Correlation between trunk stability and reaction time in wheelchair fencers: A Cross-sectional Study**” is a bonafide and genuine research work carried out by me under the guidance of **Dr. Chinmaya Kumar Patra, Principal, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar.**

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Thank you.

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LIST OF ABBREVIATIONS USED

- D-Wall – Digital Wall
- WF – Wheelchair Fencing

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ABSTRACT

Title: Correlation between Trunk Stability and Reaction Time in Wheelchair Fencers:
A Cross-Sectional Study

Background: Trunk stability and reaction time are crucial components of athletic performance, particularly in wheelchair fencing, where quick reactions and stable posture are essential for enhancing performance and success.

Objective: To investigate the correlation between trunk stability and reaction time in wheelchair fencers.

Methods: This cross-sectional study included 21 wheelchair fencers (10 males, 11 females) with a mean age of 31.2 ± 4.2 years. Trunk stability was assessed using the McGill Torso Endurance Test, and reaction time was measured using D-Wall Technobody System. Correlation analysis was performed using Pearson correlation coefficient to examine the relationship between trunk stability and reaction time.

Results: A significant negative correlation was found between trunk stability and reaction time ($r = -0.75$, $p < 0.001$), which indicated that better trunk stability is associated with faster reaction times.

Conclusion: This study demonstrates a strong correlation between trunk stability and reaction time in wheelchair fencers. Enhancing trunk stability through targeted exercises may improve reaction time and overall performance of the fencers. These findings have implications for coaches, trainers and physical therapists working with wheelchair fencers.

Keywords: Wheelchair Fencing, Para-athletes, Trunk stability, Reaction time.

INTRODUCTION

1.1 History of Wheelchair Fencing

Since its debut in the 1960 Paralympic Games, wheelchair fencing has been an official Paralympic sport ^[1]. One of the earliest sports that athletes with disabilities participate in is wheelchair fencing (WF) ^[2]. WF is also described as a sport in which explosiveness and strength must be matched with psychomotor and coordination-related skills in order to maximize exercise capacity ^[3]. The sport uses the same weapons (foil, epee, and sabre), tactics, and regulations as able-bodied fencing. One significant difference is that competitors compete while seated in a wheelchair designed specifically for their sport, which is fastened in place to maximize upper body movement and offer stability ^[2]. The two fencers are usually closer to one another, which speeds up fights, demanding considerable skill. For men, there are foil, epee, and sabre individual and team competition events; for women, there are foil and epee events. Hundreds of wheelchair fencers from over 30 countries now actively compete in the official, sanctioned events held by the International Wheelchair Fencing Federation, the official organization that oversees the sport of wheelchair fencing ^[1].

1.2 General features of Wheelchair fencing

Wheelchair fencers must have a permanent disability, such as spinal cord injury, amputation, poliomyelitis, cerebral palsy, multiple sclerosis, muscular dystrophy, or any number of congenital disorders that do not fall under any of the traditional definitions of disability, in order to be eligible to compete. To maintain equity and incorporate competitors with varying disabilities, wheelchair fencers are divided into three groups: A, B, and C. The current WF categorization scheme is said to as a functional system, with a focus on the potential effects that each impairment may have on athletic performance. Athletes go through a series of evaluations (such as a bench test) to ascertain their functional status during this procedure. The results are combined to assign them to one of these three groups ^[2].

Table 1.1 Category, definition and examples of wheelchair fencers (IWFC, 2011)

CATEGORY	DEFINATION	DISABILITY GROUPS
A	Wheelchair fencers with normal trunk and upper limb control	Lower limb amputee, low-level-lesion paraplegia (below T10), minimal involved poliomyelitis or cerebral palsy
B	Wheelchair fencers with poor trunk control and normal upper limb function	High-level-lesion paraplegia (above T10), low-level-lesion incomplete-lesion tetraplegia, tetraplegia extensively involved poliomyelitis
C	Wheelchair fencers with poor trunk and poor upper limb control	High-level-lesion tetraplegia

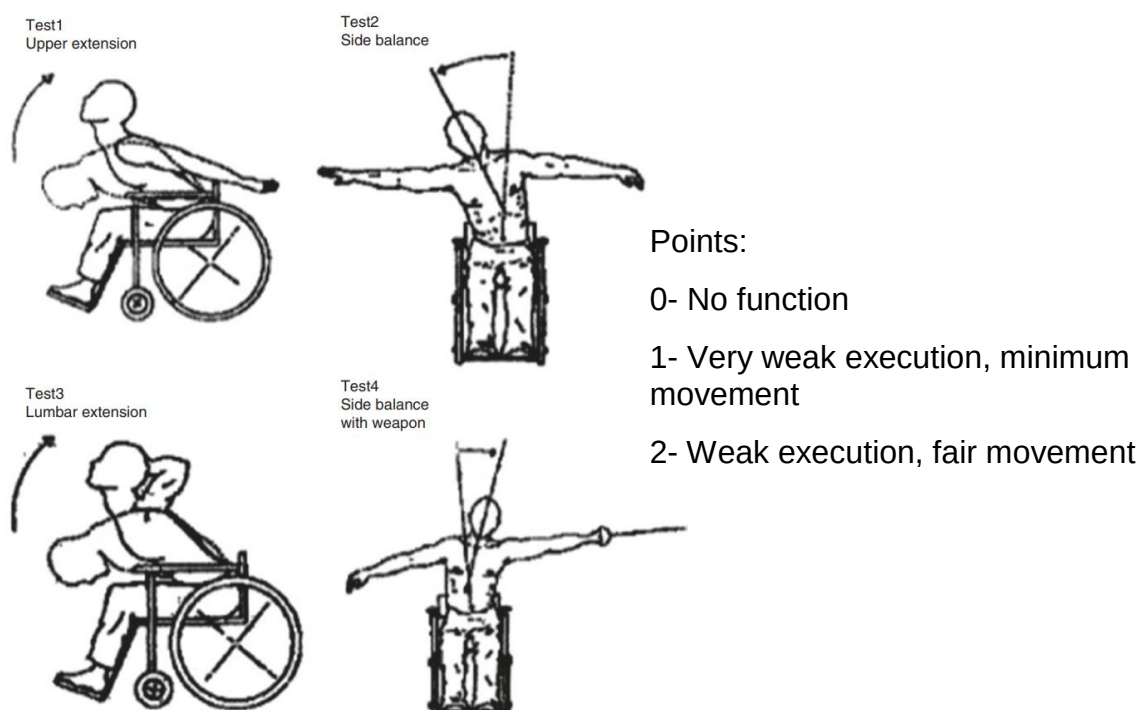


Figure 1.1 Examples of functional tests in wheelchair fencing (IWFC, 2011)

Table 1.2 Detail description of the functional test for wheelchair fencing classification (IWFC, 2011)

TESTS	FUNCTIONAL MOVEMENT
TEST 1	Dorsal muscles are tested. The athlete is forward flexed and seated in the wheelchair with arms retroflexed and tries to return to upright position
TEST 2	The athlete is tested on lateral balance and must lean laterally to right and left with arms abducted.
TEST 3	Extension of the trunk, specifically lumbar muscles. Repeat Test 1, but with hands on the back of the neck.
TEST 4	Repeat Test 2, but now with the weight of the weapon
TEST 5	Evaluates trunk movement half way between test 1 and 3 and test 2 and 4 and now the fencer can hold the wheelchair with the opposed limb.
TEST 6	Similar to Test 1, but executed with the leaning forward at 45°.

