ASSOCIATION OF BODY DIMENSIONS AND KINEMATIC VARIABLES WITH THE PERFORMANCE OF ELITE WEIGHTLIFTERS

A Thesis

Submitted in partial fulfillment of the requirements for the

award of the degree of

DOCTOR OF PHILOSOPHY

in

Physical Education

By

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11511648

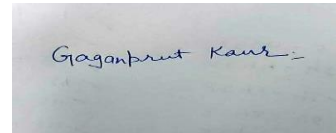**Supervised By**

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LOVELY PROFESSIONAL UNIVERSITY

PUNJAB

2021

DECLARATION

I declare that the thesis entitled "Association of body dimensions and kinematic variables with the performance of elite weightlifters" has been prepared by me under the guidance of Dr. Manohar Lal, Professor, GHG Khalsa college Gurusar Sadhar (Ludhiana), Punjab. No part of this thesis has formed the basis for the award of any degree or fellowship previously.

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CERTIFICATE

I certify that Ms. Gaganpreet Kaur has prepared her thesis entitled **"Association of body dimensions and kinematic variables with the performance of elite weightlifters"** for the award of Ph.D. degree of Lovely Professional University, under my guidance. She has carried out the work at the School of Physical Education, Lovely Professional University, Phagwara, Punjab.

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ABSTRACT

It has been found that top athlete in some sports tend to have those proportion that biomechanically aid the particular performance required. Sports biomechanics have generated different efforts at rising athletic performance in numerous games and sports. The biomechanical analysis of different events can help to understand the critical point of technical performance thus helping coaches and athletes in their preparation. Weightlifting has been a part of the Olympic Games since 1896. The basic problem in learning weight lifting techniques is to define the optimum track of the barbell. Therefore, the purpose of present investigation was to assess the association of body dimensions and kinematic variables with performance of elite weight lifters. The present study was of descriptive in nature. Purposive sample method was used to select the sample for the study. Seven female elite level weight lifters who were in India camp and preparing themselves for International competition was selected for the study. The data was collected during the trails of Youth World Weightlifting Championship 2017 on 20-2-2017 at national camp, Patiala. The championship was held at Bangkok, Thailand from 3rd to 10 April, 2017.

For measurements of body dimensions; portable weighing machine was used to measure the body weight. Anthropometric rod was used to measure the body dimensions such as height, sitting height, arm length, leg length and lower leg length, and steel tape was be used to measure the length and girth of the body. For the biomechanical analysis videography was used. The subject's snatch movements was recorded using Casio Exilim (high speed,1200/fps) camera in a field/arena setting. For identification of the subject in the video graph, each subject was given a code/number as to distinguish them in the data recorded. For identification purposes of a best lift, the trails were viewed on the computer system with expert on the subject (weight lifting) to demarcate the trail for the data acquisition.

After the collection of the data the videos were store in computer and best lift with the help of expert was selected for the further analysis. The videos trials were played with the

help of software Kinovea-0.8.25-x64 trail version to make separate clips of each player. The separate clips were then open on to the Kinovea-0.8.25-x64 software trail version. This software provides to identify the angles, velocity, displacement, time and number of frames. For the analysis of data SPSS version 22 was used. In order to examine the association of body dimensions and kinematic variables with performance, a product moment correlation method was used.

Based upon the findings following conclusions has been drawn: -

1. Performance has shown significant and positive correlation with lower leg length among the elite weight lifters. However, others body dimensions height, weight, sitting height, arm length, leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with performance among elite weightlifters.

2. During first phase of snatch skill, all the selected angular kinematic variables ankle joint angle, knee joint angle, hip joint angle, shoulder joint angle and elbow joint angle have shown insignificant correlation with performance of elite weightlifters.

3. During first pull of snatch skill only shoulder joint angle has negatively and significantly correlated with performance of elite weight lifters. However, all others angular kinematic variables ankle joint angle, knee joint angle, hip joint angle and elbow joint angle have shown insignificant correlation with performance of elite weight lifters.

4. During transition phase of snatch skill, shoulder joint angle has negatively significantly correlated, and elbow joint angle has positively significantly correlated with performance of elite weight lifters. However, all others angular kinematic variables ankle joint angle, knee joint angle and hip joint angle have shown insignificant correlation with performance of elite weight lifters.

5. During second pull of snatch skill, only knee joint angle has negatively and significantly correlated with performance of elite weight lifters. However, all others angular kinematic variables; ankle joint angle, knee joint angle, hip joint angle and

elbow joint angle have shown insignificant correlation with performance of elite weight lifters.

6. During turn over under the barbell in snatch skill, all the selected angular kinematic variables; ankle joint angle, knee joint angle, hip joint angle, shoulder joint angle and elbow joint angle have shown insignificant correlation with performance of elite weightlifters.

7. During catch phase of snatch skill, all the selected angular kinematic variables; ankle joint angle, knee joint angle, hip joint angle, shoulder joint angle and elbow joint angle have shown insignificant correlation with performance of elite weightlifters

8. The performance has shown significantly negative correlation with velocity during first pull, and positive correlation with velocity during second pull among the elite weight lifters. However, others linear kinematic variables; barbell displacement till first pull, barbell displacement till second pull and maximum vertical height of barbell have shown insignificant correlation with performance of elite weight lifters.

9. Sitting height has shown significant and positive correlation with ankle joint angle during first phase of snatch skill. However, other body dimensions such as height, weight, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with ankle joint angle among elite weight lifters.

10. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with knee joint angle during first phase of snatch skill among elite weight lifters.

11. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during first phase of snatch skill among elite weight lifters.

12. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle during first phase of snatch skill among elite weight lifters.

13. Height and sitting height have shown significant and negative correlation with elbow joint angle during first phase of snatch skill. However, other body dimensions such as weight, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with ankle joint angle among elite weight lifters.

14. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle during first pull of snatch skill among elite weight lifters.

15. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with knee joint angle during first pull of snatch skill among elite weight lifters.

16. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during first pull of snatch skill among elite weight lifters.

17. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle during first pull of snatch skill among elite weight lifters.

18. Height has shown significant and positive correlation with elbow joint angle during first pull of snatch skill. However, other body dimensions such as weight, sitting height arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth,

calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle among elite weight lifters.

19. Thigh girth and calf girth have shown significant and positive correlation with ankle joint angle during transition phase of snatch skill. However, other body dimensions such as height, weight, arm length, leg length, lower leg length, chest girth, pelvic girth, BMI and waist hip ratio have shown insignificant correlation with ankle joint angle among elite weight lifters.

20. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with knee joint angle during transition phase of snatch skill among elite weight lifters.

21. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during transition phase of snatch skill among elite weight lifters.

22. Lower leg length has shown significant and negative correlation with shoulder joint angle during transition phase of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle among elite weight lifters.

23. Weight, lower leg length and thigh girth has shown significant and positive correlation with elbow joint angle during transition phase of snatch skill. However, other body dimensions such as height, sitting height, arm length, leg length, chest girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle among elite weight lifters.

24. Weight, sitting height, pelvic girth and BMI has shown significant and positive correlation and pelvic girth has shown significant and negative correlation with the elbow joint angle during second pull of snatch skill among elite weightlifters. However, other body dimensions such as height, arm length, leg length, lower leg

length, chest girth, thigh girth, calf girth and waist hip ratio have shown insignificant correlation with ankle joint angle among elite weight lifters.

25. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with knee joint angle during second pull of snatch skill among elite weight lifters.

26. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during second pull of snatch skill among elite weight lifters.

27. Leg length has shown significant and negative correlation with shoulder joint angle during second pull of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle among elite weight lifters.

28. Pelvic girth has shown significant and positive correlation with elbow joint angle during second pull of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle among elite weight lifters.

29. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with ankle joint angle during the turn over under the barbell phase of snatch skill among elite weight lifters.

30. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with knee joint angle during the turn over under the barbell phase of snatch skill among elite weight lifters.

31. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during the turn over under the barbell phase of snatch skill among elite weight lifters.

32. Thigh girth has shown significant and positive correlation with shoulder joint angle during the turn over under the barbell phase of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle among elite weight lifters.

33. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle during the turn over under the barbell phase of snatch skill among elite weight lifters.

34. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with ankle joint angle during the catch phase of snatch skill among elite weight lifters.

35. Waist hip ratio has shown significant and positive correlation with knee joint angle during the catch phase of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth and BMI have shown insignificant correlation with knee joint angle among elite weight lifters.

36. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during the catch phase of snatch skill among elite weight lifters.

37. Chest girth has shown significant and negative correlation with shoulder joint angle during the catch phase of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, lower leg length, pelvic girth,

thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle among elite weight lifters.

38. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle during the catch phase of snatch skill among elite weight lifters.

39. Lower leg length has shown significant and negative correlation with linear kinematic variable barbell distance from the floor to first pull in snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with linear kinematic variable barbell distance from the floor to first pull among elite weight lifters.

40. Weight, lower leg length and BMI has shown significant and positive correlation with barbell distance at the end of second pull in snatch in snatch skill. However, other body dimensions such as height, sitting height, arm length, leg length, chest girth, thigh girth, pelvic girth, calf girth and waist hip ratio have shown insignificant correlation with linear kinematic variable barbell distance at the end of second pull in snatch among elite weight lifters.

41. Pelvic girth has shown significant and negative correlation with linear kinematic variable maximum distance covered by barbell in snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with linear kinematic variable maximum distance covered by barbell among elite weight lifters.

42. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with linear kinematic variable, the maximum vertical velocity during first pull in snatch among elite weight lifters.

43. Height has shown significant and positive correlation with linear kinematic variable, the maximum the maximum vertical velocity during second pull in snatch in snatch skill. However, other body dimensions such as weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth calf girth, BMI and waist hip ratio have shown insignificant correlation with linear kinematic variable, the maximum the maximum vertical velocity during second pull in snatch among elite weight lifters.

The findings of the present study can help the lifters, experts and coaches in talent identification in games and sports as which children are well suitable by comparing their physique. The findings of present study also helpful in better understanding the snatch technique to coaches, players and the professionals as the data collected was of elite level players in each phases of snatch skill. The present study also helpful in explored the shortcoming in the movement particular liable for minimizing the chance of failure in the lifting of snatch skill.

Keywords: Body Dimensions, Angular Kinematics, Linear kinematics, Performance and Weightlifters.

ACKNOWLEDGEMENT

With the grace of almighty, completion of this doctoral thesis was possible only with the support and cooperation of several people and blessing of God. I take the privilege of expressing the sincere gratitude to all the people whose constant support and cooperation has been essential in this accomplishment.
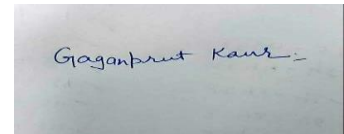
My foremost acknowledgment is for my respected guide, Dr. Manohar Lal, Professor, Department of Physical Education, G.H.G. Khalsa college, Gurusar Sadhar, he scholarly inputs and consistent encouragement I received throughout the research work. He inspired me for excellence. My foremost acknowledgment is for my respected, Dr. Neelam Sharma, Professor and HOD, Department of Physical Education, she scholarly inputs and consistent encouragement I received throughout the research work. She inspired me for excellence.

I express my deepest regard and gratitude to Sh. Ashok Mittal, The Chancellor and Smt. Rashmi Mittal, The Pro Chancellor, Lovely Professional University for providing research infrastructure and encouraging scholars for quality research work. A special thanks is being extended to Prof. Sanjay Modi, Prof. H.O.S P.P. Singh for their interest, suggestions and guidance in my research work.

Parents sacrifice unconditional for their children, words would fail to mention the greatness of my parents, who have nurtured me with great care and love. I believe my good ethics and moral values is just a reflection of their sound character. The words are inadequate to express my gratitude to my parents Late Sh. Sukhwant singh and Late Sh. Paramjit Kaur and my grandparents S. Shamsher singh and Late Sh. Surjit Kaur. My sister and brother Mrs. Sharanjit Kaur Bathh and Mr. Sharanjit Singh has always been an enormous source of motivation with full of positivity. My guardian and Coach S. Nirmal Singh Grewal, Asian medalist in athletics and Mrs. Amarjit kaur grewal who always been a great support system throughout my journey. I feel lucky for being blessed with carrying brother and sister my only pillar of strength that always encouraged and support

me to bring my best for this work. I am equally thankful to all the others members of my family for their eternal love, affection and encouragement.

I deeply acknowledge the guidance of Dr. Yuvraj singh, Dr. Satish sharma, Dr. Deepak Bangari, Dr. Susant Panda, Dr. Harmanpreet Kaur, Mrs. Shreshtha Lal, Mr. Sunil Pal and Dr. Charanjit Kaur Mahal for motivating me. My friends are always been a great support and source of encouragement to accomplish the goal Mr. Tajinder Singh Maan, Dr. Mehak Mengi & Ms. Garima Sharma.

Dated:19-07-2021   **INVESTIGATOR**

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CHAPTER-I

INTRODUCTION

Sports has emerged a very highly competitive activity in the present decade. A lot of sports competition is going on throughout countries of the world to establish supremacy. Old records are being broken and new ones are being established in almost all international competitions. This has become possible because of advancement of scientific procedures, new researches and development. A sport is a skill in which team or an individual competes against each other for enjoyment. This governed by some set of rules. It is an active recreation. Sports require some sort of physical effort of specialized skill. Skill is the ability to execute any movement without any fault. It is the basic requirement to do any task. "Regular exercise and physical activity can benefit you stay active, healthy and independent as you grow older. It aids in reducing and preventing heart ailments, diabetes, obesity, cardiovascular illness and cancer", (Elmaged, 2016). "Regular participation in sports and exercise increase physical, mental and social health. So many researches find that it is beneficial for individuals. This improves worth of life of an individual; overcome the risk of chronic disease such as diabetes, obesity and depression. Sports and games also improved longevity" (Govindarajulu, 2009). Active living is described by the joining of physical movement into day-by-day schedules and relaxation interests. The significance of physical training, games, sports and yoga for wellbeing and physical wellness of an individual's goal of expanding singular productivity can't be disregarded.

Nowadays Physical teachers, coaches, mentors and health specialists to distinguish that science plays a vital part in the effective role of physical training, games, sports and activity programs. Competition is natural activity which is inevitable in human life and every educational set up should permit and assist with the preparation of individual for battle of life. In the order of human ethics defeat in field of sporting holds a unique place. It is a combination of achievement, success, defeat and dominance of some over other

mates and players. Competition provides the right chance and in accurate means by which one simply exhibit one's worth by competing successfully.

Performance in sports competitions at different levels have become a symbol of growth, prosperity and innovations of techniques in the arena of sports. It is gaining momentum day by day. High level investigation in the field of research is going on to search the components which are beneficial for the development of sports performance and talent identification in sports. The adequate infrastructure, new incentive and standardized sports apparatus are being provided by the organizations interested in the progress of sports to see their countries at the top of award-winning country in world competitions. A lot of investigation is being done on all parts of sports performance. According to Siahkouhian (2010) "There exist solid relationships among anthropometric, body composition variables with performance in weightlifting". So investigations need to be done in this area to bring out the best outcome for the sports. According to Anup (2014) "in different studies, it has been discovered that for a specific sport there is need of a specific good physique which helps in good performance". "In scientific literature some researches have showed that how best to prepare or trained athlete and teams to develop fitness for wellbeing (Lal, 2006).

Sports researchers have been put forth attempts occasionally for the search of the most skilled kids from countless school young men and young female in the different game's discipline based on their anatomical structure, their capacities, motor capacities and different parameters of wellness. "The scientific methods of selection and training of sports in advanced countries not only helped to achieve them better performance at the various levels of international competitions, but also helped their citizen to achieve their better health condition" (Sidhu 2013). At the elite level, for an effective performance, it doesn't simply rely upon one or two performance characteristics; it additionally depends on a more components. For a successful sports performance in weightlifting, traits like strength, speed, flexibility, agility, anthropometric, cardiovascular endurance, emotional and mental ability counts a lot.

1.1 Weight Lifting

The sport of Weightlifting has gained much popularity all over the world during the last few years. "It is the most dominant sports events in the world of sport" (Khaled, 2013). In India also, this sport gained popularity. Weight lifting got its start in the year 1860 in strong man contests, with George Barker Wind ship, a physician, health reformer, and strong man, at the fore. Wind ship is credited with inventing the plate-loading barbell, which he patented in the year 1865, named it the Practical Graduating Dumb-bell. In Germany, Vladislav Krayevsky, a native of Poland, founded the St. Petersburg Amateur Weight lifting society in 1885, and a national federation was established in Germany in 1891. The earliest national competition was held in London in 1891, with lifters from Austria, Belgium, Germany, and the United States competing with their strength. In these early competitions, a differentiation was made between lifting by the assistance of one hand in particular and lifting by the assistance of two hands. Women's competitions didn't occur around then, and the weight lifters were not arranged by tallness or weight.

Weight lifting became an Olympic event in 1896, but was dropped from the games until 1920. During the 1900 Olympic Games, no weight lifting event was organized. In 1928, the three lifts-press, snatch, and jerk were established. The press was dropped from Olympic lifting in 1976 because of controversy over what constituted a proper lift" (Olympic weightlifting, n.d.). By the finish of the press after the 1972 Olympic Games in Munich only two lifts have stayed: the clean & jerk and the snatch. "Olympic weightlifting executes two lifts: first is the snatch and second is the clean and jerk" (Isaka, 1996). Each weightlifter gets three attempts or chances at both lifts, and is positioned by the total of the best weight lifted. Lifters attempt a generally low weight rather than the greatest load in the principal effort, in light of the fact that the free weight is weighted dynamically. A lifter can't effort to lift a weight that is not exactly the weight they recently attempted. "In weightlifting, snatch skill is the most technical skill" (Gourgoulis, 2004)

In the Olympic Games according to rules, in case a weightlifter is unsuccessful in all three snatch lifts, that lifter isn't permitted to attempt any clean & jerk, and consequently accomplishes no total. Competitors are placed in different weight categories, starting from 45 kilograms for women and 55 kilograms for men. In any international competition, Weightlifting teams are divided into two classes. Men's and women's teams consist of ten members; both classes can have no more than two members per weight class. "The Olympic Games have their own unique qualifying procedures, based on a country's placing at the world championships; a men's and women's team may have as maximum seven members" (Hanlon, 2009).

"The competition for women category was started at the Olympic games of 2000 which was organized in Sydney, Australia" (Solodka, 2016). Karnam Malleswari from India won Bronze medal in this competition. "In the year 2011, the International Weightlifting Federation encircled a standard that competitors could attire a full-body unitary underneath the Weight lifting uniform ensemble. Kulsoom Abdullah was the primary females to do as such at the U. S. public championships that year. Around then the competitors were permitted to do as such at the Olympics event IWF rules previously stated that an athlete's knees and elbows should be visible to the officials so that they can determine if a lift is correctly executed. "In the research field till date main focused has dedicated on the male competitors" (Hoover, 2006).

There are 4 styles of executing the snatch such as snatch in squat position, power snatch, muscle snatch and snatch with split. "The snatch is the skill in which weight lift from floor to overhead in one consistent movement" (Gourgoulis, 2004). In addition, weight lifting has become an accepted sport in many universities, schools, commercial and industrial concerns, and in the armed forces. One basic advantage of weight lifting is that there is simply no difficulty at all in making a start. From the time you lift a barbell, no matter how poor your performance, you are in field, and you will experience thrill of comparatively rapid progress you can expect during the early days of your training.

According to Nawrat (1997) in weightlifting the simple problem is outline the path of barbell which is best for the skill.

1.2 Anthropometry

Modernization covers all parts of life and sport is no exemption to it. Sports sciences have empowered present day youth to create physical restrictions whenever wished-for. The athletes can bound their movements and get their desired results. Sports in present time have become serious and more & more records are being broken day by day. The most important need of young Indian athlete now a day is the scientific training programs specially based on age, physical fitness, motor ability, psychological and cardiovascular levels according to various norms of Indian population. These types of training programs may be helpful in the popularization of sports. "Due to popularization of sports in India, there will be a lot of improvement in physical standards and mental health of the mass" (Khetarpal, 1989).