Competitions within wheelchair fencing are divided by weapon type (foil, sabre, or epee)

In foil, the fencer may target the neck, torso, back, and groin (not the arms or legs)

In epee the head, arms, body, and both hands are valid targets (not the legs)

In sabre, hits with the blade or point are valid, and the whole body above the waist, except the weapon hand, is a valid target ^[4].

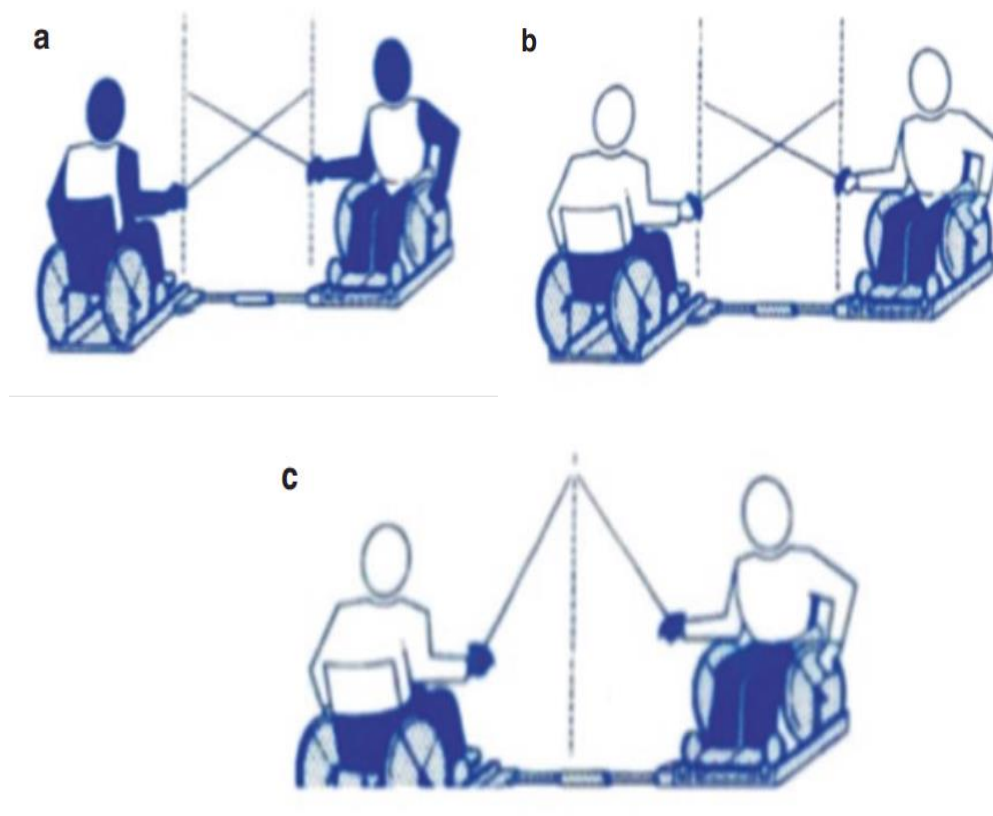


Figure 1.2 Examples of Weapon type **a.** In foil, **b.** In epee, **c.** In sabre ^[4]

1.3 Truncated kinetic chain

Wheelchair fencers are unable to execute all of the required techniques with just their arms and trunks, as they lack the assistance of feet. Wheelchair fencing is a highly repetitious, unbalanced, and impulsive sport that can put a significant amount of strain on competitors' upper extremities due to its cramped layout. The mechanical loadings on the arms of wheelchair fencers who lack trunk control may be enormous. As, the majority of the study findings for wheelchair fencer injury treatment are derived from able-bodied fencing, which presents significant challenges for wheelchair fencing in terms of specificity and practicality. It is imperative to clarify the risk considerations associated with wheelchair fencing ^[1].

The truncated kinetic chain may be connected to the potential mechanism of injury in wheelchair fencing, but this is conjectural. It has been suggested that the various body parts can be seen as a network of chains. The force exerted on one body component will gradually spread to the other body parts. Usually, the lower extremities of the body produce a ground response force at the ground, which starts the successive activation

of the kinetic chain. The distal portion of the arm is eventually reached by the sequential activation that starts in the legs and moves through the hips, trunk, scapulothoracic and glenohumeral joints. Any change in the way that the kinetic link system is activated that does not fully activate all of its components can lead to a higher risk of injury and lower overall performance. The lack of footwork in wheelchair fencing affects the fencing motion's movement sequence. More impairment in upper limb movements would be anticipated in severely disabled fencers with impaired trunk control. Wheelchair fencers may need to change their movement pattern or put more muscle into their upper limbs in order to achieve enough attacking speed. Fencers who possess this adaptive motor pattern may inherently be more susceptible to upper limb strains and accidents. Wheelchair fencers must use their upper limb and trunk movements in place of their footwork to maintain good balance, quick reflexes, and precise thrusts and lunges against their opponents ^[1].

1.4 Research gap in wheelchair fencing

As per a Delphi study conducted among Paralympic coaches, the objective of the study was to establish expert consensus regarding the physical attributes that support the performance of wheelchair fencing participants. The two researchers coded the responses, and the resulting eight themes were speed, strength, flexibility, stability and motor control, agility, fitness, and anthropometry. The attributes that were most commonly mentioned were overall speed (75%), flexibility overall (50%), stability and control overall (50%), and the ability for generating side-to-side movements (56%) ^[2].

All of the participants thought that having a high overall movement speed was a necessary quality. WF can be viewed as an open-skilled combat sport in which assaulting faster increases the likelihood of winning by giving the opponent less time to react. An additional quality that garnered 80% approval from the panel was the ability to react quickly to an opponent's movement. Athletes must use their perceptual and psychomotor abilities to predict their opponent's next move because WF is an open-skilled sport. Thus, the athlete's ability to successfully defend will depend on how fast and precisely they can counter the opponent's attack. With an 86% agreement rate, the panel also deemed side-to-side movements and general agility to be important characteristics. Further proof of the necessity to quickly adjust body

positioning in response to an opponent's movement comes from the consensus among coaches regarding the importance of rhythm change in WF performance. According to the coaches, good fencing performance seems to depend on the flexibility and synchronization of the fencing arm and wrist. Another crucial characteristic that all participants agreed upon was that fencers would be able to produce precise strikes through the ideal combination of motor control and flexibility [2].