Anthropometry is the science that assesses the size, weight and proportions of human body. It gives scientific techniques and perceptions on the living people. Anthropometric procedures (circumference, skinfold fat and diameter measurements) are famous for foreseeing body arrangement since they are very little costly, require tiny space and can be executed effectively (Behenke et al., 1974., Pollock et al., 1990).

Human motor performance is a compound of lots of factors, one of that is structure of body. The specific estimation of body length, shape and breadths can open the connection between anthropometry of the athlete and his motor fitness. "The growth of body in specific sports appears to have a close relationship with the progress of strength required in most sports performance" (Meetei, 2017). Estimation of the body size incorporate such repetitive data as weight, height and surface region, however proportions of body size show the connection among weight, height and width, length and periphery of different body segments. It has been discovered that top competitor in certain games will in general have those extent that biomechanically help the specific performance required.

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Anthropometry has been utilized to evaluate net structure and capacity, including body size, shape, and proportion and body segments. Evaluation of the human body is imperative to decide its relationship with danger of health issues, for example, overweight, movement failure and dietary problems. Anthropometry is a significant approach and method in the field of general wellbeing and nutrition. The competitors are both, born and made. The fundamental structure must be available for the competitor to develop. According to (Tanner, 1964) "Some researches show that inappropriate body affects the performance in sports strongly". This essential structure or build of a competitor is probably going to rely upon one's heredity or family line patterns. "According to Olympic participants body was connected to a great level of achievement in some sports" (Cureton, 1991)

Assessment of the human body to tackle the issues corresponding to the human movement, body execution and all different issues related with nutrition is significant. Thus, Kinanthropometry might be considered as a central control in human research. In regard to a specific sort of essential body that makes a competitor with more prominent execution for a specific time came up around the center of the twentieth era. "Investigations in India, in this specific arena had not been conducted from many years. In different nations, researches in this field have been since very long performing" (Hirata, 1979).

The competitors are observed and chosen normally based on their physical qualities for a specific game or sports. According to Hirata (1979), "selection of Olympic competitors for succeeding in a specific event mainly depends on the precise figure appropriate to the features of the sports event". It is obvious that each man and woman starts existence with a morphological and useful potential, which sets restrictions for wellbeing and physical fitness, creation and body shapes, size, bone structure and state of lung, heart and instinctive organs. The all out number of muscles and nerve cells inside the body are fixed during childbirth. In this way, it shows that a few people are brought into the world with a great potential for physical wellness and work execution though others are most

certainly not. It demonstrates that the morphological or physical attributes are dictated by heredity; however, it is hard to evaluate the function of heredity and ecological variables influencing physical types. "In young male lifters, size of physique was major cause of weightlifting capability" (Mayhew, 1993). The physical exercise and other preparing can improve the presentation of a competitor just up to certain furthest reaches that is set by his genotypes. Notwithstanding, the part of anthropometry as a sports science is maybe one of the most pivotal in this respect. "This is basic in light of the fact that the physique, body composition, physical movement and one's motor improvement are of basic significance in building up the talents of sportspersons and determination and advancement in sports" (Sodhi, 1991).

The fundamental issue in knowledge of weight lifting methods is to characterize the ideal path of the barbell. The essential concern is instructing the movement of weight lifting is to have a norm for the movement of the barbell weight with relationship to the body measurements and the weight (Worobiew, 1977; Nawrat, 1983; Roman, 1986 and Wolkow, 1987). The path of the barbell weight's track is separate and subject to a wide range of elements. One of the most significant elements is the anthropometric body measurements of the competitor. "For the improvement of snatch skill, association between barbell path and anthropometry must be keeping in mind" (Musser, 2014).

It can be inferred that the body size and the type of physique are important factors to describe the ultimate limit of a sportsman. It follows that certain body specifications may be conducive to efficiency in some apparatuses, while the same may be obstacles in smooth and easy performance on others. It appears to be that a few people have with high potential for physical fitness and work execution, while other isn't. Thus, it is not possible to control all these constitutional variables as such; there would inevitably be difference in the performance of each individual. In weightlifting "Female exhibit performance features which are different from those stated in men weightlifting" (Hoover, 2006).

1.3 Sports Biomechanics

The modern age of sports is the age of excellence, thus in each sports perfection and purification of talent has its vast importance. Biomechanics aim to clarify the mechanics of life. Sports biomechanics have additionally generated different efforts at rising athletic performance in numerous games and sports. Sports biomechanics might be a quantitative based, generally study and examination of talented competitors and games normally. "During this subfield of biomechanics, the laws of mechanics components applied in order to understand a bigger liberal of athletic execution through numerical displaying, model and action" (Sports biomechanics, 2020).

In the 21st century, biomechanics is an expert area of study. In biomechanics, movements are concentrated so as to comprehend the hidden instruments associated with the actions or in the securing and guideline of expertise. "The exceptionality of biomechanics as a territory of education advances not from a remarkable assemblage of information, yet from the inquiries that are posed moderately to comprehend human movements" (Bates, 1991). "Procedures and techniques from further logical controls, for example, material science and designing, are utilized to look at the human movements. Thusly, biomechanics includes mechanical estimations utilized in the combination with natural translations" (Higgins, 1985). Biomechanics is a sports science that applies the laws of mechanics and physical science to human execution, so as to increase a more noteworthy comprehension of execution in the athletic occasions through demonstrating, recreation and estimation. "Biomechanics gives main information for skill training in sports" (Kipp, 2012).

Biomechanical assessment of sports method is a part of the human body just as the athletic gears as a mechanical arrangement of the moving. In the advanced mechanized frameworks, the computer programs are utilized to assess the gathered human movements/movements information and demonstrate it. By these product programs, it is presently conceivable to make modern computation and examination among the cases, the subjects and the models correlated with the movement. "Participants who wants to

improve weightlifting performance should try to use proof-based response" (Winchester, 2009). "Movement analysts worked together with different fields like material science, mechanical building and so forth can adequately or minutely decide the irregular movement designs, measure deviances from an ideal example, and asses an assortment of biomechanical blunders complete by a competitor" (Higgins, 1985).

Technological advancements have brought biomechanical applications into a good vary of fields from medical science to recreation. Coaches, therapists, and physicians have neglected biomechanics to boost performance, rehabilitation, and therefore the hindrance of sports connected injuries occurred. Useful analyses of athletic movements that were not possible some years gone are offered and used these days. "Understanding of performance actions in the snatch skill benefit lifters and coaches to completely enhance the training which lead to competition" (Hoover, 2006). With new advancements, the probabilities for investigation the manner an individual interact and reacts to environmental conditions are ever increasing.

1.4 Biomechanical Analysis

Biomechanical investigations assess the movement of being and the impact of forces on it. The biomechanical way to deal with the movement investigation can be qualitative, with movement watched and depicted, implying that some part of the movement estimated. The usage of the term biomechanics in this substance gets the subjective parts together with a more express quantitative strategy. "In methodology, the development individualities of a human or a thing are depicted using such limits as speed and bearing, how the development is made through use of the powers both outside and inside the body, and the ideal body locations and exercises for beneficial and convincing development" (Kreighbaum,1985)

The biomechanical investigation of various trials can assist with understanding the basic purpose of specialized execution of skill/technique along these lines helping mentors and competitors in their readiness. One zone of significant consideration in the course of

recent ages is that of biomechanical investigation. Acccording to Gourgoulis (2004), "In different level, lifters biomechanical features also exist differently, due to which variations found between performances." Human movement examination is regularly utilized today for both clinical and exploration purpose. The workmanship and the study of movement examination have extended past the fundamental depictions of mobile examples to incorporate the forefront clinical functions in restoration, medical procedure, orthotics, prosthetics, ergonomics and Athletics. Biomechanical analyses are of four types.

Noncinematographic examination is the utmost widely recognized scientific procedure utilized in the games by mentors, competitors and others. No film or tape is utilized in catching the performance and the segment portions of the implementation of the motor ability. It involves a restrained way to deal with watching and afterward examining abilities, yet doesn't need entangled numerical estimations. It needs a full comprehension of biomechanical standards. Clearly, a subjective investigation is dependent upon some mistake in the translation.

Basic cinematographic examination includes the utilization of film or tape for improving the presentation of a competitor. It likewise doesn't include any numerical counts. One favorable position of non-cinematographic investigation is that we could grasp the movements in a moderate movement. The investigation takes into account seeing what truly happened versus what we may think occurred. It is useful in lessening the measure of mystery and, along these lines mistake in the revising device capacities since it is a subjective examination.

Intermediate cinematographic investigation needs some numerical computations to improve the examination. In this sort of examination, the utilization of film is important to catch the motor ability and ensuing investigation. It is a quantitative investigation, in which the speed and power alongside other information are determined, hence considering a huge decrease in mystery in examination of the segment portions of a given ability. Accordingly, the investigation expands the odds of showing the ability precisely.

Biomechanics research includes exceptionally advanced biomechanical equipment's, for example, rapid cameras, movement examination programming, power plates, EMG for muscle inclusion, transducers, PCs and significantly more. The gears consider precise assurance of variables that impact the human presentation. It is the technique for distributing in the scientific journals and generally a Ph.D. in biomechanics is required. As we would envision, it requires a ton of effort to decrease the information previously treated with the measurable strategies.

Two dimensional analyses are the kind of investigation normally utilizes 1 camera and fewer markers regarding the matter than in further 3-D investigation. In spite of the fact that it has constraints, it was the primary technique utilized by sport scientists and biomechanicst, is as yet utilized nowadays by several exploration labs that use movement examination, and is effectively adjusted for understudy research. Video examination once video or film is documented it requisite be broken down. This generally involves digitizing focuses off of a film or video utilizing an extraordinary machine, or in any event, utilizing following paper overlaid on a screen. Video can be caught by a PC and important focuses digitized straightforwardly utilizing picture examination projects, for example, NIH Image and Measurement in Motion. In the movement examination action included here, Quick Time motion pictures are utilized to digitize focuses that make up a point among the leg, lower leg and foot. This edge lets one examine the impact shoes have on pronation and supination. Videography is the utmost widely recognized target information assortment strategies utilized in biomechanics in light of the fact that they give a lasting and visual record of execution. There are the non-imaging estimation methods that give important biomechanical information to the target examination of movement. It might be best now and again to quantify a portion of the kinematics parts of a movement straight forwardly, instead of get the estimations from film or tape. Digitize Images, regardless of film or video, should be prepared into an organization that the PC can utilize. Video catch cards are utilized to catch video and change it into a digitized structure, prepared for investigation. The game specialist likewise utilizes this term concerning catching the directions of markers set on the body for movement

investigation. The method for movement investigation with measurement in motion involves digitizing markers on a competitor's leg to make a point that can be utilized for examination fast video.

Nowadays numerous scientists are going to video analysis that can take shots at a pace of 30 to 10,000 pictures for every second. A portion of the cameras utilized for rapid video that can likewise be fit to naturally digitize markers. The time from recording, or information assortment, to information examination has been sliced from weeks to days with such advancements. Cinematographic system in the sports, exploration and movement examination, researchers utilized cameras that could shoot 16 mm film at rates more prominent than 200 edges for every second. This permits analysts to catch information from events that happen extremely quickly. The drawback to utilizing film is that it is costly, together to buy and create and takes additional time and exceptional apparatus to analyze.

There are presently several studies accessible in literature that inspected the mechanics of the snatch skill in elite and feminine weightlifters. Though, few studies have centered on the weight, its mechanics and also the angular mechanics of the limb throughout the snatch in adolescent and elite weightlifters. "From 1960 onwards world records in snatch shows little improvement in all weight categories. There needs to be a better understanding how snatch skill can increase performance even by a minor margin" (Ho, 2014).There are not many studies that have been done on the Indian weightlifting on the body dimensions and kinematics variables that had very much effect on the performance of the lifters in snatch skill. This study will help the lifters to understand the kinematic variables which affect their snatch skill performance, and their relationship with body dimensions.

1.5 Significance of the study

In the period of computer, the movement research programming made the biomechanical research particularly in kinematics feasible to examine the lifters movement. The norm of

procedure/expertise and sports execution is poor of our lifters in India as comparison to International lifters. The absence of logical assistances to the improvement of technique/skill instructing or correction of movement's example and so on has stimulated flawed movements, at long last disintegration of the best demonstrations. The results of this study will help the Indian weightlifters to improve their patterns in skill or performance. This examination will be adding to research the segmental positions, amazing expertise developments and point of the lower appendages to get about the greatest lift speed. The current study might be beneficial in sports where the recommending to children can be provided to which games and sports, they are well suitable by comparing their physique. The coaches, players and the professionals of snatch technique of weightlifting were greatly helped with the response providing of the prevailing method of executing the snatch technique. The present study might be helpful in understanding the relationship of body dimension with performance in each phase of snatch. The mechanical investigation of many movements performed by a weightlifter involved in the procedure of snatch lift was discovered the flaw in the movement particular liable for reducing the chance of failure in the lifting. The outcomes of the study will be evolving new measures for refining the performance of Indian weightlifters and a long way in benefit from the chance of award winning of our Indian weightlifters at International competitions. The result of the study will profits the budding weightlifters that could be best prepared from earliest reference point of their learning cycle to build up a perfect motor habit by utilizing the standards got from the current investigation

1.6 Statement of the problem

This present study is focuses on the selected body dimensions; linear measurements and girth of body segments and kinematic variables; i.e. segmental angles and linear velocity of barbell at different phases of snatch lift. It helps to find out the relationship with the performance of elite weightlifters. Therefore, the current study has been entitled as "association of body dimensions and kinematic variables with performance of elite weightlifters".

1.7 Operational definition of the terms

Body dimensions are the measurements of the structure of the human body at specific sites to give measures of length, girth and width.

Kinematics is the description of motion without reference to force. In this research, it deals with motion of weightlifters during the snatch lift as angular distance, displacement and linear velocity etc.

Linear kinematics is the description of linear motion. In this study, it deals with the linear kinematics of barbell during the snatch lift.

Angular kinematics is the description of angular motion. In this study, it deals with the angles of joint during the snatch lift in each phase.

Biomechanical analysis assesses the movements of a living being and the impact of forces on it. In this investigation snatch lift in weightlifting was selected for biomechanical analysis.

The Snatch is associated with lifting the weight on barbell in one continuous motion.

Performance considered for analysis is lifting of weight in snatch skill during trails of junior world championship.

Elite weightlifters are those weight lifters who were the medalists in national level weightlifting competition.

1.8 Objectives of the study

In order to achieve the aim of the present study, the following objectives have been specified:

- To assess the association of body dimensions with performance of elite weightlifters in snatch skill.
- To assess the association of kinematic variables with performance of elite weightlifters in snatch skill.
- To assess the association of body dimensions with kinematic variables of elite weightlifters in snatch skill.

1.9 Hypotheses of the study

On the bases of earlier research readings and literature studied, opinion of the experts and understanding of the investigator, it was hypothesized that:

H₁: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio with performance of elite weightlifters in snatch skill.

H₂ₐ: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during first phase of snatch skill.

H₂ᵦ: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during first pull of snatch skill.

H₂꜀: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during transition phase of snatch skill.

H₂d: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during second pull of snatch skill.

H₂ₑ: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during the turn over under the barbell of snatch skill.

H₂f: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during the catch phase of snatch skill.

H₃: There exists significant relationship of selected linear kinematic variables; barbell height at the end of the first pull, barbell height at the end of the second pull, maximum barbell height, the maximum vertical velocity of the barbell in the first pull and the maximum vertical velocity of the barbell in the second pull with performance of elite weightlifters in snatch skill.

H₄ₐ: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during first phase of snatch skill.

H₄ᵦ: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during first pull of snatch skill.

H₄c: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during transition phase of snatch skill.

H₄d: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during second pull of snatch skill.

H₄e: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during the turn over under the barbell of snatch skill.

H₄f: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during catch phase of snatch skill.

H₅a: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected linear kinematic variables; i.e. barbell height at the end of the first pull among elite weightlifters in snatch skill.

H₅b: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio with selected linear kinematic variable; i.e. barbell height at the end of the second pull among elite weightlifters in snatch skill.

H₅c: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh

girth, calf girth, BMI and waist hip ratio with selected linear kinematic variable; i.e. maximum barbell height among elite weightlifters in snatch skill.

H$_{5d}$: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio with selected linear kinematic variable; i.e. the maximum vertical velocity of the barbell in the first pull among elite weightlifters in snatch skill.

H$_{5e}$: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio with selected linear kinematic variable; i.e. the maximum vertical velocity of the barbell in the second pull among elite weightlifters in snatch skill.

1.10 Delimitations of the study

1. The study was delimited to the elite level female weight lifters under-18 years who clinched medals in national level competition and were a part of national camp at NIS, Patiala.
2. This study was delimited only to snatch skill in weightlifting. This skill requires effective and efficient technique and less error to be done during lift. As comparison to clean & jerk the lifter lifts less weight in snatch because it is difficult to master.
3. The study delimited to selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio.
4. This study delimited to angular kinematics variables angles of ankle joint, knee joint, hip joint, shoulder joint and elbow joint.
5. The study was further delimited to linear kinematics of barbell; height of barbell till the end of the first pull, height of barbell height till the end of the second pull,

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maximum height of barbell, the maximum vertical velocity of the barbell in the first pull and the maximum vertical velocity of the barbell in the second pull.

6. The performance of weightlifter was delimited to 85% of 1 repetition maximum (RM) of snatch lift in kilograms for analysis.

1.11 Limitations of the study

1. The prior experience of the lifters in the field of weightlifting, which might be impact on the data collection, was not considered.

2. Factors like psychological, food habits, rest period and life style, etc., which would have an effect on the performance, were not controlled.

3. The weather situations as atmospheric temperature, atmospheric pressure and humidity throughout the data collection were also not considered.

4. The changes of the psychological, physiological characteristics as well as social situation of the weightlifters throughout the data collection were not controlled.

CHAPTER-2

REVIEW OF RELATED LITERATURE

Review of research studies serve as a connection between the new and the old, between the recognized and the unclear. Review of literature builds up the scientist's understanding and sets up his scholarly prevalence over others. An investigation of relevant writing is a basic advance to get a decent appreciation of what must be finished as to the issue under investigation. The Literature in any field shapes the establishment where upon all future work will be constructed. The review of related literature of the current investigation which would be gathered from various sources of reference is further categorized in this section:-

- 2.1 Review related to kinematic Variables
- 2.1 Review related to body dimensions

2.1 Reviews related to kinematic variables

The modern age of sports is the age of excellence, thus in each sports perfection and purification of talent has its vast importance. Biomechanics is a professional area of study. In biomechanics, movements are concentrated so as to comprehend the hidden systems associated with the movements or in the securing and guideline of ability. The biomechanical examination of snatch ability can assist with understanding the basic purpose of specialized execution consequently helping mentors and competitors in their preparation. The literature was given below related to kinematic variables in Weightlifting.

Kipp (2020) investigated the overall significance of net joint moment (NJM) according to barbell kinematics at the time of clean. Ground response power and 3-D movement information were recorded as 7 lifters executed cleans at 85% of their most extreme, and were utilized to figure hip, knee, and lower leg NJM. Non-parametric insights demonstrated that the lower leg NJM displayed the best relative significance comparable

to bar speed, though the knee and lower leg NJM indicated the best relative significance according to bar increasing speed. These outcomes demonstrate that the NJM delivered at the knee and lower leg joint are vital in adding to bar kinematics throughout weightlifting.

Oleshkovalentin et al. (2020) investigated the accuracy of skill, practically applied in performing activities by weightlifters of various genders that have distinctive body weight, with the assistance of biomechanical structure of free weight take off. They have considerable amplitude value of barbell departure in the stage of final acceleration and the magnitude of barbell displacement into assisting squat with the benefit of biomechanical structure of barbell displacement by lifters of various genders that have dissimilar body weight. This permits evaluating efficacy of the clean and jerk and snatch skill in the procedure of refining their sportsmanship. Biomechanical formation of barbell displacement in last acceleration phase and associate squat has some dissimilarity dependent on competitive exercise, genders of sportspersons and their association to the cluster of weight groups.

Oleksandrantoniuk et al. (2017) described the use of trajectory type in snatch lift for elite woman lifters. Findings shows that the analyses of effective tries in barbell snatch lifting during competitions in international tournaments shows correlation of elite weightlifters knowledge of barbell motion trajectory in sagittal plane in difference with other weight categories. It has been defined that the second type of trajectory in snatch lift is more used by female weightlifters in lightweight categories (48-58 kg). It has been found that female athletes (53) and female athletes in heavyweight category (75+) use the third type of barbell motion trajectory (C).

Hirunrat and Ingkatecha (2015) examined the jumping serve performance of 15 female volleyball players. The players selected 8 from national and seven from youth national. The videography technique was used to collect data and later analyzed on spector software. Angular and linear acceleration of upper and lower body, center of gravity examined during the contact of ball. Results revealed that no difference find out among

both the groups. It also indicates that during the ball contact in jumping serve youth players showed better acceleration as comparison to national level players.

Singh et al. (2015) investigated the association of angular kinematic variables with performance of volleyball players in float serve skill. For the sampling ten men players were selected. For the biomechanical analysis videography technique was used. The Pearson product moment correlation was used. Results show an insignificant relationship of angular kinematics during the float serve.

Ho et al. (2014) conducted survey of research patterns in weightlifting writing identifying with the comprehension of method and its function in effective snatch execution. Reference to the world records in the snatch from the 1960s onwards demonstrates little advancement over all weight classes. With such unremarkable advances in execution of snatch at the International level, there is a need to see how snatch method can improve performance. Strategies for information securing for specialized examination of the snatch have included generally 2-dimensional free weight and joint kinematics. Albeit key factors which assume a function in the effective result of a snatch lift have been intensely explored, not many investigations have consolidated factors relating both the free weight and the weightlifter in their examinations.

Harbili and Alptekin (2014) compared the linear mechanics of the barbell and the angular mechanics of the lower limb throughout the snatch lifts of 2 totally unique barbell weights in male young weightlifters. The snatch lifts were recorded by two camcorders underneath conditions in arrangement amount earlier the European Junior Competition and conjointly the 2 heaviest lifts were chosen for kinematic examination. The outcomes exhibit that the skeletal muscles of the hip all through the first pull and second pull need to improve. Coaches need to add assisting activities to surge explosive strength in the second pull, which will improve maximum strength in male adolescent lifters.

Musser et al. (2014) revealed that there exist relationships among horizontal free weight displacement throughout the stages of the snatch and jerk. The results display that relationships existed among second pull and total free weight displacement and a number

of other anthropometrical proportions involving torso and height. Important correlations were additionally found between horizontal free weight displacement and absolute anthropometrical variables within the 53kg and 57kg weight categories. All anthropometrical variables were considerably completely different between weight categories with the exceptions of torso and thigh lengths.

Ulareanu et al. (2014) analyzed the dynamic and kinematic features of phases of clean & jerk in anaerobic workouts performance. Seven weightlifters were selected for analysis. Movements for analysis captures on video. Data revealed that trajectories mostly found between joints concerned in movement. The results also revealed the characteristics of phases of clean & jerk, specifically the jerk that has influence on the performance in competition.

Singh (2013) investigated the overhead serve skill and the performance relationship among kinematic variables in volleyball. For the data collection 10 men player under the age group 20-24 years from national level were selected. The findings indicate that in overhead serve chosen kinematic variables shows insignificant relationship with performance among players.

Chiu and Salem (2012) determined the intense impacts of weightlifting on vertical joint kinetics; execution was evaluated previously, during, and after snatch pull practice in men competitors. Jumping was surveyed utilizing 3D movement examination and reverse elements. Jump height was upgraded at the midpoint and end of the activity meeting, showing a more prominent power creating capacity. At the midpoint, knee extensor net joint work was expanded and related with expanded bounce tallness. Following activity, lower leg plantar flexor net joint work was expanded and related with expanded bounce. Snatch pull practice inspired intense upgrades in vertical bounce execution. At the midpoint of the activity meeting, more prominent work at the knee joint added to improved execution. Toward the finish of the activity, more prominent work at the lower leg added to improved execution. Therefore, potentiation isn't inspired consistently across joints during multi joint exercise.

Swinton et al. (2012) studied the biomechanics of the customary squat with two well-known exercise varieties generally denoted as squat in powerlifting position and squat from box. The customary squat was executed with a limited position. In the unusual period of the conventional squat, the knee will go over the toes bringing about foremost removal of the framework focal point of mass (COM). Conversely, in squat from powerlifting position and squat form box, shin position was kept more vertical, bringing about back removals of the framework COM. For the two joints, the biggest pinnacle second was delivered in the conventional squat, trailed by the powerlifting squat, at that point box squat. Critical contrasts (p< 0.05) were likewise known at the hip joint where the biggest second in every one of the 3 planes was delivered during the powerlifting squat.

Yadav (2012) analyzed the kinematic variables in volleyball of jump spike service. For the sampling ten male volleyball players under the age group 19-25 years from university and national level were selected. The Nikon d-100 camera was used to record the data of jump service. In this skill variables were selected angular and linear kinematics and center of gravity of players. T-test was used for the analysis. The outcomes revealed that there were no vital changes found among both the groups.

Hales et al. (2009) investigated biomechanical parameters between the regular style deadlift and the back squat executed by twenty five lifters competing in local powerlifting competition. The 3-dimensional examination joined 460 Hz synchronized cameras for gathering information from twenty five members. The outcomes show the back squat speaks to a synergistic or synchronous development, though the deadlift exhibits a consecutive or portioned development. The kinematic investigation of the squat and the traditional deadlift demonstrate that the individual lifts are notably extraordinary (p< 0.01), suggesting that no immediate or explicit traverse impact exists amid the individual lifts.

Miletello et al. (2009) analyzed the differences among three groups- college powerlifters, high school and novice powerlifters during the maximum squat to define the impact of

skill on performance. Three squats were executed by powerlifters and last squat was their one repetition maximum. Results revealed that difference found between college powerlifters and high school lifters in the angular velocity of knee. Results also showed that to prevent injury and to attain optimal outcomes in powerlifting, lifting skill need to be improved.

Okada et al. (2009) analyzed the snatch techniques of Japanese and worldwide female weightlifters by kinematic investigation. Motion analysis of the snatch skill recorded at the 2006 bodybuilding Women's Junior World Championship. The outcomes demonstrated no vital variations between the snatch technique of Japanese and international weightlifters. Anyhow, the time period between the height speeds of the vertical speed of the practicing weight was longer for Japanese weightlifters, whereas the ability applied to the practicing weight was bigger for global weightlifters. These discoveries show that varieties in strength and power creation influenced the technique of Japanese and international weightlifters.

Chenfu and Lin (2007) investigated the volleyball float serve and jump serve with their kinematic characteristics. For this thirteen volleyball players were selected to perform serve. Jump serves were recorded using 2 Jvc 9800 cameras (120 Hz). The findings indicate that as comparison to ball speed during jump float serve shows larger values in jump spin. The results also suggest that the findings of this study will helpful for the coaches to teach both serves in volleyball.

Rosi et al. (2007) concluded whether there were asymmetries in barbell kinematics and kinetics between the left and right sides of the barbell among 19 weightlifters. The subsequent reason for comparing was to analyze free weight direction grouping of the clean and snatch lifts between the left and right sides of the hand weight. Free weight kinematic and active information were gathered and investigated with 2 VS-120 weightlifting-examination frameworks. Hand weight directions (A, B, and C) for the left and right sides were analyzed for each lift. No significant distinction was found in direction arrangement between sides of the hand weight for either lift. The frequencies

examination uncovered that type C free weight directions were the most pervasive in each lift. At the point when the privilege and left sides of the free weight were thought about the snatch and clean, no noteworthy contrasts were resolved for any kinematic or active factors.

Gourgoulis et al. (2004) compared the linear mechanics and energy changes of the exercising weight, in conjunction with the angular mechanics of the leg movement throughout the snatch technique, between male adolescent and adult weightlifters. Results reveal no vital variations between the adolescent and the adult weightlifters within the majority of the kinematic variables. It indicated that the adolescent weightlifters were characterized by a great level of snatch skill and separated from the grown-ups at the less dominant implementation of the movement.

Mcguigan et al. (1996) examined variances in kinematics among conventional and sumo style deadlift skill execute by powerlifters. Videography technique was used to collect data. Results revealed that sumo lifters kept a straighter stance at lift off as comparison to the conventional lifters. The distance essential to lift the bar to finishing point was significantly reduced in the sumo skill. No significant change was found among the skills as to where the sticking point happened.

Bauman et al. (1988) investigated the snatch technique in terms of kinematic, and internal and external kinetic parameters, and analyze the outcomes for competitors of various gatherings and weight classes. By methods for three-dimensional film examination and estimations of ground response powers during the 1985 World Championships in Sweden, it was conceivable to break down the spatial developments and to ascertain joint snapshots of power in every leg. Regarding the kinematics, a snatch strategy beginning with a solid draw toward the lifter could be built up. The most fascinating motor outcomes are that the knee joint minutes are generally little and don't relate very well with the complete burden. The best lifters appear to be ready to restrict the knee joint moment by exact control of the knee position regarding the ground response power.

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Garhammer (1985) examined the heaviest effective clean & jerk lift for five Gold medalists in weight-lifting at the 1984 Olympic Games from 16mm film. Bar directions demonstrated that as the hand weight was lifted from the stage it pushed toward the competitor during the first pull, at that point away from the competitor lastly toward him again as it dropped during the catch stage. Bar speed profiles indicated that most lifters decelerated the hand weight toward the finish of the first pull, while balancing their body position for the subsequent power. Determined power outputs were enormous in amount and demonstrated significant similarities for chosen phases of the lifts of a given competitor. Power yield esteems for complete snatch and clean pulls commonly in somewhere in the range of 28 and 35 W/Kg of weight. Higher qualities were found for sub periods of the pulls and for the jerk pushes.

2.2 Reviews related to body dimensions

Attila & Andras (2020) revealed that for the biomechanical assessment of the relative performance, the body system (body + barbell) should be considered. In addition, another factor is the body-composition (fat, muscle and bone ratios) of the lifters. The major controlling factor is the muscle-ratio, which is notably less in the super-heavyweight group than in the others. Changing parameter is the build of the athlete (dominantly the body height), because to extent higher level with the barbell while pulling it is required to have higher speed, so as a result the lifter has to accomplish higher acceleration and require more strength to proceed. The body height is significant from the view of energetics; as well the physical work executed by a taller lifter is more inducing. The physique and body composition has an influence on the movement-structure and the technical ability (level) of attempts. In the super-heavyweight the skill is often far from the optimal, regarding the biomechanical demands. The final aspect is the division of lifters in the diverse categories, inevitably if the number of lifters is not alike in the different groups, the sport level can also be dissimilar.

Andrew et al. (2018) examined the relative influences of anthropometric, biomechanical and psychological variables to the estimate of maximum parallel barbell back squat

strength. Twenty-one college participants were selected. One repetition maximum (1RM) of barbell back squat for performance was selected. The results revealed that in heterogeneous population anthropometric plays first role, biomechanical and psychological plays second role. These outcomes confirm the significance of weight classes in strength sports.

Lovera and Keogh (2015) investigated that there exist relationship among anthropometric profile and maximal strength in powerlifting. For this study 63 male powerlifters from Argentine National Tournament and 31 anthropometric variables were selected. Results revealed that champions shows significantly positive larger proportional muscle, muscle to bone mass and crucial index than the non-champions. They further revealed that powerlifters show unique anthropometric profiles. Successful powerlifter's shows higher degree of muscle mass in height and bone mass but similar length segment and length ratio segments as comparison to less successful liters.

Rajesh and Krishnakanthan (2014) compared the selected physical variables between hockey, football and basketball players. For the data collection 45 players from which fifteen from each sport was selected. The players were selected from Tamilnadu colleges in which they participated in intramural and extramural competitions. The findings indicate that basketball players were better in speed as compare to others. In football players cardio respiratory endurance was better as comparison to others.

Khaled (2013) investigated the contribution ratios of anthropometric estimations and somatotypes, and physical capacities as a capacity to predict the selection of skilled junior weightlifters. The investigation was completed on a sample of (205) individual schools and youth center over the governorates of Egypt. The outcomes indicated that the anthropometric dimensions and physical patterns, body organization and physical capacities contribute in the selection of junior weightlifters. These outcomes must be considered by the Weightlifting Federation and coaches to be utilized as a sign for the selection of skilled junior weightlifters.

Latif et al. (2012) investigated the connection among maximum strength dimensions, relative strength and anthropometric factors of 13 national weightlifters from Turkish

national weightlifting team. Results shows that the association among weight, height, BMI, sport age, width, circumference, body fat percentage and snatch, squat, clean & jerk relative strength and chest pull were found negative association at the 0.05 and 0.01 levels. Outcomes suggest that weightlifters with short height, low BMI and light body weight shows more benefit than relative strength.

Siahkouhian and Hedayatneja (2010) assessed the relationships of anthropometric and body composition factors with the performance of weightlifters. From the outcomes, it was found that there were solid connections present among weightlifter execution and the anthropometric and body structure factors. Additionally, it is suggested that the cormic list (CI) is a remedial aspect for BMI values.

Pilli (2010) analyzed the association of anthropometric and physical variables among handball and kho-kho players. The players were selected from school games team of Andhra Pradesh. The findings revealed that kho-kho players were better in endurance and speed as comparison to handball players. Other than that handball players were shows significant connection in variables as muscular endurance, explosive strength, weight and body fat.

Keogh et al. (2007) investigated the anthropometric dimensions of power lifters across several body mass categories. 54 male Oceania power lifters (nine lightweight, thirty middleweights, and fifteen heavyweights) were enlisted from 1 international and 2 national level tournament held in New Zealand. Anthropometric attributes were more articulated in heavyweights, who were fundamentally heavier, had more noteworthy muscle and fat mass, were more endo-monomorphic, and had bigger circumferences and hard breadths than the lighter lifters. Despite the fact that middle weight and heavyweight lifters normally had longer fragment lengths than the lightweights. While population correlations would be needed to distinguish any association between explicit anthropometric measurements that give an upper hand to the outflow of maximal quality, anthropometric profiling may demonstrate valuable for ability recognizable proof and for the appraisal of preparing movement in power lifting.

Devi (2006) investigated the 32 meitei female weightlifters from state, national and international level. Twenty one anthropometric variables were selected. She also compared the 100 meitei female who were non-athletes with the same physical structure. The findings suggest that lifters have significantly shorter size with shorter forearm lengths and upper arm lengths as compared to non-athletes. They results shows they have greater mean value of lean body mass and total body fat than the non-athletes.

Mayhew et al. (1993) evaluated that how much strength performance is related with fundamental dimensions in beginner young powerlifters. The weight lifting performance has maximum connection with body mass and limb circumferences. Eliminating the influence of body mass affectedly reduced the relations among lift performances and structural dimensions. Findings suggest that 68.9% and 62.4% of variance in dead lift and bench press is contributed by size and structural dimensions. It has been also found that body size is discriminating factors in weightlifting capacity in young adult men competitors, with basic measurements assuming a smaller function in deciding achievement.

CHAPTER-3

RESEARCH METHODOLOGY

Method and procedure involve an organized plan of actions by which the investigator begins from identification and selection of research problem to writing the conclusions. It provides the tools and techniques by which the problem can be solved. According to the objectives of the study the investigator has planned the entire process of research work in term of method and procedure. To explain the study, the investigator has to describe the technique used for collecting data. The methods and procedure of research study are closely linked with its purpose as they provide a framework within which the goals are to be achieved. Thus, it involved number of steps to complete this investigation and explained below as.

3.1 Research design

Descriptive research design was used to assess the association of body dimensions and kinematic variables with performance of elite weightlifters. The purposive sampling technique was used to select the sample for the study. The present study was conducted on seven female elite level weight lifters who were in India camp and preparing themselves for National and International competition. The measurements of body dimensions; anthropometric rod, weighing machine and steel tape was used. Videography technique was used for biomechanical analysis of snatch skill. For the analysis of movement- Kinovea-0.8.25-x64 trail version software was used. The product moment method of correlation was used to analyze the data.

3.2 Sampling

To investigate the association of body dimensions and kinematic variables with performance, the seven (n=7) female weightlifters of elite level were chosen as the subjects for the examination. The purposive sampling technique was applied for the selection of the subjects. The subjects for the investigation were chosen from the India camp at Netaji Subhash National Institute of Sports (NIS) Patiala. The data was collected

during the trails of Youth World Weightlifting Championship 2017 on 20-2-2017 at national camp, Patiala. Only 7 weight lifters have qualified for the Youth World Weightlifting Championship. The championship was held at Bangkok, Thailand from 3 to 10 April, 2017.

3.3 Sampling layout
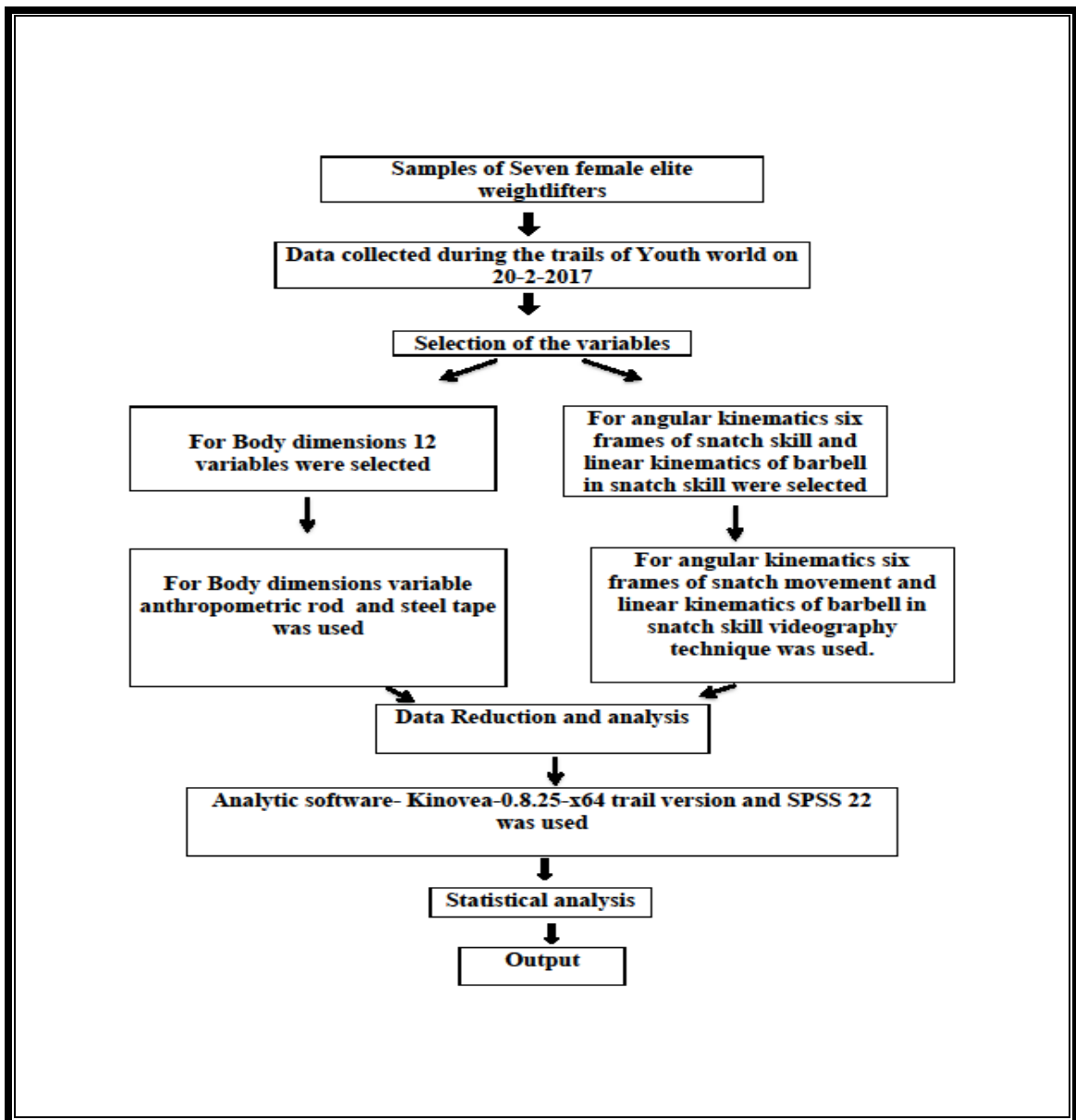
Fig. 3.1 Work Flow chart

3.4 Selection of the variables

Based on available writing and considering the entire feasibility following variables were selected:-