Every coach was in agreement that trunk stability and strength were critical components that supported WF performance. Furthermore, there was an 80% consensus among the panellist's regarding hip strength. The muscles in the hips and trunk are thought to be in charge of postural stability. In fact, athletes from category A usually have good sitting balance, but athletes from category B, such as those with spinal cord injuries T1–T9, have fair sitting balance because of diminished trunk and hip function. Athletes must extend their arms and, if needed, lean toward their opponents in order to score in WF. Numerous studies have demonstrated that, in the able-bodied population, trunk control plays a crucial role in regulating arm movement for reaching tasks while seated [2].

Currently available research in WF is limited to investigating the physiological demands of the sport, injury epidemiology, and analysing the lunge attack using kinematics and electromyography. These studies offer useful and insightful information, but they are insufficient to identify the specific physical characteristics that support performance and the relationship between them.

1.5 Trunk Stability and Reaction Time

The term "trunk stabilization" describes the ability to consciously or unconsciously control gross or fine movements in joints, as well as the control of the muscles required to maintain stability surrounding the trunk. Balance and postural control difficulties may arise from an increased strain on the soft tissues and spinal structure due to instability in the trunk. Consequently, all functional movements start with the trunk's stability. Trunk muscles participate in anticipatory postural control in the limbs or trunk, operate as agonists or synergists in spontaneous trunk movements, and are automatically

implicated in unexpected sudden limb movements or trunk motions. Trunk stabilization is necessary to regulate trunk movement during routine tasks like sitting, standing, and walking, but it can also make it more difficult to execute precise arm and hand functions [5].

Fencers need to possess strong attention, a fast reaction time (RT), a short movement time, and well-developed, automatic movement patterns in order to perform well. Reaction time (RT) is the interval between the occurrence of an unexpected stimulus and the beginning of a response. The precise and timely completion of tactical and technical responsibilities is very important for the development of fencing technique [8].

NEED OF THE STUDY

Today, the Paralympic Games is the second biggest sporting event in the world. Hundreds of international tournaments covering a wide range of disabled sport events, wheelchair fencing being one of them are hosted every year around the world. It is expected the number of disabled athletes participating in various disabled sport events will continue to increase.

Findings generally agreed that reaching movement in seated position involved a tight coupling between trunk and arm. The fencing lunge attack motion is a fast reaching and pointing task that requires a lot of trunk and upper limb coordination. In wheelchair fencers lack of trunk stability is compromised in addition to lack of footwork; and even higher upper limb effort is required. With the footwork being eliminated, wheelchair fencers rely on their upper limb and trunk movements in order to achieve good balance, timely reactions, as well as accurate lunges and thrusts to the opponents.

Currently available research in WF is limited to investigating the physiological demands of the sport, injury epidemiology, and analysing the lunge attack using kinematics and electromyography. These studies offer useful and insightful information, but they are insufficient to identify the specific physical characteristics that support performance and the relationship between them. To overcome the paucity of literature and to better understand on how to improve performance, quantitative research finding relationship between trunk stability and reaction time should be undertaken as these two physical characteristics are the most important in improving performance. Finding the relation between reaction time and trunk stability will further help to design rehab based on these functional components thereby enhancing performance of the athlete in this sport.

AIM AND OBJECTIVES

Aim of the study: To find correlation between trunk stability and reaction time in wheelchair fencing

Objectives of the study: To find relationship between trunk stability and reaction time using

- D-Wall TechnoBody System – for reaction time
- McGill's Torso Endurance Test – for trunk stability

HYPOTHESIS

Independent Variable – Trunk Stability

Dependent Variable – Reaction Time

Null Hypothesis

- H_0 - There will be no significant negative correlation between trunk stability and reaction time.

Alternative hypothesis

- H_1 - There will be a significant negative correlation between trunk stability and reaction time.

REVIEW OF LITERATURE

1. **CHUNG Wai Man et.al, (2015)**, conducted a study on “Kinematic and Electromyographic Analysis of Wheelchair Fencing” with an aim to examine and compare the injury patterns between elite and able bodied fencers and wheelchair fencers and the results from the study provide the foundation from which to investigate the underlying mechanisms of wheelchair fencers injuries, and to establish injury prevention program or rehabilitation strategies specific to wheelchair fencing.
2. **Bihter AKINOGLU et.al, (2016)**, conducted a study on “Determination of the relationship between core endurance and sitting balance in wheelchair basketball players: a pilot study” with an aim to determine the relationship between core endurance and sitting balance in wheelchair (WC) basketball players and concluded that core endurance is an important parameter on sitting balance in WC basketball players and adding exercises which will improve core endurance parameters, will affect functional sitting balance of WC players positively.
3. **Mary Caldwell and Arthur Jason, De Luigi, (2018)**, conducted a study on “Wheelchair Fencing” which gave an overview of the competition, athlete classification system, equipment, and common injuries seen and concluded that players commonly have spinal cord injuries, cerebral palsy, or amputations. There are three categories (A, B, or C) for each competition event (foil, sabre, or epee) based on the five athlete classifications.
4. **Zbigniew Borysiuk et.al, (2019)**, conducted a study on “Movement patterns and sensorimotor responses: comparison of men and women in wheelchair fencing based on the Polish Paralympic team” with an aim to gain knowledge about the movement patterns among women and men in wheelchair fencing with a particular emphasis on postural muscles which concluded that it seems necessary to extend the scope of the training process to include postural

muscle training with the purpose of strength and explosive power development. The recruitment of additional motor units should promote greater coordination and therefore enhance the speed of movement, both for women and men in wheelchair fencing.

5. **Zbigniew Borysiuk et.al, (2020)**, conducted a study on “Neuromuscular, Perceptual, and Temporal Determinants of Movement Patterns in Wheelchair Fencing: Preliminary Study” with an aim to determine the structure of the movement pattern performed during a wheelchair fencing lunge that is executed in response to visual and sensory stimuli and the results proved the role of postural muscles: external abdominal oblique and latissimus dorsi on the effectiveness of the attacks executed in wheelchair fencing.
6. **Alexandre Villiere, Barry Mason et.al, (2021)**, conducted a study titled “The physical characteristics underpinning performance of wheelchair fencing athletes: A Delphi study of Paralympic coaches” with an aim to study to reach expert consensus on the physical characteristics that underpin performance of athletes competing in the sport in order to achieve an evidence-based classification system. The study provided a clear guidance of the physical qualities to be developed to maximise athletic performance while also providing the initial framework to guide future wheelchair fencing classification research.
7. **Zbigniew Borysiuk et.al, (2022)**, conducted a study on “Electromyography, Wavelet Analysis and Muscle Co-Activation as Comprehensive Tools of Movement Pattern Assessment for Injury Prevention in Wheelchair Fencing” with an aim to determine the correct movement patterns of fencing techniques in wheelchair fencers and concluded that many overload injuries of the shoulder girdle, elbow, postural muscles, spine, and neck have been found to be preventable through modification of current training programs dominated by specialist exercises.
8. **Michal Starczewski et.al, (2024)**, conducted a study on “The impact of high-intensity arm crank exercise on reaction time in wheelchair fencers:

gender differences and mechanical predictors” with an aim to assess the relationship between the results of the repeated sprint ability (RSA) test and reaction time (RT) in Wheelchair Fencing, and to evaluate changes in RT after repeated high-intensity sprints in the group of an international-level Wheelchair Fencing athletes, which concluded that , repeated high-intensity arm crank exercise has a positive impact on simple postexercise cognitive tasks in WF fencers, especially in women, and leads to a decrease in RT and the RSA parameters can be predictors of changes in RT in men and women wheelchair fencers.