A) Body dimensions:
- ✓ Height
- ✓ Weight
- ✓ Sitting height
- ✓ Arm length
- ✓ Leg length
- ✓ Lower Leg length
- ✓ Chest girth
- ✓ Pelvic girth
- ✓ Thigh girth
- ✓ Calf girth
- ✓ BMI
- ✓ Waist-Hip Ratio

B) Kinematic variables

a) Angular Kinematics
- ✓ Ankle joint angle
- ✓ Knee joint angle
- ✓ Hip joint angle
- ✓ Shoulder joint angle
- ✓ Elbow joint angle

b) Linear kinematics of barbell
- ✓ Barbell height at the end of the first pull
- ✓ Barbell height at the end of the second pull
- ✓ Maximum barbell height
- ✓ The maximum vertical velocity of the barbell in the first pull

✓ The maximum vertical velocity of the barbell in the second pull

3.5 Selection of frames for analysis

To identify the frame of snatch movements for analysis was divided in to five phases:

(a) Phase-I (the first phase/lift off)

(b) Phase-II (the first pull),

(c) Phase-III (the transition phase),

(d) Phase-IV (the second pull),

(e) Phase-V (turnover under the barbell)

(f) Phase-VI (the catch/hold phase)

a) Lift-off   b) First Pull   c) Transition Phase   d) Second Pull   e) Turnover Phase   f) Catch Phase
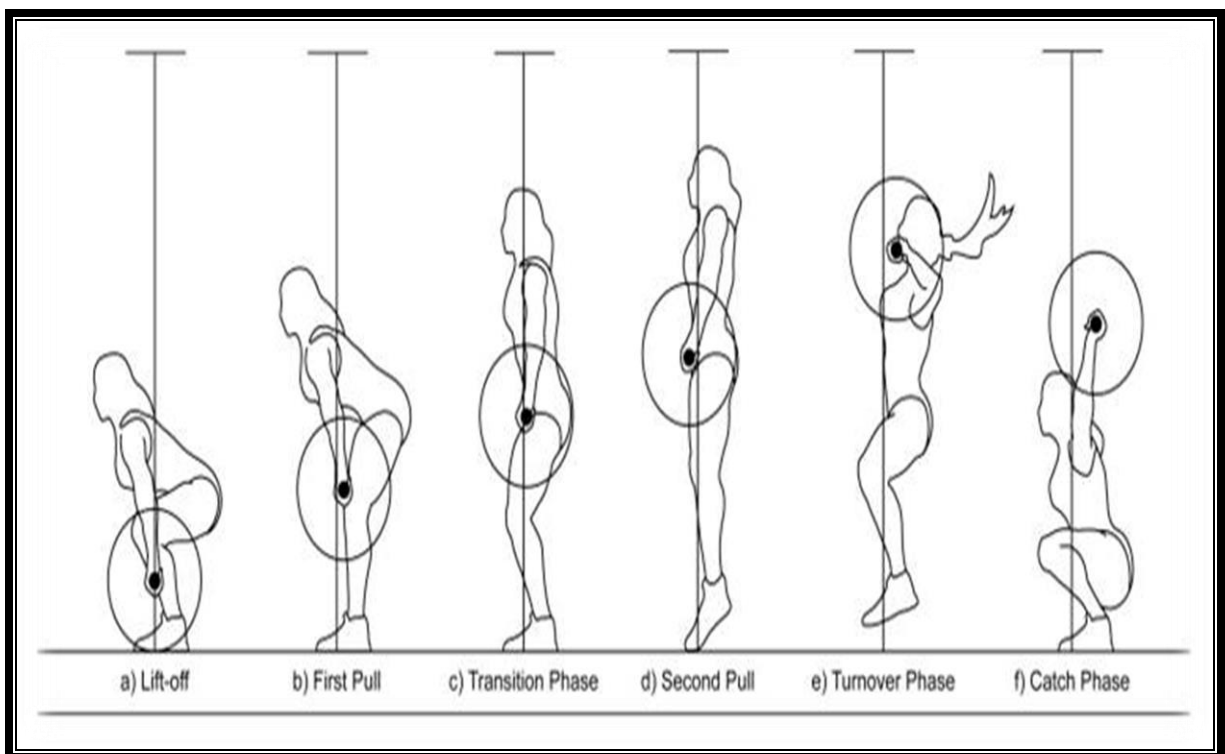
Fig. No.3.2- Frames of Snatch

3.6 Apparatus and software used

1. Portable weighing machine- To measure the body weight of the lifters.

2. Anthropometric rod - To measure the body dimensions like height, sitting height, arm length, leg length and lower leg length.

3. Steel tape- To measure the body dimensions like chest girth, pelvic girth, thigh girth, calf girth and waist hip ration of the body.
4. Biomechanical analysis- Videography technique was used.
5. Analysis of movement- Kinovea-0.8.25-x64 Trail Version software was used.

3.7 Procedure of data collection

Prior to the collection of data, the researcher informed the relative authority to explain in detail the purpose of the study. Investigator called upon biomechanical expert Dr. Suhel Raza, Asst. Prof. in P.P.N. College, Kanpur, U.P. India with his camera team for the biomechanical data collection. He held a position of video analyst in various sports academics for the improvement of techniques and skills of players. Prior permission was taken from the Indian team chief coach Mr. Vijay Sharma, India Camp, NIS, Patiala for the data collection. The data was collected with the consent from the higher authority of NIS Patiala. The coaches and lifters were informed about the purpose of the study.

3.7.1 The procedure of measurements of Body dimensions

(i) Height: It is the vertical distance from the vertex to the even floor.

Equipment: Anthropometric rod.

Procedure: The estimation was taken with the individual standing straight without shoes against an upstanding divider, contacting it with heels, bottom and scapulae. The heels contact one another and with the toes 30 degree separated. The head was situated in the Frankfort plane. The anthropometric rod was held vertically before the subject in mid-sagittal plane and the even movable bar was brought down to contact the point vertex.

ii) Body weight: It refers to the total mass of the body at a particular point or time.

Equipment: Portable weighing machine.

Procedure: The subject wearing least dress, stood erect in the focal point of the scaled foundation of the versatile gauging machine and the weight was recorded in kilogram when the scale of the machine got fixed. To record precise qualities, the subjects were

requested not to make any sort of movement while remaining on the machine. The zero of the scale was checked prior to taking every measurement.

(iii) Sitting Height- It is a measure of the length from upper segment of the body including the trunk, neck, and head heights.

Equipment: Anthropometric rod.

Procedure: The subject was asked to sit on the seat with the legs hanging unsupported over the edge and with the hands lying on the thighs in a cross-gave position. The knees shall be coordinated straight ahead, and the rear of the knees must be close to the edge of the seat however not in contact with it. The muscles of the thighs and buttocks shall be loose. The anthropometric bar was held vertically from the most noteworthy point on the head to the base sitting surface.

(iv) Arm Length: It is the distance between acromion point and dactylion point.

Equipment: Anthropometric rod.

Procedure: Direct the subject to get some distance from you. Request that the person to stand upstanding with the weight uniformly circulated on the two feet, the right arm twisted 90º at the elbow, and the right palm looking up. Show the right position if necessary. At that point measure arm length with the Anthropometric bar and record it.

(v) Leg length: The distance between the anterior superior iliac and the standing surface

Equipment: Anthropometric rod.

Procedure: The subject was asked to remain in an erect position. The distance between the front prevalent iliac and the standing surface was estimated with the anthropometric bar with the subject similarly situated as that for the height. The estimation is recorded to the closest 0.1 cm.

(vi) Lower leg length: It is the straight distance between the superior surface of the medial condylar of the tibia and the floor.

Equipment: Anthropometric rod.

Procedure: The subject was asked to remain in an erect position. The distance between the tibial and the surface was estimated with the anthropometric bar. The estimation is recorded to the closest 0.1 cm

(vii) Chest girth: It is the girth of chest at the level of nipples.

Equipment: Flexible steel tape.

Procedure: Measurement was taken just under the lower corner of scapula and right above the arm-pit and the front of the nipple at the body. The subject kept both his arms a little apart from the body, then the lowered his arm on both the sides when measurement is taken. It is also observed that pressure of the steel tape has not disturbed the skin contours. The circumference was measured in centimeter by the unit of 0.1 centimeter

(viii) **Pelvic girth:** It is the girth of pelvic gridle.

Equipment: Flexible steel tape.

Procedure: - The waist size is taken at the thinnest waist level, or if this is not apparent, at the midpoint among the lowest rib and the top of the hip bone of the subject. If you are uncertain if this measurement was taken at the thinnest level, take numerous measurements at different points and right the lowest measurement.

(ix)Thigh girth: It is the girth at a point half way between the land marks trochanteriid and femoral.

Equipment: Flexible steel tape.

Procedure: The subject stands straight with their weight uniformly disseminated on the two feet and legs somewhat separated. The girth size is taken at the degree of the mid-point on the horizontal (external side) surface of the thigh, halfway between trochanter particle (top of the thigh bone, femur) and tibialelaterale (top of the tibia bone). While recording, it was certain that the tape isn't excessively close or excessively free, is lying level on the skin, and with the tape even. The girth was estimated in centimeter by the unit of 0.1 centimeter.

(x) Calf girth: It is the maximum girth of the calf/lower leg.

Equipment: Flexible steel tape.

Procedure: The subject stands erect with their weight uniformly dispersed on the two feet and legs marginally separated. The estimation is taken at the degree of the biggest periphery of the calf. The maximal size isn't generally self-evident, and maybe the tape ought to be gone here and there to discover the purpose of greatest periphery. When recording, you need to ensure the tape isn't excessively close or excessively free, is lying level on the skin, and is flat. It might assist with having the subject remain on a container to make the estimation simpler. The circumference was estimated in centimeter by the unit of 0.1 centimeter.

(xi) BMI (Body mass index): The body mass index is calculated based on the below formula:

Body weight in kilograms divided by height in meters squared

or

BMI = x KG / (y M X y M)

Where:

x=bodyweight in KG

y=height in m

Example for 175 cm height and 70 kg weight:

BMI = 70 / (1.75 X 1.75) = 22.86

(xii) Waist Hip Ratio: It is the ratio of waist circumference and hip circumference.

Equipment: Flexible steel tape

Procedure: The subject was asked stands erect with their weight evenly spread on both feet and legs slightly apart. Measure the circumference around the smallest part of the waist, just above belly button. This was the waist circumference. After that steel tape placed and measures around the biggest part of hips the broadest part of the buttocks.

This was the hip circumference. Then calculate WHR by dividing your waist circumference by your hip circumference.

3.7.2 The procedure of measurement of Kinematic variables

For measurement of angular and kinematics variables of snatch skill videography technique was used. The step by step procedure was explained below-

3.7.2.1 Videography Techniques

The video graphic technique was further organized into three segments. These are:

(i) Video graphic equipment's and location,

(ii) Camera speed,

(iii) Subject and trail identification.

(i) Videography equipment's and location

The subject's snatch movements were recorded utilizing Casio exilim (high speed, 1200/fps) camera in a field/arena setting. The camera was set-up on a rigid tripod and secured to the floor in the location.

3.7.2.2 Camera Speed

One advanced camera was situated on the stage a ways off of 5.28 m from the lifting arena, shaping a roughly 45° angle with the sagittal plane of the weightlifters. The snatch lifts were recorded utilizing 1 computerized camera (Casio exilim), which caught pictures at 1200 fields for every second. The camera was set at sports mode and the inspecting pace of the camcorder was sixty fields for each second. A quick screen speed can freeze the movement of a quick subject and moderate shade paces can obscure the subject to give the impression of the movement. Consequently, the screen speed of the camera was fixed at quick speed (1/4000 quick shade speed permit quickly subject to catch each edge in turn clearly) to wipe out the haze while video recording.

3.7.2.3 Subject and trail identifications

For recognizable proof of the subject in the video diagram, each subject was given a code/number as to recognize them in the information recorded. For identification purpose

of a best lift, the path was seen on the PC framework with master regarding the matter (weight lifting) to delineate the path for the information procurement.

3.7.2.4 Analytic Software

To analyse the recorded videos following software was used.

a) Kinovea-0.8.25-x64 Trail Version

c) SPSS 22

3.7.2.5 Computer System

Video recording camera was utilized to catch the movement of the chose weight lifters execution for additional assessment and investigation. The caught movement of the subjects was put away in PC for the audit, recognizable proof and examinations with programming. The caught execution and movement in the field setting straight forwardly downloaded into PC for additional information investigations.

3.7.2.6 Data Reduction and Analysis

After video recording meetings, the recorded videos were recorded in to the scientist's PC for preliminary recognizable proof. The distinguished trails were played with the assistance of programming Kinovea-0.8.25-x64 trail version to make separate clips of every player. The different clips were then open on to the Kinovea-0.8.25-x64 trail adaptation programming. The best lift chose for the investigation. This product gives to recognize the points, speed, relocation, time and number of frames.

3.8 Statistical techniques

For the analysis of data SPSS version 22 was used. In order to examine the association of body dimensions and kinematic variables with performance, a product moment correlation method was used.

CHAPTER-4
RESULTS AND INTERPRETAION

This chapter divided into two parts. First part deals with the result of the study in form of tables and interpretation. The second part of the chapter deals with the discussion on findings along with testing of hypotheses.

4.1 Results

The statistical analyzed data has been presented in this chapter in the following sections:

1. Results pertaining to relationship of body dimensions with performance of elite weight lifters.

2. Results pertaining to relationship of kinematic variables with performance of elite weight lifters.

3. Results pertaining to relationship of body dimensions with kinematic variables of elite weight lifters.

4.1.1. Results pertaining to relationship of body dimensions with performance of elite weight lifters

The correlation coefficient computed between body dimensions and performance of weight lifters is presented in tables 4.1

Table: 4.1 Relationship of body dimensions with performance of elite weight lifters (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	**Performance**	Height	.734

2		Weight	.501
3		Sitting Height	.427
4		Arm Length	.293
5		Leg Length	-.015
6		Lower Leg length	.798*
7		Chest Girth	.275
8		Pelvic Girth	-.020
9		Thigh Girth	.535
10		Calf Girth	.206
11		BMI	.302
12		Waist-Hip Ratio	-.194

(*significant at .05 level; r=.754) & (** significant at .01 level; r-.874)

Table 4.1 depicts significant and positive correlation between performance and lower leg length (r=.798, p < .05) among elite weight lifters. However, insignificant and positive correlation were also exist with height (r=.734), weight (r=.501), sitting height (r=.427), arm length (r=.293), chest girth (r=.275), thigh girth (r=.535), calf girth (r=.206), BMI (r=.302) among elite weightlifters.

Negative insignificant correlation were also exist with leg length (r=-.015), pelvic girth (r=-.020) and waist hip ratio (r=-.194) among elite weightlifters.

4.1.2. Results pertaining to relationship of kinematic variables with performance of elite weight lifters

The correlation coefficient computed between kinematic variables and performance of weight lifters is presented in tables 4.2 to 4.8

Table: 4.2 Relationship of angular kinematic variables with performance at first phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Ankle joint angle	.151
2		Knee joint angle	.654
3	Performance	Hip joint angle	.217
4		Shoulder joint angle	.625
5		Elbow joint angle	-.744

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.2 depicts insignificant and positive correlation of performance with ankle joint angle (r=.151), knee joint angle (r=.654), hip joint angle (r=.217), shoulder joint angle (r=.625) among elite weightlifters during the first phase of snatch. However, negative insignificant correlation was also exist between performance elbow joint angle (r=-.744) among elite weightlifters during the first phase of snatch.

Table: 4.3 Relationship of angular kinematic variables with performance at first pull of snatch (N=7)

Sr.	Variables correlated with performance	Co-efficient of

No			correlation
1		**Ankle joint angle**	-.580
2		**Knee joint angle**	.054
3	**Performance**	**Hip joint angle**	.282
4		**Shoulder joint angle**	-.826*
5		**Elbow joint angle**	.588

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.3 depicts insignificant and positive correlation of performance with knee joint angle (r=.054), hip joint angle (r=.282), elbow joint angle (r=.588) among elite weightlifters during the first pull of snatch.

Negative significant correlation was exist between performance and shoulder joint angle (r=-.826, p < .05) among elite weightlifters during the first pull of snatch. However, negative insignificant correlation was also exist between performance and ankle joint angle (r=-.580) among elite weightlifters during the first pull of snatch.

Table: 4.4 Relationship of kinematic variables with performance at transition phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		**Ankle joint angle**	-.016
2	**Performance**	**Knee joint angle**	.462
3		**Hip joint angle**	-.078

4		Shoulder joint angle	-.814*
5		Elbow joint angle	.759*

(*significant at .05 level; r=.754) & (** significant at .01 level; r-.874)

Table 4.4 depicts significant and positive correlation between performance and elbow joint angle (r=.759) among elite weightlifters during the transition phase of snatch. However, insignificant and positive correlation was also exist between performance and knee joint angle (r=.462) among elite weightlifters during the transition phase of snatch.

Negative insignificant correlation was exist between performance and shoulder joint angle (r=-.814, p < .05) among elite weightlifters during the transition phase of snatch. However, negative insignificant correlation were also exist of performance with ankle joint angle (r=-.016) and hip joint angle (r=-.078) among elite weightlifters during the transition phase of snatch.

Table: 4.5 Relationship of kinematic variables with performance at second pull of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Ankle joint angle	.212
2		Knee joint angle	-.785*
3	Performance	Hip joint angle	.090
4		Shoulder joint angle	-.426
5		Elbow joint angle	.126

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.5 depicts insignificant and positive correlation of performance with ankle joint angle (r=.212), hip joint angle (r=.090) and elbow joint angle (r=.126) among elite weightlifters during the second pull of snatch.

Negative significant correlation was exist between performance and knee joint angle (r=-.785, p < .05) among elite weightlifters during the second pull of snatch. However, insignificant correlation was also exist between performance and shoulder joint angle (r=-.426) among elite weightlifters during the second pull of snatch.

Table: 4.6 Relationship of kinematic variables with performance at turn over under the barbell of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Ankle joint angle	-.077
2		Knee joint angle	-.100
3	Performance	Hip joint angle	.428
4		Shoulder joint angle	-.272
5		Elbow joint angle	.716

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.6 depicts insignificant and positive correlation of performance with hip joint angle (r=.428) and elbow joint angle (r=.716) among elite weightlifters during the turn over under the barbell of snatch.

Negative insignificant correlation of performance were also exist with ankle joint angle (r=-.077), knee joint angle (r=-.100) and shoulder joint angle (r=-.272) among elite weightlifters during the turn over under the barbell of snatch.

Table: 4.7 Relationship of kinematic variables with performance at catch phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Ankle joint angle	.476
2		Knee joint angle	-.675
3	Performance	Hip joint angle	.207
4		Shoulder joint angle	-.012
5		Elbow joint angle	-.536

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.7 depicts insignificant and positive correlation of performance with ankle joint angle (r=.476) and hip joint angle (r=.207) among elite weightlifters during the catch phase of snatch.

Negative insignificant correlation of performance were also exist with knee joint angle (r=-.675), shoulder joint angle (r=-.012) and elbow joint angle (r=-.536) among elite weightlifters during the catch phase of snatch.

Table: 4.8 Relationship of linear kinematic variables of barbell with performance of elite weight lifters (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	Competition Performance	Barbell displacement till First Pull	-.699

2		**Barbell displacement till Second Pull**	.538
3		**Maximum Height of Barbell**	-.112
4		**Velocity during First Pull**	-.769*
5		**Velocity during Second Pull**	.783*

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.8 depicts significant and positive correlation of performance with velocity during second pull (r=.783, p < .05) among elite weightlifters. However, insignificant and positive correlation of performance was also exist with barbell displacement till second pull (r=.538) among elite weightlifters.