MATERIALS AND METHODOLOGY

- **Study design** - Cross sectional study
- **Study population** - Wheelchair fencers
- **Sampling technique**: Purposive Sampling
- **Sample Size**: 21
- **Study setting**: Fencing academy in Bhubaneshwar and CARE Hospitals, Bhubaneshwar
- **Study duration**: 1 year

SELECTION CRITERIA

INCLUSION CRITERIA

- Athletes that participate in wheelchair fencing must have lower limb impairments.
- Wheelchair fencers of category A and category B.
- Age: 20-35
- both male and female

EXCLUSION CRITERIA

- Wheelchair fencers of category C.
- Recent upper limb fractures or any musculoskeletal condition like strain, sprain, dislocation in less than 6 months to the fencing arm.
- wheelchair fencers training for less than 2 years

OUTCOME MEASURES

PRIMARY OUTCOME MEASURES

- D-Wall TechnoBody System – for reaction time
- McGill's Torso Endurance Test – for trunk stability (ICC = 0.95)

Instrument and Tools

- Elevated, sturdy exam table
- Nylon strap
- Stopwatch
- Wheelchair

D-WALL

TecnoBody, D-Wall is an assessment and rehabilitation device for improving movement quality with auditory and visual feedback support. D-Wall, which is widely used especially in the field of sports sciences, offers assessment and training in different mobility and aerobic training modes. The main areas of use of D-Wall are; assessment and training in different mobility and aerobic training modes in sports sciences, postural structure-specific assessment and training during movement, assessment and training of segmental and global coordination and sensory-motor skills, assessment and training for correction of joint dysmetries /asymmetries, and determination of the degrees and biomotor values of joints during movement kinematics, focusing on the head, trunk, shoulders, hips and knees.

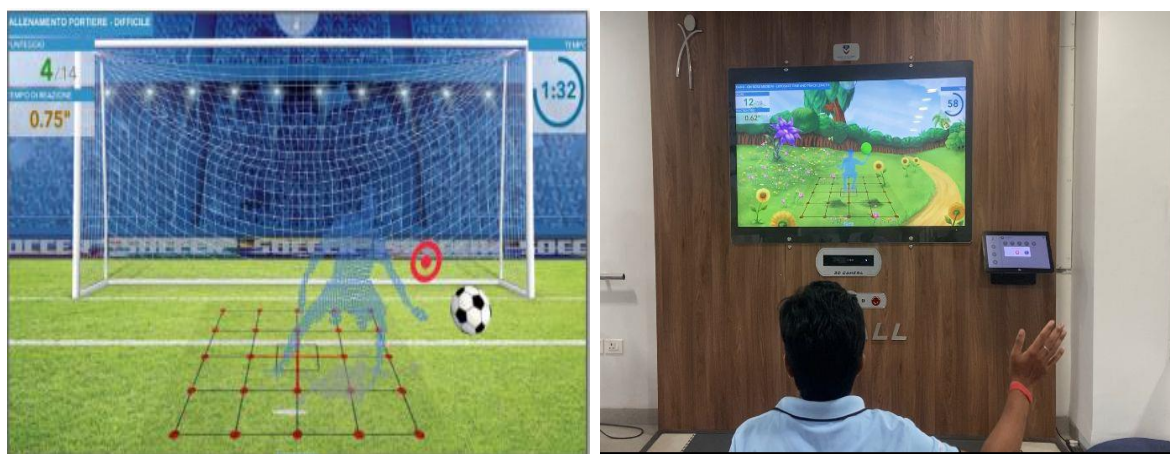


Figure 2.1 Agility and reaction time calculation in D-wall.

The 3D camera technology is high resolution, equipped with **infrared rays** and the **IR optics**, by emitting a beam of rays on the mass of the subject, is able to reconstruct it in three-dimensional mode in real time, for immediate feedback. The **four load cells** present in the strength platform allow you to perform Squat Jump Tests, Fitness Tests and Health Tests with all the precision necessary to evaluate strength [9].

Reaction Time was calculated under the program – Hands training on Bosu (Medium). In this the participants were instructed to reach to the target objects on the screen as fast as possible. Reaction time was calculated on the screen of the digital wall via virtual reality.

McGill's Torso Endurance Test

Trunk Flexor Endurance Test

The flexor endurance test is the first in the battery of three tests that assesses muscular endurance of the deep core muscles (i.e., transverse abdominis, quadratus lumborum, and erector spinae). It is a timed test involving a static, isometric contraction of the anterior muscles, stabilizing the spine until the individual exhibits fatigue and can no longer hold the assumed position.

Pre-test procedure:

- After explaining the purpose of the flexor endurance test, describe the proper body position.
- The starting position requires the client to be seated, with the hips and knees bent to 90 degrees, aligning the hips, knees, and second toe.
- Instruct the client to fold his or her arms across the chest, lean against a board positioned at a 60-degree incline, and keep the head in a neutral position
- The goal of the test is to hold this 60-degree position for as long as possible without the benefit of the back support.
- Encourage the client to practice this position prior to attempting the test.



Figure 2.2 Trunk flexor endurance test

Trunk Lateral Endurance Test

The trunk lateral endurance test, also called the side-bridge test, assesses muscular endurance of the lateral core muscles (i.e., transverse abdominis, obliques, quadratus lumborum, and erector spinae). Similar to the trunk flexor endurance test, this timed test involves static, isometric contractions of the lateral muscles on each side of the trunk that stabilize the spine. After explaining the purpose of this test, describe the proper body position.

- The starting position requires the client to be on his or her side with extended legs, aligning the feet on top of each other or in a tandem position (heel-to-toe).
- Have the client place the lower arm under the body and the upper arm on the side of the body.
- When the client is ready, instruct him or her to assume a full side-bridge position, keeping both legs extended and the sides of the feet on the floor. The elbow of the lower arm should be positioned directly under the shoulder with the forearm facing out (the forearm can be placed palm down for balance and support) and the upper arm should be resting along the side of the body or across the chest to the opposite shoulder.
- The hips should be elevated off the mat and the body should be in straight alignment (i.e., head, neck, torso, hips, and legs). The torso should be supported only by the client's foot/feet and the elbow/forearm of the lower arm.
- • The goal of the test is to hold this position for as long as possible. Once the client breaks the position, the test is terminated.



Figure 2.3 Trunk Lateral Endurance Test

Trunk Extensor Endurance Test

The trunk extensor endurance test is generally used to assess muscular endurance of the torso extensor muscles (i.e., erector spinae, longissimus, iliocostalis, and multifidi). This is a timed test involving a static, isometric contraction of the trunk extensor muscles that stabilize the spine.

After explaining the purpose of the test, explain the proper body position.

- The starting position requires the client to be prone, positioning the iliac crests at the table edge while supporting the upper extremity on the arms, which are placed on the floor or on a riser.
- While the client is supporting the weight of his or her upper body, anchor the client's lower legs to the table using a strap. If a strap is not used, the CMES will have to use his or her own body weight to stabilize the client's legs.
- The goal of the test is to hold a horizontal, prone position for as long as possible. Once the client falls below horizontal, the test is terminated.
- Encourage the client to practice this position prior to attempting the test ^[10].



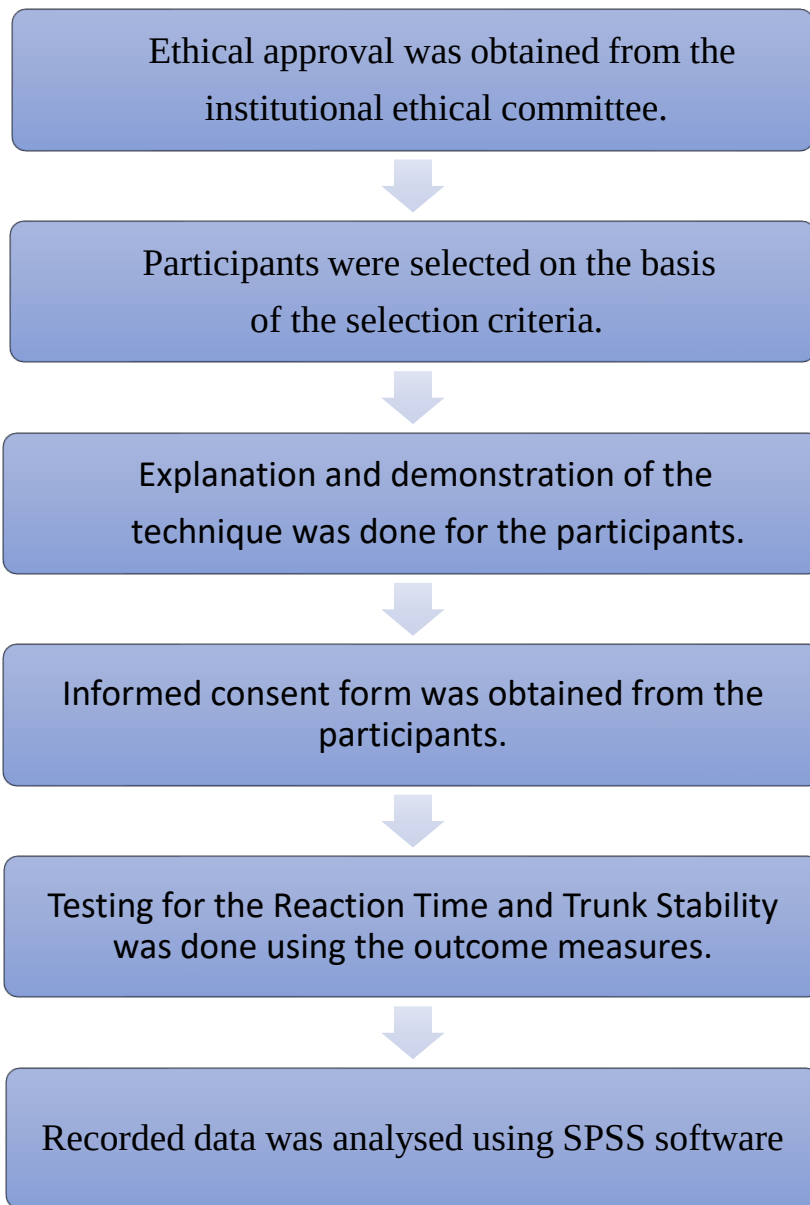
Figure 2.4 Trunk Extensor Endurance Test

The evaluation of stability and stabilization limits was done as per the convenience of the player, due to players' disability and playing with wheelchair.

PROCEDURE

- Ethical approval was obtained from the institutional ethical committee.
- NOC was taken from CARE Hospitals
- Participants were selected on the basis of the selection criteria.
- Explanation and demonstration of the technique was done for the participants.
- Informed consent form was obtained from the participants.
- Demographic data was obtained which included name, age, gender, category, dominance, years of playing experience and condition.
- Testing for the Reaction Time and Trunk Stability was done using the outcome measures
- All the data was recorded and was analysed using the latest version of SPSS (version 29.0) software.

FLOWCHART



STATISTICAL ANALYSIS

All the data was recorded and was analysed using the latest version of SPSS (version 29.0) software. The Demographic Data obtained was checked for normality using Shapiro-Wilk Test where the level of significance was set to $p > 0.05$. Descriptive Analysis was done to assess mean and standard deviation of the demographic characteristics. Correlation analysis was done using Pearson correlation coefficient.

RESULTS

DESCRIPTIVES

	MEAN	STANDARD DEVIATION	SHAPIRO- WILK W	df	SHAPIRO- WILK p
AGE	31.2	2.52	0.937	21	0.193
TRAINING YEARS	5.67	1.98	0.908	21	0.050