Negative significant correlation was exist between performance and velocity during first pull (-.769, p < .05) among elite weightlifters. However, negative insignificant correlation of performance were also exist with barbell displacement till first pull (r=-.699) and maximum height of barbell (r=-.112) among elite weightlifters.

4.1.3. Results pertaining to relationship of body dimensions with kinematic variables of elite weight lifters

Results pertaining to relationship of body dimensions with kinematic variables of elite weight lifters

The correlation coefficient computed between body dimensions with kinematic variables of weight lifters is presented in tables 4.9 to 4.42.

Table: 4.9 Association of body dimensions with angular kinematic variable ankle joint angle of elite weightlifters during first phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	.295
2		Weight	.193
3		Sitting Height	.794*
4		Arm Length	.117
5		Leg Length	-.685
6	Ankle joint angle	Lower Leg length	-.084
7		Chest Girth	.369
8		Pelvic Girth	-.266
9		Thigh Girth	.158
10		Calf Girth	.182
11		BMI	.095
12		Waist-Hip Ratio	-.011

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.9 depicts significant and positive correlation between sitting height and ankle joint angle (r=.794, $p < .05$) among elite weight lifters during first phase of snatch. Insignificant and positive correlation between height and ankle joint angle (r = 0.295), weight and ankle joint angle (r = 0.193), arm length and ankle joint angle (r = 0.117),

chest girth and ankle joint angle (r = 0.369), thigh girth and ankle joint angle (r = 0.158), calf girth and ankle joint angle (r = 0.182), and BMI and ankle joint angle (r = 0.095) among elite weight lifters during first phase of snatch.

Negative insignificant correlation were also exist between leg length and ankle joint angle (r = --.685), lower leg length and ankle joint angle (r = -.084), pelvic girth and ankle joint angle (r = -.266), and waist hip ratio and ankle joint angle (r = -.011) among elite weight lifters during first phase of snatch.

Table: 4.10 Association of body dimensions with angular kinematic variable knee joint angle of elite weightlifters during first phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	.420
2		Weight	-.209
3		Sitting Height	.125
4		Arm Length	-.097
5	**Knee joint angle**	Leg Length	-.171
6		Lower Leg length	.149
7		Chest Girth	.536
8		Pelvic Girth	.126
9		Thigh Girth	-.252

Sr. No			Co-efficient of correlation
10		Calf Girth	-.452
11		BMI	-.439
12		Waist-Hip Ratio	-.725

(*significant at .05 level; r=.754) & (** significant at .01 level; r-.874)

Table 4.10 depicts insignificant and positive correlation between height and knee joint angle (r=.420), sitting height and knee joint angle (r=.125), lower leg length and knee joint angle (r=.149), chest girth and knee joint angle (r=.536), pelvic girth and knee joint angle (r=.126) among elite weight lifters during first phase of snatch.

Negative insignificant correlation were also exist between weight and knee joint angle (r=-.209), arm length and knee joint angle (r=-.097), leg length and knee joint angle (r=-.171), thigh girth and knee joint angle (r=-.252), calf girth and knee joint angle (r=-.452), BMI and knee joint angle (r=-.439), and waist knee ratio and knee joint angle (r=-.725) among elite weight lifters during first phase of snatch.

Table: 4.11 Association of body dimensions with angular kinematic variable hip joint angle of elite weightlifters during first phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.123
2	Hip joint angle	Weight	.179
3		Sitting Height	-.018
4		Arm Length	-.379

Sr.		Variables correlated with performance	Co-efficient of
5		Leg Length	-.012
6		Lower Leg length	.317
7		Chest Girth	.023
8		Pelvic Girth	.106
9		Thigh Girth	.467
10		Calf Girth	.437
11		BMI	.280
12		Waist-Hip Ratio	-.247

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874) p < .05)

Table 4.11 depicts insignificant and positive correlation between weight and hip joint angle (r=.179), lower leg length and hip joint angle (r=.317), chest girth and hip joint angle (r=.023), pelvic girth and hip joint angle (r=.106), thigh girth and hip joint angle (r=.467), calf girth and hip joint angle (r=.437), BMI and hip joint angle (r=.280) among elite weightlifters during first phase of snatch.

Negative insignificant correlation were also exist between height and hip joint angle (-.123), sitting height and hip joint angle (r=-.018), arm length and hip joint angle (r=-.379), leg length and hip joint angle (r=-.012), and waist-hip ratio and hip joint angle(r=-.247) among the elite weightlifters during first phase of snatch.

Table: 4.12 Association of body dimensions with angular kinematic variable shoulder joint angle of elite weightlifters during first phase of snatch (N=7)

Sr.	Variables correlated with performance	Co-efficient of

No			correlation
1		Height	.220
2		Weight	.570
3		Sitting Height	.313
4		Arm Length	-.336
5		Leg Length	-.483
6		Lower Leg length	.382
7	Shoulder joint angle	Chest Girth	.188
8		Pelvic Girth	-.376
9		Thigh Girth	.693
10		Calf Girth	.712
11		BMI	.607
12		Waist-Hip Ratio	-.239

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.12 depicts insignificant and positive correlation between height and shoulder joint angle (r=.220), weight and shoulder joint angle (r=.570), sitting height and shoulder joint angle (r=.313), lower leg length and shoulder joint angle (r=.382), chest girth and shoulder joint angle (r=.188), thigh girth and shoulder joint angle (r=.693), calf girth and

shoulder joint angle (r=.712), and BMI and shoulder joint angle (r=.607) among elite weight lifters during first phase of snatch.

Negative insignificant correlation were also exist between arm length and shoulder joint angle (r=-.336), leg length and shoulder joint angle(r=-.483), pelvic girth and shoulder joint angle (r=-.376), and waist-hip ratio and shoulder joint angle (r=-.239) among the elite weightlifters during first phase of snatch.

Table: 4.13 Association of body dimensions with angular kinematic variable elbow joint angle of elite weightlifters during first phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.841*
2		Weight	-.679
3		Sitting Height	-852*
4		Arm Length	-.480
5	Elbow joint angle	Leg Length	.342
6		Lower Leg length	-.589
7		Chest Girth	-.461
8		Pelvic Girth	.403
9		Thigh Girth	-.383
10		Calf Girth	-.130

11		BMI	-.458
12		Waist-Hip Ratio	-.148

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.13 depicts insignificant and positive correlation between leg length and elbow joint angle (r=.342), and pelvic girth and elbow joint angle (r=.403) among elite weight lifters during first phase of snatch.

Negative significant correlation were exist between height and elbow joint angle(r=-841, p < .05), and sitting height and elbow joint angle (r=-852, p < .05) among elite weight lifters during first phase of snatch. However, negative insignificant correlation were also exist between, weight and elbow joint angle (r=.-679), arm length and elbow joint angle (r=-.480), lower leg length and elbow joint angle (r=-.589), chest girth and angle of elbow joint (r=-.461), thigh girth and elbow joint angle (r=-.383), calf girth and elbow joint angle (r=-.130), BMI and elbow joint angle (r=-.458), and waist-hip ratio and elbow joint angle (r=-.148) among the elite weightlifters during first phase of snatch.

Table: 4.14 Association of body dimensions with angular kinematic variable ankle joint angle of elite weightlifters during first pull of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.602
2		Weight	.104
3	**Ankle joint angle**	Sitting Height	-.025
4		Arm Length	-.529

Sr.		Variables correlated with performance	Co-efficient of
5		Leg Length	-.542
6		Lower Leg length	-.544
7		Chest Girth	-.240
8		Pelvic Girth	-.408
9		Thigh Girth	.117
10		Calf Girth	.532
11		BMI	.385
12		Waist-Hip Ratio	.192

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.14 depicts insignificant and positive correlation between weight and ankle joint angle (r=.104), thigh girth and ankle joint angle (r=.117), calf girth and ankle joint angle (r=.532), BMI and ankle joint angle (r=.385), waist-hip ratio and ankle joint angle (r=.192) among elite weightlifters during first pull of snatch.

Negative insignificant correlation were also exist between height and ankle joint angle (r=-.602), sitting height and ankle joint angle (r=-.025), arm length and ankle joint angle (r=-.529), leg length and ankle joint angle (r=-.542), lower leg length and ankle joint angle (r=-.544), chest girth and ankle joint angle (r=-.240), pelvic girth and ankle joint angle (r=-.408) among elite weightlifters during first pull of snatch.

Table: 4.15 Association of body dimensions with angular kinematic variable knee joint angle of elite weightlifters during first pull of snatch (N=7)

Sr.	Variables correlated with performance	Co-efficient of

No			correlation
1		Height	-.136
2		Weight	.004
3		Sitting Height	-.245
4		Arm Length	-.390
5		Leg Length	-.370
6		Lower Leg length	-.336
7	Knee joint angle	Chest Girth	.004
8		Pelvic Girth	-.392
9		Thigh Girth	.019
10		Calf Girth	.265
11		BMI	.065
12		Waist-Hip Ratio	-.219

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.15 depicts insignificant and positive correlation between weight and knee joint angle (r=.004), chest girth and knee joint angle (r=.004), thigh girth and knee joint angle (r=.019), calf girth and knee joint angle(r=.265), BMI and knee joint angle (r=.065) among elite weightlifters during first pull of snatch.

Negative insignificant correlation were also exist between height and knee joint angle (r=-.136), sitting height and knee joint angle (r=-.245), arm length and knee joint angle (r=-.390), leg length and knee joint angle (r=-.370), lower leg length and knee joint angle (r=-.336), pelvic girth and knee joint angle (r=-.392), waist hip ratio and knee joint angle (r=-.219) among elite weightlifters during first pull of snatch.

Table: 4.16 Association of body dimensions with angular kinematic variable hip joint angle of elite weightlifters during first pull of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.341
2		Weight	-.164
3		Sitting Height	-.013
4		Arm Length	-.681
5	Hip joint angle	Leg Length	-.591
6		Lower Leg length	-.175
7		Chest Girth	-.126
8		Pelvic Girth	.184
9		Thigh Girth	.103
10		Calf Girth	.250

11		BMI	-.038
12		Waist-Hip Ratio	-.668

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.16 depicts insignificant and positive correlation between pelvic girth and hip joint angle (r=.184), thigh girth and hip joint angle (r=.103), calf girth and hip joint angle (r=.250) among elite weightlifters during first pull of snatch.

Negative insignificant correlation were also exist between height and hip joint angle (r=-.341), weight and hip joint angle (r=-.164), sitting height and hip joint angle (r=-.013), arm length and hip joint angle (r=-.681), leg length and hip joint angle (r=-.591), lower leg length and hip joint angle (r=-.175), chest girth and hip joint angle (r=-.126), BMI and hip joint angle (r=-.038), waist hip ratio and hip joint angle (r=-.668) among elite weightlifters during first pull of snatch.

Table: 4.17 Association of body dimensions with angular kinematic variable shoulder joint angle of elite weightlifters during first pull of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.425
2		Weight	-.234
3	Shoulder joint angle	Sitting Height	-.319
4		Arm Length	.234
5		Leg Length	.431

Sr.		Variables correlated with performance	Co-efficient of
6		Lower Leg length	-.343
7		Chest Girth	-.439
8		Pelvic Girth	.141
9		Thigh Girth	-.271
10		Calf Girth	-.145
11		BMI	-.105
12		Waist-Hip Ratio	.594

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.17 depicts insignificant and positive correlation between arm length and shoulder joint angle (r=.234), leg length and shoulder joint angle (r=.431), pelvic girth and shoulder joint angle (r=.141), waist hip ratio and shoulder joint angle (r=.594) among elite weightlifters during first pull of snatch.

Negative insignificant correlation were also exist between height and shoulder joint angle (r=-.425), weight and shoulder joint angle (r=-.234), sitting height and shoulder joint angle (r=-.319), lower leg length and shoulder joint angle (r=-.343), chest girth and shoulder joint angle (r=-.439), thigh girth and shoulder joint angle (r=-.271), calf girth and shoulder joint angle (r=-.145), BMI and shoulder joint angle(r=-.105) among elite weightlifters during first pull of snatch.

Table: 4.18 Association of body dimensions with angular kinematic variable elbow joint angle of elite weightlifters during first pull of snatch (N=7)

Sr.	Variables correlated with performance	Co-efficient of

No			correlation
1		Height	.850*
2		Weight	.459
3		Sitting Height	.583
4		Arm Length	.571
5		Leg Length	-.148
6		Lower Leg length	.387
7	Elbow joint angle	Chest Girth	.512
8		Pelvic Girth	-.445
9		Thigh Girth	.079
10		Calf Girth	-.149
11		BMI	.180
12		Waist-Hip Ratio	.162

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.18 depicts significant and positive correlation between height and elbow joint angle (r=.850, p < .05) among elite weigh lifters. Insignificant and positive correlation between height and elbow joint angle (r=.850, p < .05), weight and elbow joint angle (r=.459), sitting height and elbow joint angle (r=.583), arm length and elbow joint angle (r=.571), lower leg length and elbow joint angle (r=.387), chest girth and elbow joint

angle (r=.512), thigh girth and elbow joint angle (r=.079), BMI and elbow joint angle (r=.180), waist hip ratio and elbow joint angle (r=.162) among elite weightlifters during first pull of snatch.

Negative insignificant correlation were also exist between leg length and elbow joint angle (r=-.148), pelvic girth and elbow joint angle (r=-.445), calf girth and elbow joint angle (r=-.149) among elite weightlifters during first pull of snatch.

Table: 4.19 Association of body dimensions with angular kinematic variable ankle joint of elite weightlifters during the transition phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.323
2		Weight	.468
3		Sitting Height	-.024
4		Arm Length	-.230
5	Ankle joint angle	Leg Length	-.106
6		Lower Leg length	.214
7		Chest Girth	-.546
8		Pelvic Girth	-.084
9		Thigh Girth	.768*
10		Calf Girth	.926**

11		BMI	.728
12		Waist-Hip Ratio	.306

<center>(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)</center>

Table 4.19 depicts significant and positive correlation between thigh girth and ankle joint angle (r=.768, p < .05), and calf girth and ankle joint angle (r=.926, p < .01) among elite weightlifters during the transition phase of snatch. Insignificant and positive correlation between weight and ankle joint angle (r=.468), lower leg length and ankle joint angle (r=.214), BMI and ankle joint angle (r=.728), waist hip ratio and ankle joint angle (r=.306) among elite weightlifters during the transition phase of snatch.

Negative insignificant correlation were also exist between height and ankle joint angle (r=-.323), sitting height and ankle joint angle (r=-.024), arm length and ankle joint angle (r=-.230), leg length and ankle joint angle (r=-.106), chest girth and ankle joint angle (r=-.546), pelvic girth and ankle joint angle (r=-.084) among elite weightlifters during the transition phase of snatch.

Table: 4.20 Association of body dimensions with angular kinematic variable knee joint of elite weightlifters during the transition phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	.259
2	Knee joint angle	Weight	.570
3		Sitting Height	.150
4		Arm Length	.470

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5		Leg Length	.221
6		Lower Leg length	.633
7		Chest Girth	-.585
8		Pelvic Girth	.105
9		Thigh Girth	.748
10		Calf Girth	.612
11		BMI	.606
12		Waist-Hip Ratio	.476

(*significant at .05 level; r=.754) & (** significant at .01 level; r-.874)

Table 4.20 depicts insignificant and positive correlation between height and knee joint angle (r=.259), weight and knee joint angle (r=.570), sitting height and knee joint angle (r=.150), arm length and knee joint angle (r=.470), leg length and knee joint angle (r=.221), lower leg length and knee joint angle (r=.633), pelvic girth and knee joint angle (r=.105), thigh girth and knee joint angle (r=.748), calf girth and knee joint angle (r=.612), BMI and knee joint angle (r=.606), waist hip ratio and knee joint angle (r=.476) among elite weightlifters during the transition phase of snatch. However, insignificant and negative correlation were also exist between chest girth and knee joint angle (r=.-585) among elite weightlifters during the transition phase of snatch

Table: 4.21 Association of body dimensions with angular kinematic variable hip joint of elite weightlifters during the transition phase of snatch (N=7)

Sr.	Variables correlated with performance	Co-efficient of

No			correlation
1		Height	-.174
2		Weight	.044
3		Sitting Height	.042
4		Arm Length	.288
5		Leg Length	.406
6		Lower Leg length	.366
7	**Hip joint angle**	Chest Girth	-.580
8		Pelvic Girth	.607
9		Thigh Girth	.289
10		Calf Girth	.139
11		BMI	.146
12		Waist-Hip Ratio	.324

(*significant at .05 level; r=.754) & (** significant at .01 level; r-.874)

Table 4.21 depicts insignificant and positive correlation between weight and hip joint angle(r=.044), sitting height and hip joint angle (r=.042), arm length and hip joint angle (r=.288), leg length and hip joint angle (r=.406), lower leg length and hip joint angle (r=.366), pelvic girth and hip joint angle (r=.607), thigh girth and hip joint angle (r=.289), calf girth and hip joint angle (r=.139), BMI and hip joint angle (r=.146), waist hip ratio

and hip joint angle (r=.324) among elite weightlifters during the transition phase of snatch.

Negative insignificant correlation were also exist between height and hip joint angle (r=-.174), chest girth and hip joint angle (r=-.580) among elite weightlifters during the transition phase of snatch.

Table: 4.22 Association of body dimensions with angular kinematic variable shoulder joint of elite weightlifters during the transition phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.709
2		Weight	-.584
3		Sitting Height	-.339
4		Arm Length	-.633
5	Shoulder joint angle	Leg Length	-.418
6		Lower Leg length	-.990**
7		Chest Girth	.030
8		Pelvic Girth	-.159
9		Thigh Girth	-.671
10		Calf Girth	-.265

| 11 | | BMI | -.418 |
| 12 | | Waist-Hip Ratio | -.233 |

(*significant at .05 level; r=.754) & (** significant at .01 level; r-.874)

Table 4.22 depicts insignificant and positive correlation between chest girth and shoulder joint angle (r=.030) among elite weightlifters during the transition phase of snatch.

Negative significant correlation exist between lower leg length and shoulder joint angle (r=-.990, p < .01) among elite weightlifters during the transition phase of snatch. However, insignificant correlation were also exist between height and shoulder joint angle (r=-.709), weight and shoulder joint angle (r=-.584), sitting height and shoulder joint angle (r=-.339), arm length and shoulder joint angle (r=-.633), leg length and shoulder joint angle (r=-.418), pelvic girth and shoulder joint angle (r=-.159), thigh girth and shoulder joint angle (r=-.671), calf girth and shoulder joint angle(r=-.265), BMI and shoulder joint angle (r=-.418), waist hip ratio and shoulder joint angle (r=-.233) among elite weightlifters during the transition phase of snatch.

Table: 4.23 Association of body dimensions with angular kinematic variable elbow joint of elite weightlifters during the transition phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	Elbow joint angle	Height	.750
2		Weight	.755*
3		Sitting Height	.431
4		Arm Length	.647

5		Leg Length	.342
6		Lower Leg length	.992**
7		Chest Girth	.039
8		Pelvic Girth	-.065
9		Thigh Girth	.773*
10		Calf Girth	.409
11		BMI	.605
12		Waist-Hip Ratio	.383

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.23 depicts significant and positive correlation between weight and elbow joint angle (r=.755, p < .05), lower leg length and elbow joint angle (r=.992, p < .01), and thigh girth and elbow joint angle (r=.773, p < .05) among elite weightlifters during the transition phase of snatch. However,   insignificant and positive correlation were also exist between height and elbow joint angle (r=.750), sitting height and elbow joint angle (r=.431), arm length and elbow joint angle (r=.647), leg length and elbow joint angle (r=.342), chest girth and elbow joint angle (r=.039), calf girth and elbow joint angle (r=.409), BMI and elbow joint angle (r=.605), waist hip ratio and elbow joint angle (r=.383) among elite weightlifters during the transition phase of snatch.

Negative insignificant correlation was also exist between pelvic girth and elbow joint angle (r=-.065) among elite weightlifters during the transition phase of snatch.