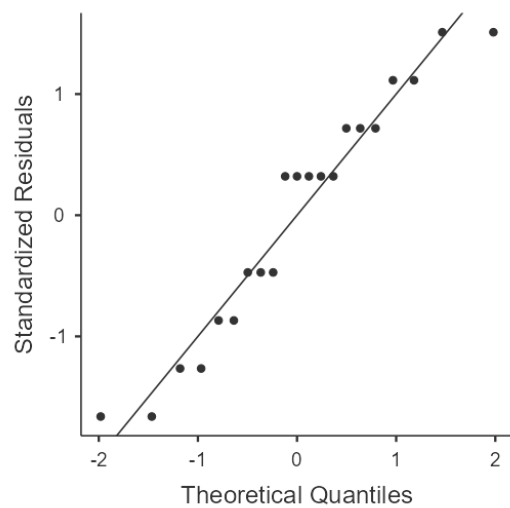


Figure 3.1 Q-Q Plot for Age

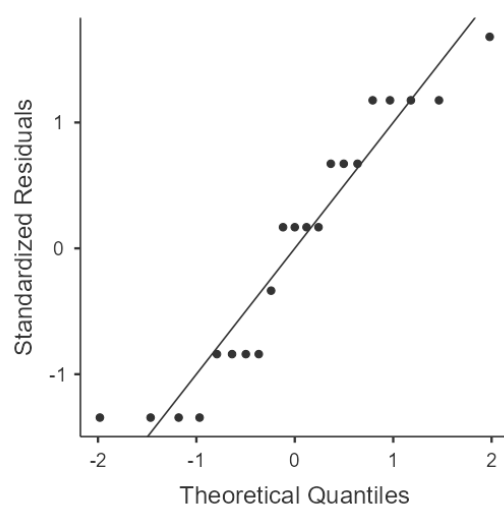


Figure 3.2 Q-Q Plot for Training Years

Frequencies of Gender

GENDER	Counts	% of Total	Cumulative %
FEMALE	11	52.4%	52.4%
MALE	10	47.6%	100.0%

Frequencies of Category

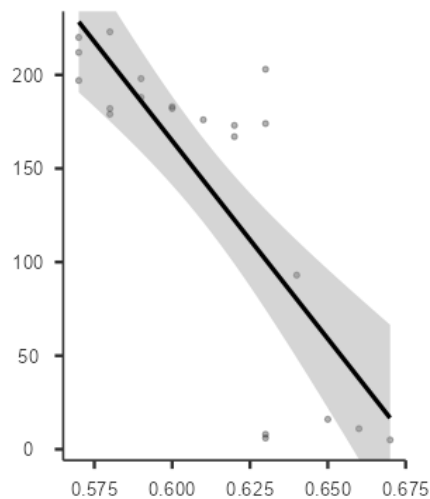
CATEGORY	Counts	% of Total	Cumulative %
CATEGORY A	16	76.2%	76.2%
CATEGORY B	5	23.8%	100.0%

The age, gender and training years were normally distributed as selection was done specifically.

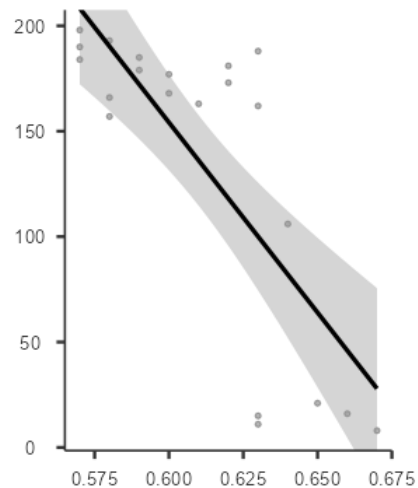
Correlation between reaction time and the variables of trunk stability i.e., flexor endurance, extensor endurance, lateral right endurance and lateral left endurance was calculated using Pearson Correlation coefficient. The significance i.e., p value was set to <0.05.

	Pearson's r	df	p value	N
Reaction time and Flexor Endurance Test	-0.806***	19	< .001	21
Reaction time and Extensor Endurance Test	-0.772***	19	< .001	21
Reaction time and Lateral Right Endurance Test	-0.796***	19	< .001	21
Reaction time and Lateral Left Endurance Test	-0.763***	19	< .001	21

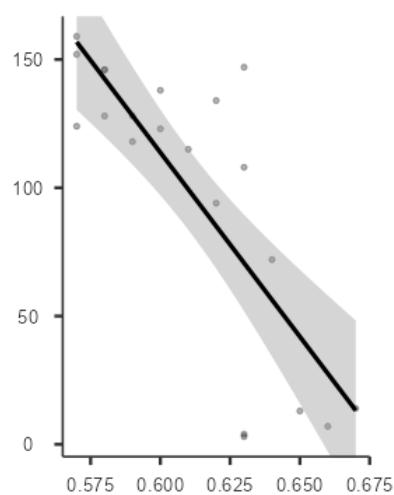
Note. * p < .05, ** p < .01, *** p < .001



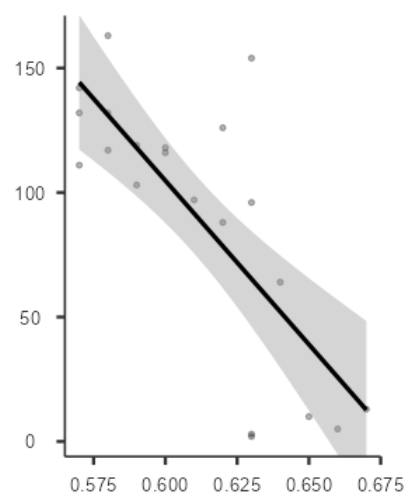
Flexor Endurance Test



Extensor endurance Test



Lateral Right Endurance Test



Lateral Left Endurance Test

On the basis of the correlation coefficient and the p-value the results showed a strong negative correlation between trunk stability and reaction time.

Correlation coefficient ranges are used to interpret the strength and direction of the linear relationship between two variables. -1.0 to -0.7 indicates strong negative correlation (as one variable increases, the other tends to decrease).

DISCUSSION

In our work, we have examined the correlation between the trunk stability and reaction time in Wheelchair Fencers. This study revealed a significant negative correlation between trunk stability and reaction time in wheelchair fencers, indicating that better trunk stability is associated with faster reaction times.

Considering the category, we have found that Category A alone showed a greater negative correlation as compared to Category B. It can be inferred that Category A fencers may have faster reaction times due to their better trunk stability and postural control in comparison with Category B. Injury rates from earlier studies also show that kinematic chain deficiencies are the cause of shoulder injuries. Wheelchair fencers tend to be subjected to considerable postural stability constraints during battle, which can result in increased compensating of the upper limb and eventually lead to postural muscle overloads and injuries. The fact that shoulder and postural muscle injuries were more common in wheelchair fencers (paraplegics) in Category B (lower trunk control) than in wheelchair athletes in Category A (better trunk control) lends more credence to this notion. This finding is consistent with previous research highlighting the importance of core stability in athletic performance.

The strong correlation between trunk stability and reaction time suggests that trunk stability plays a critical role in facilitating quick reactions in wheelchair fencing. This may be attributed to the fact that a stable trunk provides a solid foundation for movement, allowing athletes to generate force and respond rapidly to visual stimuli. With better trunk control, fencers can focus on their arm and blade movements without interference from trunk instability, leading to faster reaction time. Also, trunk stability is linked to improved neuromuscular coordination, which can facilitate faster reaction times and more precise movements.

The results have practical implications for coaches, trainers and physical therapists working with wheelchair fencers. Incorporating exercises that enhance trunk stability, such as core strengthening and endurance training, may improve reaction time and overall fencing performance.

To our best knowledge this is first study attempting to explore a correlation between the physical qualities underpinning success in the sport of wheelchair fencing.

Suggestive implications of this study help us in various aspects such as; prioritizing on exercises that improve trunk stability, such as core strengthening and balance training, which will not only optimize their performance but also help prevent injuries caused by poor posture, overcompensation, or loss of balance.

A careful examination of wheelchair fencing training shows that the majority of their training consists of one-on-one sessions with trainers and competitive sparring with other team members. In the light of the conducted research, it appears that postural muscle training is a crucial component of the training process when it comes to developing strength and explosive power. The firing of extra muscle units ought to result in improved coordination and, as a result, increase the speed of attack.

LIMITATIONS

In order to generalize the results achieved, it is suggested to increase the sample in the future research. Furthermore, it is recommended that participants be stratified according to a recognized scale, encompassing various levels of disability and sports classification in future research.

FUTURE SCOPE OF STUDY

The current research is the first study attempting to explore a correlation between the physical characteristics and performance metrics underpinning success in the sport of wheelchair fencing.

Future Research Directions

- Investigations into the effects of trunk stability training on reaction time and fencing performance for different fencer groups.
- Exploration of correlations between trunk stability and other performance metrics in wheelchair fencing is also very important in enhancing the overall performance.

CONCLUSION

This study demonstrates a strong correlation between trunk stability and reaction time in wheelchair fencers. Enhancing trunk stability through targeted exercises may improve reaction time and overall fencing performance. These findings have implications for coaches, trainers and physical therapists working with wheelchair fencers. By highlighting the importance of trunk stability in wheelchair fencing, this study contributes to the development of evidence-based training programs aimed at enhancing athletic performance in this population.

Implications

- **Training focus:** Wheelchair fencers should prioritize exercises that improve trunk stability, such as core strengthening and balance training.
- **Injury prevention:** Enhancing trunk stability can help prevent injuries caused by poor posture, overcompensation, or loss of balance.
- **Performance optimization:** Fencers with better trunk stability and faster reaction times can optimize their performance, gaining a competitive edge.

REFERENCES

1. Chung WM. Kinematic and electromyographic analysis of wheelchair fencing.
2. Villiere A, Mason B, Parmar N, Maguire N, Holmes D, Turner A. The physical characteristics underpinning performance of wheelchair fencing athletes: A Delphi study of Paralympic coaches. *Journal of Sports Sciences*. 2021 Sep 2;39(17):2006-14.
3. Starczewski M, Bobowik P, Urbanski PK, Makowski S, Morys M. The impact of high-intensity arm crank exercise on reaction time in wheelchair fencers: gender differences and mechanical predictors. *Scientific Reports*. 2024 May 27;14(1):12116.
4. Caldwell M, De Luigi AJ. Wheelchair Fencing. *Adaptive Sports Medicine: A Clinical Guide*. 2018:181-9.
5. Cha HG. Effects of trunk stabilization exercise on the local muscle activity and balance ability of normal subjects. *Journal of Physical Therapy Science*. 2018;30(6):813-5.
6. Borysiuk Z, Nowicki T, Piechota K, Błaszczyszyn M. Neuromuscular, perceptual, and temporal determinants of movement patterns in wheelchair fencing: preliminary study. *BioMed Research International*. 2020;2020(1):6584832.
7. Borysiuk Z, Błaszczyszyn M, Piechota K, Cynarski WJ. Electromyography, Wavelet Analysis and Muscle Co-Activation as Comprehensive Tools of Movement Pattern Assessment for Injury Prevention in Wheelchair Fencing. *Applied Sciences*. 2022 Feb 25;12(5):2430.
8. Starczewski M, Bobowik P, Urbanski PK, Makowski S, Morys M. The impact of high-intensity arm crank exercise on reaction time in wheelchair fencers: gender differences and mechanical predictors. *Scientific Reports*. 2024 May 27;14(1):12116.
9. Üzümcü B, Açar G, Konakoğlu G, Mutuş R. Investigation of the Effectiveness of TecnoBody Devices in Rehabilitation. *Istanbul Gelisim University Journal of Health Sciences*. 2024 Apr 1(22):383-94.
10. American Council on Exercise. McGill's Torso Muscular Endurance Test Battery. ACE Fitness. 2015 Oct 2.

11. Martín-Ruiz J, Alarcón-Jiménez J, de-Bernardo N, Iglesias X, Ruiz-Sanchis L. Cardiocirculatory, metabolic, and perceptual responses in elite wheelchair fencing competition.
12. Tweedy S, Diaper N. Introduction to wheelchair sport. *Wheelchair sport: A complete guide for athletes, coaches and teachers*. 2010 Jan 1:3-28.
13. Morriën F, Taylor MJ, Hettinga FJ. Biomechanics in Paralympics: implications for performance. *International journal of sports physiology and performance*. 2017 May 1;12(5):578-89.
14. Harmer PA. Incidence and characteristics of time-loss injuries in competitive fencing: a prospective, 5-year study of national competitions. *Clinical journal of sport medicine*. 2008 Mar 1;18(2):137-42.
15. Iglesias X, Rodriguez F, Tarragó R, Bottoms L, Vallejo L, Rodríguez-Zamora L, Price M. Physiological demands of standing and wheelchair fencing in able-bodied fencers. *The Journal of Sports Medicine and Physical Fitness*. 2019.
16. Fung Y, Chow BC, Fong D, Chan K. A kinematic analysis of trunk ability in wheelchair fencing: a pilot study. *InISBS-Conference Proceedings Archive* 2010.
17. Vanlandewijck YC, Chappel RJ. Integration and classification issues in competitive sports for athletes with disabilities.
18. Vanlandewijck Y. Sport science in the Paralympic movement. *Journal of Rehabilitation Research & Development*. 2006 Nov 1;43(7):xvii-.
19. Turner A, James N, Dimitriou L, Greenhalgh A, Moody J, Fulcher D, Mias E, Kilduff L. Determinants of Olympic fencing performance and implications for strength and conditioning training. *The journal of strength & conditioning research*. 2014 Oct 1;28(10):3001-11.
20. Borysiuk Z, Czyz S, Markowska N, Konieczny M, Pakosz P. Fencing fleche performed by elite and novice epeeists depending on type of perception.
21. Fung YK, Chan DK, Caudwell KM, Chow BC. Is the wheelchair fencing classification fair enough? A kinematic analysis among world-class wheelchair fencers. *European Journal of Adapted Physical Activity*. 2013;6(1):17-29.
22. Robbins DW, Goodale TL, Docherty D, Behm DG, Tran QT. The effects of load and training pattern on acute neuromuscular responses in the upper body. *The Journal of Strength & Conditioning Research*. 2010 Nov 1;24(11):2996-3007.