Table: 4.24 Association of body dimensions with angular kinematic variable ankle joint of elite weightlifters during the second pull of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	.470
2		Weight	.834*
3		Sitting Height	.768*
4		Arm Length	.159
5		Leg Length	.566
6		Lower Leg length	.233
7	Ankle joint angle	Chest Girth	.431
8		Pelvic Girth	-.863*
9		Thigh Girth	.491
10		Calf Girth	.531
11		BMI	.798*
12		Waist-Hip Ratio	.430

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.24 depicts significant and positive correlation between weight and ankle joint angle (r=.834, p < .05), sitting height and ankle joint angle (r=.768, p < .05), and BMI

and ankle joint angle (r=.798, p < .05) among elite weightlifters during the second pull of snatch. However, insignificant and positive correlation between height and ankle joint angle (r=.470), arm length and ankle joint angle (r=.159), leg length and ankle joint angle (r=.566), lower leg length and ankle joint angle (r=.233), chest girth and ankle joint angle (r=.431), thigh girth and ankle joint angle (r=.491), calf girth and ankle joint angle (r=.531), and waist hip ratio and ankle joint angle (r=.430) among elite weightlifters during the second pull of snatch.

Negative significant correlation was also exist between pelvic girth and ankle joint angle (r=-.863) among elite weightlifters during the second pull of snatch.

Table: 4.25 Association of body dimensions with angular kinematic variable knee joint of elite weightlifters during the second pull of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	Knee joint angle	Height	-.375
2		Weight	-.465
3		Sitting Height	-.124
4		Arm Length	-.032
5		Leg Length	.127
6		Lower Leg length	-.521
7		Chest Girth	.073
8		Pelvic Girth	.118

9		Thigh Girth	-.625
10		Calf Girth	-.523
11		BMI	-.421
12		Waist-Hip Ratio	.141

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.25 depicts insignificant and positive correlation between leg length and knee joint angle (r=.127), chest girth and knee joint angle (r=.073), pelvic girth and knee joint angle (r=.118), waist hip ratio and ankle joint angle (r=.141) among elite weightlifters during the second pull of snatch.

Negative insignificant correlation were also exist between height and knee joint angle (r=-.375), weight and knee joint angle (r=-.465), sitting height and knee joint angle (r=-.124), arm length and knee joint angle (r=-.032), lower leg length and knee joint angle (r=-.521), thigh girth and knee joint angle (r=-.625), calf girth and knee joint angle (r=-.523), BMI and knee joint angle (r=-.421) among elite weightlifters during the second pull of snatch.

Table: 4.26 Association of body dimensions with angular kinematic variable hip joint of elite weightlifters during the second pull of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	Hip joint angle	Height	.292
2		Weight	.271

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3		Sitting Height	.635
4		Arm Length	.378
5		Leg Length	-.005
6		Lower Leg length	.387
7		Chest Girth	.165
8		Pelvic Girth	.123
9		Thigh Girth	.130
10		Calf Girth	-.098
11		BMI	.198
12		Waist-Hip Ratio	.261

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.26 depicts insignificant and positive correlation between height and hip joint angle (r=.292), weight and hip joint angle (r=.271), sitting height and hip joint angle (r=.635), arm length and hip joint angle (r=.378), lower leg length and hip joint angle (r=.387), chest girth and hip joint angle (r=.165), pelvic girth and hip joint angle (r=.123), thigh girth and hip joint angle (r=.130), BMI and hip joint angle (r=.198), waist hip ratio and hip joint angle (r=.261) among elite weightlifters during the second pull of snatch.

Negative insignificant correlation were also exist between leg length and hip joint angle (r=-.005), calf girth and hip joint angle (r=-.098) among elite weightlifters during the second pull of snatch.

Table: 4.27 Association of body dimensions with angular kinematic variable shoulder joint of elite weightlifters during the second pull of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.330
2		Weight	.189
3		Sitting Height	.395
4		Arm Length	-.468
5		Leg Length	-.817*
6	Shoulder joint angle	Lower Leg length	-.501
7		Chest Girth	.171
8		Pelvic Girth	-.560
9		Thigh Girth	-.003
10		Calf Girth	.329
11		BMI	.360
12		Waist-Hip Ratio	.085

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.27 depicts insignificant and positive correlation between weight and shoulder joint angle (r=.189), sitting height and shoulder joint angle (r=.395), chest girth and

shoulder joint angle (r=.171), calf girth and shoulder joint (r=.329), BMI and shoulder joint angle (r=.360), waist hip ratio and shoulder joint angle (r=.085) among elite weightlifters during the second pull of snatch.

Negative significant correlation was exist leg length and shoulder joint angle (r=-.817, p < .05) among elite weightlifters during the second pull of snatch. However, insignificant correlation were also exist between height and shoulder joint angle (r=-.330), arm length and shoulder joint angle (r=-.468), lower leg length and shoulder joint angle (r=-.501), pelvic girth and shoulder joint angle (r=-.560), thigh girth and shoulder joint angle (r=-.003) among elite weightlifters during the second pull of snatch.

Table: 4.28 Association of body dimensions with angular kinematic variable elbow joint of elite weightlifters during the second pull of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	**Elbow joint angle**	Height	-.323
2		Weight	-.608
3		Sitting Height	-.428
4		Arm Length	-.142
5		Leg Length	.399
6		Lower Leg length	.085
7		Chest Girth	-.425
8		Pelvic Girth	.971**

9		Thigh Girth	-.200
10		Calf Girth	-.350
11		BMI	-.580
12		Waist-Hip Ratio	-.510

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.28 depicts significant and positive correlation between pelvic girth and elbow joint angle (r=.971, p < .05) among elite weightlifters during the second pull of snatch. However, insignificant and positive correlation were also exist between leg length and elbow joint angle (r=.399), lower leg length and elbow joint angle (r=.085), among elite weightlifters during the second pull of snatch.

Negative insignificant correlation were also exist between height and elbow joint angle (r=-.323), weight and elbow joint angle (r=-.608), sitting height and elbow joint angle (r=-.428), arm length and elbow joint angle (r=-.142), chest girth and elbow joint angle (r=-.425), thigh girth and elbow joint angle (r=-.200), calf girth and elbow joint angle (r=-.350), BMI and elbow joint angle (r=-.580), waist hip ratio and elbow joint angle (r=-.510) among elite weightlifters during the second pull of snatch.

Table: 4.29 Association of body dimensions with angular kinematic variable ankle joint of elite weightlifters during the turnover under the barbell of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	Ankle joint angle	Height	-.175
2		Weight	.289

3		Sitting Height	.127
4		Arm Length	-.570
5		Leg Length	-.451
6		Lower Leg length	-.91
7		Chest Girth	.320
8		Pelvic Girth	-.488
9		Thigh Girth	.316
10		Calf Girth	.510
11		BMI	.419
12		Waist-Hip Ratio	-.139

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.29 depicts insignificant and positive correlation between weight and ankle joint angle (r=.289), sitting height and ankle joint angle (r=.127), chest girth and ankle joint angle (r=.320), thigh girth and ankle joint angle (r=.316), calf girth and ankle joint angle (r=.510), BMI and ankle joint angle (r=.419) among elite weightlifters during the turnover under the barbell of snatch.

Negative insignificant correlation were also exist between height and ankle joint angle (r=-.175), arm length and ankle joint angle (r=-.570), leg length and ankle joint angle (r=-.451), lower leg length and ankle joint angle (r=-.91), pelvic girth and ankle joint angle

(r=-.488), waist hip ratio and ankle joint angle (r=-.139) among elite weightlifters during the turnover under the barbell of snatch.

Table: 4.30 Association of body dimensions with angular kinematic variable knee joint of elite weightlifters during the turnover under the barbell of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.437
2		Weight	.169
3		Sitting Height	-.171
4		Arm Length	-.512
5		Leg Length	-.089
6		Lower Leg length	.069
7	Knee joint angle	Chest Girth	-.262
8		Pelvic Girth	.021
9		Thigh Girth	.502
10		Calf Girth	.656
11		BMI	.406
12		Waist-Hip Ratio	-.063

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.30 depicts insignificant and positive correlation between weight and knee joint angle (r=.169), lower leg length and knee joint angle (r=.069), pelvic girth and knee joint angle (r=.021), thigh girth and knee joint angle (r=.502), calf girth and knee joint angle (r=.656), BMI and knee joint angle (r=.406) among elite weightlifters during the turnover under the barbell of snatch.

Negative insignificant correlation were also exist between height and knee joint angle (r=-.437), sitting height and knee joint angle (r=-.171), arm length and knee joint angle (r=-.512), leg length and knee joint angle (r=-.089), chest girth and knee joint angle (r=-.262), waist hip ratio and knee joint angle (r=-.063) among elite weightlifters during the turnover under the barbell of snatch.

Table: 4.31 Association of body dimensions with angular kinematic variable hip joint of elite weightlifters during the turnover under the barbell of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.170
2		Weight	.223
3		Sitting Height	-.238
4	Hip joint angle	Arm Length	-.429
5		Leg Length	-.030
6		Lower Leg length	.339
7		Chest Girth	-.295

Sr. No			Co-efficient of correlation
8		Pelvic Girth	.127
9		Thigh Girth	.657
10		Calf Girth	.691
11		BMI	.367
12		Waist-Hip Ratio	-.298

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.31 depicts insignificant and positive correlation between weight and hip joint angle (r=.223), lower leg length and hip joint angle (r=.339), pelvic girth and hip joint angle (r=.127), thigh girth and hip joint angle (r=.657), calf girth and hip joint angle (r=.691), BMI and hip joint angle (r=.367) among elite weightlifters during the turnover under the barbell of snatch.

Negative insignificant correlation were also exist between height and hip joint angle (r=-.170), sitting height and hip joint angle (r=-.238), arm length and hip joint angle (r=-.429), leg length and hip joint angle (r=-.030), chest girth and hip joint angle (r=-.295), waist hip ratio and hip joint angle (r=-.298) among elite weightlifters during the turnover under the barbell of snatch.

Table: 4.32 Association of body dimensions with angular kinematic variable shoulder joint of elite weightlifters during the turnover under the barbell of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	**Shoulder joint angle**	Height	.148

2		Weight	-.346
3		Sitting Height	.213
4		Arm Length	.116
5		Leg Length	-.278
6		Lower Leg length	-.511
7		Chest Girth	.497
8		Pelvic Girth	-.224
9		Thigh Girth	-.779*
10		Calf Girth	-.743
11		BMI	-.509
12		Waist-Hip Ratio	-.098

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.32 depicts insignificant and positive correlation between height and shoulder joint angle (r=.148), sitting height and shoulder joint angle (r=.213), arm length and shoulder joint angle (r=.116), chest girth and shoulder joint angle (r=.497) among elite weightlifters during the turnover under the barbell of snatch.

Negative significant correlation was exist between thigh girth and shoulder joint angle (r=-.779, p < .05) among elite weightlifters during the turnover under the barbell of snatch. However, insignificant correlation were also exist between weight and shoulder joint angle (r=-.346), leg length and shoulder joint angle (r=-.278), lower leg length and

shoulder joint angle (r=-.511), pelvic girth and shoulder joint angle (r=-.224), calf girth and shoulder joint angle (r=-.743), BMI and shoulder joint angle (r=-.509), waist hip ratio and shoulder joint angle (r=-.098) among elite weightlifters during the turnover under the barbell of snatch.

Table: 4.33 Association of body dimensions with angular kinematic variable elbow joint of elite weightlifters during the turnover under the barbell of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	.373
2		Weight	-.018
3		Sitting Height	.198
4		Arm Length	.018
5		Leg Length	.104
6	Elbow joint angle	Lower Leg length	.560
7		Chest Girth	.272
8		Pelvic Girth	.434
9		Thigh Girth	.146
10		Calf Girth	-.184
11		BMI	-.175

| 12 | | Waist-Hip Ratio | -.539 |

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.33 depicts insignificant and positive correlation between height and elbow joint angle (r=.373), sitting height and elbow joint angle (r=.198), arm length and elbow joint angle (r=.018), leg length and elbow joint angle (r=.104), lower leg length and elbow joint angle (r=.560), chest girth and elbow joint angle (r=.272), pelvic girth and elbow joint angle (r=.434), thigh girth and elbow joint angle (r=.146) among elite weightlifters during the turnover under the barbell of snatch.

Negative insignificant correlation were also exist between weight and elbow joint angle(r=-.018), calf girth and elbow joint angle (r=-.184), BMI and elbow joint angle (r=-.175), waist hip ratio and elbow joint angle (r=-.539) among elite weightlifters during the turnover under the barbell of snatch.

Table: 4.34 Association of body dimensions with angular kinematic variable ankle joint of elite weightlifters during the catch phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	.348
2		Weight	.588
3	Ankle joint angle	Sitting Height	.586
4		Arm Length	.339
5		Leg Length	.016

6		Lower Leg length	.740
7		Chest Girth	-.113
8		Pelvic Girth	.140
9		Thigh Girth	.675
10		Calf Girth	.426
11		BMI	.577
12		Waist-Hip Ratio	.271

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.34 depicts insignificant and positive correlation between height and ankle joint angle (r=.348), weight and ankle joint angle (r=.588), sitting height and ankle joint angle (r=.586), arm length and ankle joint angle (r=.339), leg length and ankle joint angle (r=.016), lower leg length and ankle joint angle (r=.740), pelvic girth and ankle joint angle (r=.140), thigh girth and ankle joint angle (r=.675), calf girth and ankle joint angle(r=.426), BMI and ankle joint angle (r=.577), waist hip ratio and ankle joint angle (r=.271) among elite weightlifters during the catch phase of snatch.

Negative insignificant correlation was also exist between chest girth and ankle joint angle (r=-.113) among elite weightlifters during the catch phase of snatch.

Table: 4.35 Association of body dimensions with angular kinematic variable knee joint of elite weightlifters during the catch phase of snatch (N=7)

Sr. No	Variables correlated with performance	Co-efficient of correlation

		Height	-.162
1		Height	-.162
2		Weight	.221
3		Sitting Height	.039
4		Arm Length	.259
5		Leg Length	.167
6		Lower Leg length	-.179
7	Knee joint angle	Chest Girth	-.142
8		Pelvic Girth	-.342
9		Thigh Girth	.030
10		Calf Girth	.170
11		BMI	.328
12		Waist-Hip Ratio	.763*

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.35 depicts significant and positive correlation between waist hip ratio and knee joint angle (r=.763, p < .05) among elite weightlifters during the catch phase of snatch. However, insignificant and positive correlation were also exist between weight and knee joint angle (r=.221), sitting height and knee joint angle (r=.039), arm length and knee joint angle (r=.259), leg length and knee joint angle (r=.167), thigh girth and knee joint

angle (r=.030), calf girth and knee joint angle (r=.170), BMI and knee joint angle (r=.328), among elite weightlifters during the catch phase of snatch.

Negative insignificant correlation were also exist between height and knee joint angle (r=-.162), lower leg length and knee joint angle (r=-.179), chest girth and knee joint angle (r=-.142), pelvic girth and knee joint angle (r=-.342) among elite weightlifters during the catch phase of snatch.

Table: 4.36 Association of body dimensions with angular kinematic variable hip joint of elite weightlifters during the catch phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	Hip joint angle	Height	.053
2		Weight	.271
3		Sitting Height	-.181
4		Arm Length	.146
5		Leg Length	.036
6		Lower Leg length	.105
7		Chest Girth	-.431
8		Pelvic Girth	-.159
9		Thigh Girth	.364
10		Calf Girth	.444

11		BMI	.322
12		Waist-Hip Ratio	.250

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.36 depicts insignificant and positive correlation between height and hip joint angle (r=.053), weight and hip joint angle (r=.271), arm length and hip joint angle (r=.146), leg length and hip joint angle (r=.036), lower leg length and hip joint angle (r=.105), thigh girth and hip joint angle (r=.364), calf girth and hip joint angle (r=.444), BMI and hip joint angle (r=.322), waist hip ratio and hip joint angle (r=.250) among elite weightlifters during the catch phase of snatch.

Negative insignificant correlation were also exist between sitting height and hip joint angle (r=-.181), chest girth and hip joint angle (r=-.431), pelvic girth and hip joint angle (r=-.159) among elite weightlifters during the catch phase of snatch.

Table: 4.37 Association of body dimensions with angular kinematic variable shoulder joint of elite weightlifters during the catch phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.390
2		Weight	-.016
3	**Shoulder joint angle**	Sitting Height	-.396
4		Arm Length	.049
5		Leg Length	.506

6		Lower Leg length	.323
7		Chest Girth	-.879**
8		Pelvic Girth	.658
9		Thigh Girth	.466
10		Calf Girth	.425
11		BMI	.178
12		Waist-Hip Ratio	.193

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.37 depicts insignificant and positive correlation between arm length and shoulder joint angle (r=.049), leg length and shoulder joint angle (r=.506), lower leg length and shoulder joint angle (r=.323), pelvic girth and shoulder joint angle (r=.658), thigh girth and shoulder joint angle (r=.466), calf girth and shoulder joint angle (r=.425), BMI and shoulder joint angle (r=.178), waist hip ratio and shoulder joint angle (r=.193)among elite weightlifters during the catch phase of snatch.

Negative significant correlation was exist between chest girth and shoulder joint angle (r=-.879, p < .01) among elite weightlifters during the catch phase of snatch. However, negative insignificant correlation were also exist between height and shoulder joint angle (r=-.390), weight and shoulder joint angle (r=-.016), sitting height and shoulder joint angle (r=-.396) among elite weightlifters during the catch phase of snatch.

Table: 4.38 Association of body dimensions with angular kinematic variable elbow joint of elite weightlifters during the catch phase of snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	Elbow joint angle	Height	-.486
2		Weight	-.200
3		Sitting Height	-.718
4		Arm Length	-.385
5		Leg Length	.254
6		Lower Leg length	-.402
7		Chest Girth	-.165
8		Pelvic Girth	-.203
9		Thigh Girth	-.055
10		Calf Girth	.218
11		BMI	-.035
12		Waist-Hip Ratio	.067

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.38 depicts insignificant and positive correlation between leg length and elbow joint angle (r=.254), calf girth and elbow joint angle (r=.218), waist hip ratio and elbow joint angle (r=.067) among elite weightlifters during the catch phase of snatch.

Negative insignificant correlation were also exist between height and elbow joint angle (r=-.486), weight and elbow joint angle (r=-.200), sitting height and elbow joint angle (r=-.718), arm length and elbow joint angle (r=-.385), lower leg length and elbow joint angle (r=-.402), chest girth and elbow joint angle (r=-.165), pelvic girth and elbow joint angle (r=-.203), thigh girth and elbow joint angle (r=-.055), BMI and elbow joint angle (r=-.035) among elite weightlifters during the catch phase of snatch.

Table: 4.39 Relationship of body dimensions with linear kinematic variable barbell distance from the floor to first pull in snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.472
2		Weight	-.270
3		Sitting Height	.100
4		Arm Length	-.423
5	**Barbell distance from the floor to first pull**	Leg Length	-.640
6		Lower Leg length	-846*
7		Chest Girth	.133
8		Pelvic Girth	-.365
9		Thigh Girth	-.521
10		Calf Girth	-.160

| 11 | | BMI | -.142 |
| 12 | | Waist-Hip Ratio | -.011 |

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.39 depicts insignificant and positive correlation between linear kinematic barbell distance from the floor to first pull in snatch with sitting height (r=.100) and chest girth (r=.133) among elite weightlifters.

Negative significant correlation was exist between linear kinematic barbell distance from the floor to first pull in snatch with lower leg length (r=-.846, $p < .05$) among elite weightlifters. However, negative insignificant correlation were also exist between linear kinematic barbell distance from the floor to first pull in snatch with height (r=-.472), weight (r=-.270), arm length (r=-.423), leg length (r=-.640), pelvic girth (r=-.365), thigh girth (r=-.521), calf girth (r=-.160), BMI (r=-.142) and waist hip ratio(r=-.011) among elite weightlifters.