23. Borysiuk ZB, Cynarski WJ. Czas reakcji i czas ruchu, typy odpowiedzi czuciowo-ruchowych, tempo szermiercze (Reaction time and movement time, types of sensorimotor responses and fencing tempo). *Ido-Ruch dla Kultury/Movement for Culture*. 2009; 9:189-200.
24. Oates LW, Campbell IG, Iglesias X, Price MJ, Muniz-Pumares D, Bottoms LM. The physiological demands of elite épée fencers during competition. *International Journal of Performance Analysis in Sport*. 2019 Jan 2;19(1):76-89.
25. Bernardi M, Guerra E, Di Giacinto B, Di Cesare A, Castellano V, Bhambhani Y. Field evaluation of paralympic athletes in selected sports: implications for training. *Medicine & Science in Sports & Exercise*. 2010 Jun 1;42(6):1200-8.
26. Boguszewski D, Torzewska P. Martial arts as methods of physical rehabilitation for disabled people. *Journal of Combat Sports and Martial Arts*. 2011;1(2):1-6.
27. Bottoms L, Greenhalgh A, Sinclair J. Kinematic determinants of weapon velocity during the fencing lunge in experienced épée fencers. *Acta of bioengineering and biomechanics*. 2013;15(4):109-13.
28. Chung WM, Yeung S, Wong AY, Lam IF, Tse PT, Daswani D, Lee R. Musculoskeletal injuries in elite able-bodied and wheelchair foil fencers—a pilot study. *Clinical Journal of Sport Medicine*. 2012 May 1;22(3):278-80.
29. Connick MJ, Beckman E, Deuble R, Tweedy SM. Developing tests of impaired coordination for Paralympic classification: Normative values and test–retest reliability. *Sports Engineering*. 2016 Sep;19:147-54.
30. Dean C, Shepherd R, Adams R. Sitting balance I: trunk–arm coordination and the contribution of the lower limbs during self-paced reaching in sitting. *Gait & posture*. 1999 Oct 1;10(2):135-46.

APPENDIX 1
(CONSENT FORM)

I have been informed by Ms. Diya Gunwant Jain; pursuing MPT (Sports) conducting a scientific study guided by Dr. Chinmaya Kumar Patra, Principal, Department of Physiotherapy, Abhinav Bindra Sports Medicine And Research Institute (ABSMARI), Bhubaneswar.

I have no objection regarding the study. I also understand that the study does not negatively affect my health. I understand that the information produced by the study will become a part of the institute's record and will be utilized as per the institute's confidentiality regulations. I am also aware that the data might be used for medical literature and teaching purposes, but all my personal details will be kept confidential.

I am well informed to ask as many questions as I can to Ms. Diya Gunwant Jain during the study or later. I wish to discuss my participation and concerns regarding this study with a person not directly involved.

I understand that my assent is voluntary and I reserve the right to withdraw or discontinue participation in the study at any point of time during the study.

I have explained to Mr./Miss/Mrs. _____ the purpose of the research, and the procedure required in the language he/she could understand to the best of my ability.

(Investigator)

(Date)

I confirm that Ms. Diya Gunwant Jain (Investigator) has explained to me in the language I can understand, the purpose of the study and the procedure.

Therefore, I agree to give my assent for participation as a subject in this study and I will be accountable for the decisions.

(Signature)

(Date)

APPENDIX 2

(ASSESSMENT FORM)

Demographic Details:

- Name:
- Age:
- Gender:
- Dominance:
- Category:
- Training years:

Trunk stability:

- Flexor Endurance Test:
- Extensor Endurance Test:
- Lateral Right Endurance Test:
- Lateral Left Endurance Test:

Reaction Time:

ETHICAL CLEARANCE



ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2023/068

Date: 16/10/2023

APPROVAL LETTER

APPENDIX- VIII

To,

Diya Jain
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: Correlation between Trunk Stability and Reaction Time in Wheelchair Fencers – A Cross Sectional Study

Protocol ID.: ABS-IEC-2023-PHY-020

Subject: Approval for the conduct of the above referenced study

Dear Mr./Ms./Dr **Diya Jain**

With reference to your Submission letter dated 12/08/2023 the ABSMARI IEC has of the Ethics reviewed and discussed your application for conduct of clinical trial on dated 02/09/2023 (Sat Day).

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	08-08-2023
2	Informed Consent Form	08-08-2023
3	Undertaking form PI	08-08-2023
4	CRF	08-08-2023
5	COI from the Investigators	08-08-2023

The following members were present at meeting held on 02-09-2023

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
1	Prof. Dr. E. Venkata Rao	Professor (MBBS, MD, Dept. of Community Med.) IMS & Sum Hospital, BBSR	Chair Person	M	N
2	Dr. Satyajit Mohanty	Director-Medicare Hospital, BBSR	Basic Medical Scientist	M	N
3	Dr. Ashok Singh Chauhan	PhD. Pharmacology, Assoc. Prof. Dept. of Pharmacology, Hi-Tech Medical College & Hospital, BBSR	Basic Medical Scientist	M	N

1



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ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2023/068

Date: 16/10/2023

MEMBERS

Dr. Smaraki Mohanty,
Clinician

Dr. Satyajit Mohanty,
Basic Medical Scientist

Dr. Ashok Singh Chouhan
Basic Medical Scientist

Mr. Shib Shankar Mohanty
Legal Expert

Ms. Annie Hans,
Social Scientist

Ms. Subhashree Samal,
Lay Person

Mr. Deepak Ku. Pradhan,
Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
4	Dr. Smaraki Mohanty	Asst. Prof-IMS & Sum Hospital/MBBS, MD (Community Med)	Clinician	F	N
5	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
6	Mr. Shiba Sankar Mohanty	Junior Counsel-Lt. Ramachandra Sarangi's Chamber / BA LLB	Legal Expert	M	N
7	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
8	Ms. Subhashree Samal	Ref. Reader-Pol Sc.	Lay Person	F	N
9	Mr. Deepak Kumar Pradhan	Asst. Prof-ABSMARI, MPT	Scientific Member	M	Y

This is to confirm that only members who are independent of the Investigator and the Sponsor of the trial have voted/ provided opinion on the trial.

This Committee approves the documents and the conduct for the trial in the presented form with necessary recommendation.

The ABSMARI IEC must be informed about the progress of the study, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent and requests to be provided a copy of the final report.

The ABSMARI IEC follows procedures that are in compliance with the requirements of ICH (International Conference on Harmonization) guidance related to GCP (Good Clinical Practice) and applicable Indian regulations.



Yours sincerely

Mr. Chinmaya Kumar Patra
Member Secretary

ABSMARI Ethics Committee
Pahal, Bhubaneswar
Member Secretary
ABSMARI ETHICS COMMITTEE

2



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MASTERCHART

SR NO.	AGE	TRAININ G YEARS	REACTIO N TIME (secs)	TRUNK ENDURANCE (secs)			
				FLEXO R	EXTENSO R	LATERA L (RIGHT)	LATERA L (LEFT)
1	27	4	0.67	5	8	14	13
2	34	3	0.63	203	188	147	154
3	32	6	0.62	173	181	134	126
4	30	3	0.64	93	106	72	64
5	33	7	0.6	183	168	138	116
6	30	5	0.66	11	16	7	5
7	28	3	0.65	16	21	13	10
8	32	4	0.63	174	162	108	96
9	29	4	0.62	167	173	94	88
10	35	8	0.63	6	11	3	3
11	33	6	0.63	8	15	4	2
12	28	4	0.58	223	193	146	163
13	27	3	0.57	220	198	152	132
14	29	8	0.58	179	157	146	132
15	30	9	0.57	212	184	159	142
16	35	8	0.57	197	190	124	111
17	32	7	0.59	188	179	118	103
18	33	7	0.6	182	177	123	118
19	32	6	0.61	176	163	115	97
20	32	6	0.59	198	185	128	119
21	34	8	0.58	182	166	128	117