Table: 4.40 Relationship of body dimensions with linear kinematic variable barbell distance at the end of second pull in snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	**Barbell distance at the end of second pull**	Height	.688
2		Weight	.885**
3		Sitting Height	.728
4		Arm Length	.690

5		Leg Length	.010
6		Lower Leg length	.787*
7		Chest Girth	.004
8		Pelvic Girth	-.289
9		Thigh Girth	.730
10		Calf Girth	.481
11		BMI	.784*
12		Waist-Hip Ratio	.630

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.40 depicts significant correlation between linear kinematic barbell distance at the end of second pull in snatch with weight (r=885, $p < .01$), lower leg length (r=.787, $p < .05$) and BMI (r=.784, $p < .05$) among elite weightlifters. However, insignificant and positive correlation between linear kinematic barbell distance at the end of second pull in snatch with height (r=.688), sitting height (r=.728), arm length (r=.690), leg length (r=.010), chest girth (r=.004), thigh girth (r=.730), calf girth (r=.481), and waist hip ratio (r=.630) among elite weightlifters.

Negative insignificant correlation was also exist between linear kinematic barbell distance at the end of second pull in snatch with pelvic girth (r=-.289) among elite weightlifters.

Table: 4.41 Relationship of body dimensions with linear kinematic variable maximum distance covered by barbell in snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	.246
2		Weight	.493
3		Sitting Height	.677
4		Arm Length	.092
5		Leg Length	-.678
6	**Maximum distance covered by barbell**	Lower Leg length	.185
7		Chest Girth	.374
8		Pelvic Girth	-.784*
9		Thigh Girth	.060
10		Calf Girth	.207
11		BMI	.475
12		Waist-Hip Ratio	.376

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.41 depicts insignificant and positive correlation between linear kinematic variables maximum distance covered by barbell in snatch with height (r=.246), weight (r=.493), sitting height (r=.677), arm length (r=.092), lower leg length (r=.185), chest girth (r=.374), thigh girth (r=.060), calf girth (r=.207), BMI (r=.475) and waist hip ratio (r=.376) among elite weightlifters.

Negative significant correlation was exist between linear kinematic variables maximum distance covered by barbell in snatch with pelvic girth (r=-.784, p < .05) among elite weightlifters. However, negative insignificant correlation was also exist between linear kinematic variables maximum distance covered by barbell in snatch with leg length (r=-.678) among elite weightlifters.

Table: 4.42 Relationship of body dimensions with linear kinematic variable the maximum vertical velocity during first pull in snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1		Height	-.214
2		Weight	-.204
3		Sitting Height	-.134
4	The maximum vertical velocity during first pull	Arm Length	.372
5		Leg Length	.320
6		Lower Leg length	-.383
7		Chest Girth	-.212

8		Pelvic Girth	-.020
9		Thigh Girth	-.425
10		Calf Girth	-.333
11		BMI	-.168
12		Waist-Hip Ratio	.612

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.42 depicts insignificant and positive correlation between linear kinematic variables the maximum vertical velocity during first pull in snatch with arm length (r=.372), leg length (r=.320) and waist hip ratio (r=.612) among elite weightlifters.

Negative insignificant correlation was also exist between linear kinematic variables the maximum vertical velocity during first pull in snatch with height (r=-.214), weight (r=-.204), sitting height (r=-.134), lower leg length (r=-.383), chest girth (r=-.212), pelvic girth (r=-.020), thigh girth (r=-.425), calf girth (r=-.333) and BMI (r=-.168) among elite weightlifters.

Table: 4.43 Relationship of body dimensions with linear kinematic variable the maximum the maximum vertical velocity during second pull in snatch (N=7)

Sr. No	Variables correlated with performance		Co-efficient of correlation
1	The maximum the maximum vertical velocity during second pull	Height	.772*
2		Weight	.278
3		Sitting Height	.693
4		Arm Length	.275
5		Leg Length	-.273
6		Lower Leg length	.491
7		Chest Girth	.673
8		Pelvic Girth	-.106
9		Thigh Girth	.047
10		Calf Girth	-.275
11		BMI	-.004
12		Waist-Hip Ratio	-.315

(*significant at .05 level ; r=.754) & (** significant at .01 level; r-.874)

Table 4.43 depicts significant and positive correlation between linear kinematic variables the maximum the maximum vertical velocity during second pull in snatch with height

(r=.772, p < .05) among elite weightlifters. However, insignificant and positive correlation were also exist between linear kinematic variables the maximum the maximum vertical velocity during second pull in snatch with weight (r=.278), sitting height (r=.693), arm length (r=.275), lower leg length (r=.491), chest girth (r=.673) and thigh girth (r=.047) among elite weightlifters.

Negative insignificant correlation was also exist between linear kinematic variables the maximum the maximum vertical velocity during second pull in snatch with leg length (r=-.273), pelvic girth (r=-.106), calf girth (r=-.275), BMI (r=-.004) and waist hip ratio (r=-.315) among elite weightlifters.

4.2 Discussion on findings

The performance of weightlifters has been regularly influenced to a greater extent by skills, physical ability, physiological, anthropometric and biomechanical variables. In weightlifting body composition and skills are of immense important. The mastery over handling the all the phases of snatch skill are determining factors to win the game in one's own favor. In the present study the association of body dimensions and kinematic variables with performance of weightlifters has been investigated. The results so obtained have been discussed under the following heading: -

A) Association of body dimensions with performance of elite weightlifters in snatch skill

It is evident from table 4.1 that performance of snatch skill in female elite weightlifters has shown insignificant and positive correlation with height. It indicates that greater height of a female weight lifters helps to lift more weight and improve their performance in snatch skill. The results of present study is similar with the results reported by Siahkouhian and Hedayatneja (2010). They found that in male weightlifting snatch skill has shown positive significant relationship of performance with height. The result of current investigation is not in line with result reported by Mayhew et al (1993), he indicated that in snatch skill, weightlifting performance is dominated by shorter and monomorphic body types. This is may be due to lesser number of subjects and different bodyweight categories of weight lifters, result was different.

In the variable of body weight, insignificant and positive correlation was found with performance of elite weightlifters. The findings of the current study do not coincide with results of Latif et al. (2012). They found that body weight shows negative relationship with lifting performance and maximal strength. Due to the different weight categories in weight lifting each lifter has to set their weight according to their respective category. They compete with same weighed individual in a specific weight category. Results

coincide with Mayhew et al (1993), he revealed in the results that body fatness is positively associated with greater strength.

In the variable of sitting height, insignificant and positive correlation was found with performance of elite weightlifters. The results of present study inclined with the results reported by Siahkouhian and Hedayatneja (2010). They found that there was solid association exist among weightlifter's performance and sitting height. It is also being noted that weight lifting is strength-based and power sport, and with increase of body dimensions such as sitting height performance of weight lifters also increased.

In the variable of arm length, insignificant and positive correlation was found with performance of elite weightlifters. Mayhew et al (1993) reported that experienced college athletes in bench press take benefit of the short arm length in lowering the bar to the chest which helps to perform better in weightlifting competitions. The present study coincides with the results reported by Gross et al. (2000). They found out the arm length shown positive relationship with lifting capacity. Shorter arm length helps the lifter in lifting the barbell in a minimum time during snatch and as the long arm length takes more time to lift the barbell. But in present study may be due to the relatively small subject number, magnitude of standard deviations and different weight categories the result is different.

In the variable of leg length, negative insignificant correlation was found with performance of elite weightlifters. This could be due to the individual difference of body size among the subjects. Due to small no of subjects and different weight categories leg length is not equivalent with each lifter as a result negative relationship was found. Mayhew et al (1993) revealed in their study that smaller leg length in older athletes have shown positive effect in deadlift. Because smaller the leg length smaller the way to lift the weight.

In the variable of lower leg length, it has been found that performance has shown significant and positive correlation with lower leg length among elite weight lifters. This could be due to fact that lower leg length produces more force in second pull, which

ultimately improve the lifting performance in snatch. Sarfraj and Alam (2017) have also found that leg length has significant relationship with weight lifting performance. Pierre et al. (2020) suggested that lower leg length helps the power lifters to perform better in dead lift.

In the variable of chest girth, performance has shown insignificant and positive correlation with chest girth elite weightlifters. The result of the study is similar with results of Siahkouhian and Hedayatneja (2010). They found that there was solid association exist between weightlifter's performance and chest girth. It is well-known that weight- lifting is a strength-based and power sport and it is clear that increased anthropometric variables, such as chest circumference as muscularity indicators, increased the lifting performance.

In the variable of pelvic girth, negative insignificant correlation was also found with pelvic girth with performance of elite weightlifters. Gross et al. (2000) research does not coincide they reported that pelvic girth was significantly related to maximum lifting capacity of men. This is because in present study due to gender difference in pelvic grith the result also differs. In female the pelvic girth was more, and due to that they have to expand their pelvic and balance the weight in performing the snatch, which sometime negatively affect their performance. Different body weight categories play major role in it.

Thigh girth has shown insignificant and positive correlation with performance of elite weightlifters. Gross et al. (2000) finds out that thigh girth has shown positive correlation with load lifted. The thigh girth shows that lifters with heavier thighs can lift heavier weights. Naso et al. (2012) found that weight lifters were insignificantly greater thigh circumference than power lifters, and there was also no significant correlation among the groups for any measure of thigh muscles size with any measure of strength. This is may be due to necessity of leg strength for competition in both events. Mayhew et al. (1993) revealed that weak relationship finds between thigh girth and deadlift.

In the variable of calf girth, significant and positive correlation between calf girth and performance has been found. Mayhew et al. (1993) study supports the result of present study; he found that calf girth has significant effect on deadlift technique. It indicates that greater development of muscle at calf region help the weight lifters to lift the more weight in snatch skill of weight lifting. The results of present study have justified by the findings of Michael et al. (2000) that calf girth was significantly related to load lifted. They also indicate that calf girth is significantly related to magnitude of ankle torque that subject can generate.

BMI has shown insignificant and positive correlation with performance of elite weightlifters. The result doesn't coincide with Siahkouhian and Hedayatneja (2010). They found that there was solid association exist among weightlifter performance and BMI. Mayhew et al. (1993) reported that body mass was the common factor to help lifters in amount of weight lifted by adolescent athletes executing the bench press and deadlift. They proposed that smaller athletes had greater relative strength performance. In weightlifters body mass index is a common factor which helps them to lift the maximum weight while performing the snatch.

In the variable of waist-hip ratio, negative insignificant correlation was existed between waist hip ratio and performance of elite weightlifters. It indicates that with the increase of wait hip ratio the performance of female weight lifters also decreases. The results of present study coincide with the results reported by Siahkouhian and Hedayatneja (2010). They reported that there was negative and insignificant relationship with waist hip ratio and performance.

B) Association of kinematic variables with performance of elite weightlifters in snatch skill

a) Association of angular kinematics variables with performance elite weight lifters

It is evident from table 4.2 to 4.7 that during first phase of snatch, performance has shown insignificant and positive correlation with ankle joint angle, knee joint angle, hip

joint angle, shoulder joint angle among the elite weightlifters during the first phase of snatch. The results of present investigation coincide with the findings of Liu et al. (2018). He concluded that knee joint angle was significantly greater in top elite weightlifters during the first phase of snatch lift. Body angles of joints move through the snatch phases in a continuous motion which help the lifter to list maximum weight. However, negative and insignificant correlation also existed between performance and elbow joint angle among elite weightlifters during the first phase of snatch.

During the first pull of snatch, performance has shown positive insignificant correlations with knee joint angle, hip joint angle and elbow joint angle among elite weightlifters. The findings of present investigation were supported by Korkomaz and Harbili (2015), they found out that greater extension angle was exist in the knee joint during the first pull. However, Bauman et al. (1988) discovered that knee joint moments are generally little and don't relate with the total load. The best lifters appear to be ready to constrain the knee joint moment by exact control of the knee position concerning the ground reaction force. Negative and significant correlation of performance was found with shoulder joint angle among elite weightlifters during the first pull of snatch. It indicates that with the increase of shoulder joint angle performance of weight lifter decreases, so an optimum angle must be maintained to gain the highest performance. However, negative and insignificant correlation was also existed with ankle joint angle among elite weightlifters.

During the transition phase of snatch, performance has shown significant and positive correlation with elbow joint angle and negative and significant correlation with shoulder joint angle among elite weightlifters. It indicates that angles of elbow joint and shoulder joint significantly affects the performance of elite weight lifters. So, during the first pull of snatch, more extension of elbow joint angle and less extension of shoulder joint must be maintained. Insignificant and positive correlation was also found with knee joint angle among elite weightlifters. However, performance has shown negative and insignificant correlation with ankle joint angle and hip joint angle among elite weightlifters during the transition phase of snatch.

During the second pull of snatch, performance has shown insignificant and positive correlation with ankle joint angle, hip joint angle and elbow joint angle among the elite weightlifters. In case of hip joint angle, the result is supported by Korkomaz and Harbili (2015), they found out that greater extension angle was found in the hip joint during the second pull of snatch. Negative and significant correlation of performance was found with knee joint angle among elite weightlifters. It indicates that during second pull of snatch greater knee joint extension decrease the performance of weight lifters. Bauman et al. (1988) discovered that knee joint moments are generally little and don't relate very well with the total load. However, performance has shown negative and insignificant correlation with shoulder joint angle among elite weightlifters during the second pull of snatch. Harbili and Alptekin (2014) have revealed in their results that coaches should be need to focus to associate exercises to improve explosive strength through the second pull with utmost strength in male juvenile weightlifters.

During the turn over under the barbell phase of snatch, performance has shown insignificant and positive correlation with hip joint angle and elbow joint angle among the elite weightlifters. It indicates that during turn over phase, more flexion of hip joint and elbow joint will increase the performance of the weight lifters. However, performance has shown negative and insignificant correlation with ankle joint angle, knee joint angle and shoulder joint angle among elite weightlifters during the turn over under the barbell of snatch.

During the catch phase of snatch, performance has shown insignificant and positive correlation with ankle joint angle and hip joint angle among the elite weightlifters. However, performance has shown negative and insignificant correlation with knee joint angle, shoulder joint angle and elbow joint angle among elite weightlifters during the catch phase of snatch. It shows that during catch phase of snatch, a weight lifter should do more flexion in the ankle joint and hip joint angle, and should stable the elbow joint, knee joint and shoulder joint to enhance the performance of elite weight lifters.

(b) Association of linear kinematics variables with performance of elite weight lifters

It has been found from table 4.8 that performance has shown significant and positive correlation with velocity during second pull, and negative and significant correlation with velocity during first pull among the elite weightlifters. It shows that velocity during first pull has significantly decreases the performance and velocity during second pull have significantly increases the performance among the elite weightlifters. However, performance has shown positive and insignificant correlation with barbell displacement till second pull, and negative and insignificant correlation with barbell displacement till first pull and maximum height of barbell among elite weightlifters. It indicated that in snatch skill, the displacement of barbell during first pull, second pull and at maximum height positively increase the performance the weight lifters. Akkus (2012) discovered that the maximum vertical velocity of the barbell was more prominent during the second pull than in the first pull. Miletello et al. (2009) have also studied the kinematic differences of competitive power lifters in maximum squat with novice power-lifters, where they found significant difference in high knee angular velocity among them from the bottom of the lift.

C) Association of body dimensions with kinematic variables of elite weightlifters in Snatch skill.

(a) Association of body dimensions with angular kinematics of elite weight lifters

During first phase of snatch, it is evident from table 4.9 to 4.13 that among all the body dimensions only sitting height have significantly and positively correlated with ankle joint angle. Similarly, height and sitting height have significantly and negatively correlated with elbow joint angle of elite female weight lifters. It shows that with the increase of sitting height ankle joint angle has also increase and elbow joint angle decrease. Similarly, with the increase of height elbow joint angle also decrease. As per results of present study greater elbow joint angle helped the weight lifters to enhance the

performance in transition phase of snatch skill. It indicates that shorter stature is mechanical befitted to the weight lifters. Other body dimensions like weight, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio do not correlate with angle of ankle joint and elbow joint. However, angular kinematics variables; knee joint angle, hip joint angles and shoulder joint have not significantly affected by body dimensions like height, weight, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio. The above findings are also intoned with Bauman et al. (1988) that the knee joint moments are moderately small and do not associate with the total load. The reason would be that the finest lifters seem able to bind the knee joint moment with control of the knee position with the ground reaction force. Hales et al. (2009) revealed that during the squat performance the angular position of the hip, knee and ankle joint differ from each other. The most important changes in the joint angles occurred at the end of the transition phase and between the second pull and the turnover. Dominant factors of body dimension are height which significantly affected the kinematic variables of weight lifters.

During the first pull of snatch, from table 4.14 to 4.18 it has been found that among all the body dimensions only height have significantly and positively correlated with elbow joint angle of female elite weight lifters. It indicates that during first pull of snatch height helps to generate more power among the weight lifters. As per results of present study greater elbow joint angle helped the weight lifters to enhance the performance in transition phase of snatch skill. However, other body dimensions like height, weight, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio have not correlated significantly with the ankle joint angle, knee joint angle, hip joint angles, shoulder joint and elbow joint angle among elite weightlifters during first pull of snatch. The above findings are also intoned with Bauman et al. (1988) that the knee joint moments are relatively small and do not relate with the total load. The reason would be that the best lifters seem talented to bind the knee joint moment with control of the knee position with the ground reaction force. Hales et al. (2009) also revealed that

during the squat performance the angular position of the hip, knee and ankle joint differ from each other.

During the transition of snatch, it has been found from the table 4.19 to 4.23 that among all the body dimensions thigh girth and calf girth have significantly positively correlated with ankle joint angle of elite weight lifters. It indicates that development of muscle at upper leg and lower leg significantly positively affect the ankle joint angle. Weight, lower leg length and thigh girth have also significantly correlated the elbow joint angle among elite weightlifters. As per results of present study greater elbow joint angle helped the weight lifters to enhance the performance in transition phase of snatch skill. Further, it has been found that during transition phase of snatch lower leg length has negatively correlated with the shoulder joint angle among elite weight lifters, which will help the performance of weight lifters during transition phase of snatch skill. However, other body dimensions like height, weight, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio have correlated insignificantly with ankle joint angle, knee joint angle, hip joint angles, shoulder joint and elbow joint angle among elite weightlifters during first pull of snatch. The above findings are also intoned with Bauman W. et al (1988) that the knee joint moments are quite small and do not associate with the total load.

During the second pull of snatch, it has been found from table 4.24 to 4.28 that among all the body dimensions weight, sitting height and BMI have significantly positively correlated and pelvic girth has significantly negatively correlated with ankle joint angle of elite weight lifters. Pelvic girth has also significantly and positively correlated with the elbow joint angle among elite weightlifters. As per results of present study more elbow joint angle helped the weight lifters to enhance the performance in transition phase of snatch skill. Further it has been found that during second pull of snatch leg length has negatively significantly correlated with shoulder joint angle among elite weight lifters. As per results of present study less shoulder joint angle helped the weight lifters to enhance the performance in second pull of snatch skill. However, other body dimensions like

height, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth and waist hip ratio have not significantly correlated with angular kinematic variables; the ankle joint angle, knee joint angle, hip joint angles, shoulder joint and elbow joint angle among elite weightlifters during first pull of snatch. The above findings are also intoned with Bauman et al. (1988) that the knee joint moments are relatively small and do not correlate with the total load. Hales et al. (2009) also revealed that during the squat performance the angular position of the hip, knee and ankle joint differ from each other. The most important changes in the joint angles occurred at the end of the transition phase and between the second pull and the turnover. The latter two phases are greatly important because, during the first one, enough power and momentum must be generated to lift the barbell, and, during the second, three joints are extended to lift said bar above the head (Akkus, 2012).

During the turn over under the barbell phase of snatch, it has been found from table 4.29 to 4.33 that among all the body dimensions only thigh girth has significantly and positively correlated with the shoulder joint angle among elite weightlifters. However, other body dimensions like height, weight, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio have not significantly correlated with the ankle joint angle, knee joint angle, hip joint angles, shoulder joint and elbow joint angle among elite weightlifters during first pull of snatch. Hales et al. (2009) also revealed that during the squat performance the angular position of the hip, knee and ankle joint differ from each other. It can be seen that the base of support is always greater than the shoulder width, and it increases until almost double during the turnover phase. Taking into account that the base of support is closely related to the stability of the posture, it has been shown that weightlifters must compensate to stabilize their center of mass and correctly place the bar above their heads without losing balance (Ho et al., 2014). Furthermore, the linear velocity of the barbell is slightly higher in women, possibly because they lifted less weight and, during the turnover phase, the flexion they performed was not as pronounced as that of men (Harbili, 2012).

During the catch phase of snatch, it has been found from table 4.34 to 4.38 that among all the body dimensions waist hip ratio have significantly positively correlated with the knee joint angle among elite weightlifters, which in returns helps to perform and control the balance of the body. On the other hand, chest girth has significantly decreased the shoulder joint angle among the elite weight lifters during catch phase of snatch. However, other body dimensions like height, weight, arm length, leg length, lower leg length, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have not affected significantly the ankle joint angle, knee joint angle, hip joint angles, shoulder joint and elbow joint angle among elite weightlifters during first pull of snatch. The above findings are also intoned with Bauman et al. (1988) that the knee joint moments are quite small and do not correlate with the overall load. The reason would be that the high performers lifters are able to limit knee joint moment by controlling the position of knee with the ground reaction force. Hales et al. (2009) also revealed that during the squat performance the angular position of the hip, knee and ankle joint differ from each other. The findings of Mayhew et al. (1993) are not in line with the results of present study. They found that body size in weightlifting was the major contributing factors in lifting performance.

(b) Association of body dimensions with linear kinematic variables of elite weight lifters

It has been found from table 4.39 that among all the body dimensions only lower leg length has shown negative and significant correlation with linear kinematic variable barbell distance from the floor to first pull. This shows that more lower leg length will negatively affects the barbell distance from floor to first pull, which ultimately affects the performance of elite weight lifters. However, other body dimensions; height, weight, arm length, leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have shown negative and insignificant correlation with and barbell distance from the floor to first pull in snatch among the elite weightlifters. The above results were also supported by the results reported by McGuigan et al (1996). They found out on the sumo

and conventional lifters; sumo lifters upheld a more vertical posture during the lift off of barbell.

It is evident from table 4.40 that among all the body dimensions only weight, lower leg length and BMI have shown significant and positive correlation with linear kinematic variable, barbell distance at the end of second pull in snatch among elite weightlifters. However, other body dimensions; height, sitting height, arm length, leg length, chest girth, pelvic girth, thigh girth, calf girth and waist hip ratio have shown positive and insignificant correlations with barbell distance at the end of second pull among the elite weightlifters. Kipp (2020) results specify that in weight lifting the net joint moments of knee and ankle joints are of great significance. Stone et al. (1998) suggests that lifter who is more experienced in controlling the bar path will be more successful than one who might be even stronger but wastes his power by moving the bar in unwanted directions.

It has been found from table 4.41 that among all the body dimensions only pelvic girth shown significant and negative correlation with linear kinematic variable, maximum distance covered by barbell in snatch among elite weightlifters. It indicates that more pelvic girth will decrease the maximum height of the barbell droning snatch skill in female elite weight lifters. However, other body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio have shown positive and insignificant correlations with maximum distance covered by barbell in snatch among the elite weightlifters. The leg length has shown negative and insignificant correlation with maximum distance covered by barbell in snatch. Nawrat and Vaverka (1997) analyze the relationship between anthropometric body dimension and basic parameters of barbell track. They found that individual parameters will be input data for achieving optimum barbell track. Kipp (2020) investigate net joint moments showed the greatest relative significance in relative to bar velocity.

It has been found from table 4.42 that among the body dimensions; arm length, leg length and waist hip ratio have shown insignificant and positive correlation with linear

kinematic variable, the maximum vertical velocity during first pull in snatch among elite weightlifters. However, the maximum vertical velocity during first pull in snatch have shown negative and insignificant correlation with height, weight, sitting height, lower leg length, chest girth, pelvic girth, thigh girth, calf girth and BMI among the elite weightlifters. This shows that all the selected body dimensions do not significantly affects the vertical velocity of the barbell during first pull in snatch. Hales et al. (2009) had also found significant differences were exists between the squat and dead lift vertical bar velocities. Akkus (2012) have found out that during the first pull the velocity was less as compared to second pull. Stone et al. (1998) finds out that velocity may be needed to lift a weight high enough for a lifter to catch it over head. He also states that high velocity during first pull might prevent the lifters ability to accomplish the second pull position.

It has been found from table 4.43 that among the body dimensions only height has shown significant and positive correlation with linear kinematic variable, the maximum the maximum vertical velocity during second pull in snatch among elite weightlifters. It indicates that among all the selected body dimensions only height has significantly increased the the maximum the maximum vertical velocity during second pull among the elite weight lifters. However, the maximum the maximum vertical velocity during second pull in snatch have shown negative and insignificant correlations with weight, sitting height, arm length, lower leg length, chest girth and thigh girth among the elite weightlifters. Negative insignificant correlations of the maximum the maximum vertical velocity during second pull in snatch were also exists with leg length, pelvic girth, calf girth, BMI and waist hip ratio among the elite weightlifters. The result helped the weightlifters in learning of technique by using the simulator. Oleshkovalentin (2020) found out that biomechanical structure of barbell displacement in definite acceleration part and supporting squat has a few changes relying upon competitive exercise, sexual orientation of competitors and their having a place with the gathering of weight classifications. Feher (2006) suggests that to improve technical skills of snatch several exercises differentiating the barbell velocity needs to be used. These exercises will help the lifters to obtain optimum speed.

4.3 Testing of Hypotheses

1. The hypothesis number- **(H₁)** stated that there exists significant relationship of selected body dimensions variables; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with performance of elite weightlifters in snatch skills. The results obtained from table 4.1 revealed significant correlation of performance with only lower leg among elite weight lifters. Therefore, hypothesis number-1 stands partially accepted in case of lower leg length. However, insignificant correlation has been observed in variables of height, weight, sitting height, arm length, leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio. Therefore, hypothesis number-1 also stands partially rejected in case of height, weight, sitting height, arm length, leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio variables.

2. The hypothesis number- **(H₂ₐ)** stated that there exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during first phase of snatch skill. The results obtained from Table-4.2 revealed insignificant correlation of performance with all selected angular kinematic variables. Therefore, hypothesis number- **(H₂ₐ)** stands fully rejected.

3. The hypothesis number- **(H₂ᵦ)** stated that there exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during first pull of snatch skill. The results obtained from Table-4.3 revealed significant correlation of shoulder joint angle with performance of elite weight lifters. Therefore, hypothesis number- **(H₂ᵦ)** stands partially accepted in case of shoulder joint angle. However, insignificant correlation has been observed in angular kinematic variables, ankle joint angle, knee joint angle, hip joint angle and elbow joint angle. Therefore, hypothesis number-**(H₂ᵦ)** also stands partially rejected in

case of angular kinematic variables; ankle joint angle, knee joint angle, hip joint angle and elbow joint angle variables.

4. The hypothesis number- **(H₂c)** stated that there exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during transition phase of snatch skill. The results obtained from Table-4.4 revealed significant correlation of elbow joint angle with performance of elite weight lifters. Therefore, hypothesis number- **(H₂c)** stands partially accepted in case of elbow joint angle. However, insignificant correlation has been observed in angular kinematic variables; ankle joint angle, knee joint angle, hip joint angle and shoulder joint angle. Therefore, hypothesis number-**(H₂c)** also stands partially rejected in case of angular kinematic variables; ankle joint angle, knee joint angle, hip joint angle and shoulder joint angle variables.

5. The hypothesis number- **(H₂d)** stated that there exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during second pull of snatch skill. The results obtained from Table 4.5 revealed significant correlation of knee joint angle with performance of elite weight lifters. Therefore, hypothesis number- **(H₂d)** stands partially accepted in case of knee joint angle. However, insignificant correlation has been observed in angular kinematic variables; ankle joint angle, hip joint angle, shoulder joint angle and elbow joint angle. Therefore, hypothesis number-**(H₂d)** also stands partially rejected in case of angular kinematic variables; ankle joint angle, hip joint angle, shoulder joint angle and elbow joint angle.

6. The hypothesis number- **(H₂e)** stated that there exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during turn over under the barbell of snatch skill. The results obtained from Table-4.6

revealed insignificant correlation of performance with all selected angular kinematic variables. Therefore, hypothesis number- **(H₂ₑ)** stands fully rejected.

7. The hypothesis number- **(H₂f)** stated that there exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during catch phase of snatch skill. The results obtained from Table-4.7 revealed insignificant correlation of performance with all selected angular kinematic variables. Therefore, hypothesis number- **(H₂f)** stands fully rejected.

8. The hypothesis number- **(H₃)** stated that there exists significant relationship of selected linear kinematic variables; barbell height at the end of the first pull, barbell height at the end of the second pull, maximum barbell height, the maximum vertical velocity of the barbell in the first pull and the maximum vertical velocity of the barbell in the second pull with performance of elite weightlifters in snatch skill. The results obtained from Table-4.8 revealed significant correlation of velocity during first pull and velocity during second pull with performance of elite weight lifters. Therefore, hypothesis number- **(H₃)** stands partially accepted in case of velocity during first pull and velocity during second pull. However, insignificant correlation has been observed in linear kinematic variables; barbell height at the end of the first pull, barbell height at the end of the second pull, maximum barbell height with performance of weight lifters**.** Therefore, hypothesis number-**(H₃)** also stands partially rejected in case of linear kinematic variables, barbell height at the end of the first pull, barbell height at the end of the second pull, maximum barbell height**.**

9. The hypothesis number- **(H₄ₐ)** stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during first phase of snatch skill. The results obtained from Table-4.9 to 4.13 revealed

significant correlation of sitting height with ankle joint angle, and height and sitting height with elbow joint angle during first phase of snatch. Therefore, hypothesis number- (**H$_{4a}$**) stands partially accepted in case of height and sitting height variables. However, insignificant correlation has been observed in other variables; weight, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with all selected angular kinematic variables. Therefore, hypothesis number-(**H$_{4a}$**) also stands partially rejected in case of weight, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio variables.

10. The hypothesis number- (**H$_{4b}$**) stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during first pull of snatch skill The results obtained from Table- 4.14 to 4.18 revealed significant correlation of height with elbow joint angle during first pull of snatch. Therefore, hypothesis number- (**H$_{4b}$**) stands partially accepted in case of height. However, insignificant correlation has been observed in other variables; weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with all selected angular kinematic variables. Therefore, hypothesis number-(**H$_{4b}$**) also stands partially rejected in case of weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio variables.

11. The hypothesis number- (**H$_{4c}$**) stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during transition phase of snatch skill. The results obtained from Table-4.19 to 4.23

revealed significant correlations of thigh girth and calf girth with ankle joint angle, and weight, lower leg length and thigh girth with elbow joint angle, and lower leg length with shoulder joint angle during transition phase of snatch. Therefore, hypothesis number- **(H4c)** stands partially accepted in case of thigh girth, calf girth, weight and lower leg length variables. However, insignificant correlation has been observed in other variables; height, arm length, leg length, chest girth, pelvic girth, BMI and waist hip ratio with all selected angular kinematic variables. Therefore, hypothesis number-**(H4c)** also stands partially rejected in case of height, arm length, leg length, chest girth, pelvic girth, BMI and waist hip ratio variables.

12. The hypothesis number- **(H4d)** stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during second pull of snatch skill. The results obtained from Table-4.24 to 4.28 revealed significant correlation of weight, sitting height, pelvic girth and BMI with ankle joint angle, and pelvic girth with elbow joint angle, and leg length with shoulder joint angle during second pull of snatch. Therefore, hypothesis number- **(H4d)** stands partially accepted in case of weight, sitting height, BMI, leg length and pelvic girth variables. However, insignificant correlation has been observed in other variables; height, weight, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth and waist hip ratio with all selected angular kinematic variables. Therefore, hypothesis number-**(H4d)** also stands partially rejected in case of height, weight, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth and waist hip ratio variables.

13. The hypothesis number- **(H4e)** stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist

hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during turn over under the barbell of snatch skill. The results obtained from Table-4.29 to 4.33 revealed only significant correlation of thigh girth with shoulder joint angle during turn over under the barbell of snatch skill. Therefore, hypothesis number-(H_{4e}) stands partially accepted in case of thigh girth. However, insignificant correlation has been observed in other variables; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, calf girth, pelvic girth, BMI and waist hip ratio with all selected angular kinematic variables. Therefore, hypothesis number-(H_{4e}) also stands partially rejected in case of height, weight, sitting height, arm length, leg length, lower leg length, chest girth, calf girth, pelvic girth, BMI and waist hip ratio variables.

14. The hypothesis number- (H_{4f}) stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during catch phase of snatch skill. The results obtained from Table-4.34 to 4.38 revealed only significant correlation of chest girth and with shoulder joint angle, waist hip ratio with knee joint angle during catch phase of snatch skill among elite weight lifters. Therefore, hypothesis number- (H_{4f}) stands partially accepted in case of chest girth and waist hip ratio. However, insignificant correlation has been observed in other variables; height, weight, sitting height, arm length, leg length, lower leg length, thigh girth, calf girth, pelvic girth and BMI with all selected angular kinematic variables. Therefore, hypothesis number-(H_{4f}) also stands partially rejected in case of height, weight, sitting height, arm length, leg length, lower leg length, thigh girth, calf girth, pelvic girth and BMI variables.

15. The hypothesis number- (H_{5a}) stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length,

lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected linear kinematic variable barbell height at the end of the first pull among elite weightlifters in snatch skill. The results obtained from Table-4.39 revealed only significant correlation of lower leg length with barbell height at the end of the first pull in snatch skill among elite weight lifters. Therefore, hypothesis number- **(H₅ₐ)** stands partially accepted in case of lower leg length. However, insignificant correlation has been observed in other variables; height, weight, sitting height, arm length, leg length, chest girth, thigh girth, calf girth, pelvic girth, BMI and waist hip ratio with barbell height at the end of the first pull. Therefore, hypothesis number-**(H₅ₐ)** also stands partially rejected in case of height, weight, sitting height, arm length, leg length, chest girth, thigh girth, calf girth, pelvic girth, BMI and waist hip ratio variables.

16. The hypothesis number- **(H₅ᵦ)** stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected linear kinematic variable barbell distance at the end of second pull in snatch **among** elite weightlifters in snatch skill. The results obtained from Table-4.40 revealed only significant correlation of weight, lower leg length and BMI with linear kinematic variable, barbell distance at the end of second pull in snatch among elite weight lifters. Therefore, hypothesis number-**(H₅ᵦ)** stands partially accepted in case of weight, lower leg length and BMI. However, insignificant correlation has been observed in other variables; height, sitting height, arm length, leg length, chest girth, thigh girth, calf girth, pelvic girth and waist hip ratio with barbell height at the end of the second pull**.** Therefore, hypothesis number-**(H₅ᵦ)** also stands partially rejected in case of height, sitting height, arm length, leg length, chest girth, thigh girth, calf girth, pelvic girth and waist hip ratio variables.

17. The hypothesis number- **(H₅c)** stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length,

lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected linear kinematic variable maximum barbell height in snatch skill among elite weightlifters in snatch skill. The results obtained from Table-4.41 revealed only significant correlation of pelvic girth with linear kinematic variable, maximum barbell height in snatch among elite weight lifters. Therefore, hypothesis number- (H_{5c}) stands partially accepted in case of pelvic girth. However, insignificant correlation has been observed in other variables; height, weight, sitting height, arm length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio with maximum barbell height in snatch skill. Therefore, hypothesis number-(H_{5c}) also stands partially rejected in case of height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio variables.

18. The hypothesis number- (H_{5d}) stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected linear kinematic variable the maximum vertical velocity during first pull in snatch skill among elite weightlifters in snatch skill. The results obtained from Table-4.42 revealed insignificant correlation of all body dimensions with linear kinematic variable the maximum vertical velocity during first pull in snatch skill. Therefore, hypothesis number- (H_{5d}) stands fully rejected.

19. The hypothesis number- (H_{5e}) stated that there exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected linear kinematic vertical velocity of the barbell in the second pull in snatch skill among elite weightlifters in snatch skill. The results obtained from Table-4.43 revealed significant correlation of height with linear kinematic variable vertical velocity of the barbell in the second pull in snatch skill among elite weight lifters. Therefore, hypothesis number- (H_{5e}) stands partially

accepted in case of height. However, insignificant correlation has been observed in other variables; weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio with vertical velocity of the barbell in the second pull in snatch skill. Therefore, hypothesis number-(H_{5e}) also stands partially rejected in case of weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio variables.

CHAPTER-V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Sports has emerged a very highly competitive activity in the present decade, i.e. A lot of competition is going on throughout countries of the world to establish supremacy through sports competitions. Old records are being broken and new ones are being established in almost all international competitions. This has become possible because of advancement of scientific procedures, new researches and development.

There are numerous performance factors which contribute in the excellent performance of sports such as bio-mechanical application, psychological approaches, sociological contributions, physiological diagnosis, anthropometric matching of athletes and so on. In the recent year's anthropometry has acquired fame in the realm of competitive games. Study of anthropometry manages the human body, size and structure which differs in an assortment of ways and relies on age, sex, race and geological variables. Tanner (1964) reported that it is applied to the whole of biology to constitution taken in morphological, physiological aspects. Many more scientists like Sodhi and Sidhu, 1984; Mokha et al. (1998), Sehgal, 1995 etc. studied the human proportions their body composition and morphological make up and their relationship with sports activities. They advocated that science of anthropometry while selecting the athletes for particular sport is very important because of the fact different sports have different somatotype, morphological and anthropometrical requirements. In some sports like basketball and volleyball tall person are more successful where as in gymnastic and balancing like activities short height athletes exhibit better performance. Likewise, in throwing events weight lifting and other anaerobic activities people with heavy structure give better performance where as in activities like cycling, long distance running and aerobic activities, light weight athletes are more successful. Keeping in the view of the study the investigator has made a

sincere effort to scientifically further study the association of body dimensions and kinematic variables with performance of elite female weight lifters.

Objectives of Study

- To assess the association of body dimensions with performance of elite weightlifters in snatch skill.
- To assess the association of kinematic variables with performance of elite weightlifters in snatch skill.
- To assess the association of body dimensions with kinematic variables of elite weightlifters in snatch skill.

Hypotheses of the study

On the bases of earlier research readings and literature studied, opinion of the experts and understanding of the investigator, it was hypothesized that:

H_1: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio with performance of elite weightlifters in snatch skill.

H_{2a}: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during first phase of snatch skill.

H_{2b}: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during first pull of snatch skill.

H₂c: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during transition phase of snatch skill.

H₂d: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during second pull of snatch skill.

H₂e: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during the turn over under the barbell of snatch skill.

H₂f: There exists significant relationship of selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint with performance of elite weightlifters during the catch phase of snatch skill.

H₃: There exists significant relationship of selected linear kinematic variables; barbell height at the end of the first pull, barbell height at the end of the second pull, maximum barbell height, the maximum vertical velocity of the barbell in the first pull and the maximum vertical velocity of the barbell in the second pull with performance of elite weightlifters in snatch skill.

H₄a: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during first phase of snatch skill.

H₄b: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle

of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during first pull of snatch skill.

H₄c: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during transition phase of snatch skill.

H₄d: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during second pull of snatch skill.

H₄e: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during the turn over under the barbell of snatch skill.

H₄f: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected angular kinematic variables; angle of ankle joint, knee joint, hip joint, shoulder joint and elbow joint of elite weightlifters during catch phase of snatch skill.

H₅a: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and Waist hip ratio with selected linear kinematic variables; i.e**.** barbell height at the end of the first pull among elite weightlifters in snatch skill.

H$_{5b}$: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio with selected linear kinematic variable; i.e. barbell height at the end of the second pull among elite weightlifters in snatch skill.

H$_{5c}$: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio with selected linear kinematic variable; i.e. maximum barbell height among elite weightlifters in snatch skill.

H$_{5d}$: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio with selected linear kinematic variable; i.e. the maximum vertical velocity of the barbell in the first pull among elite weightlifters in snatch skill.

H$_{5e}$: There exists significant relationship of selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio with selected linear kinematic variable; i.e. the maximum vertical velocity of the barbell in the second pull among elite weightlifters in snatch skill.

Methods and Procedure

The present study was descriptive in nature. The main objective was to find the association of body dimensions and kinematic variables with performance of elite weightlifters. Purposive sample method was used to select the sample for the study. The present study was conducted on seven female elite level weight lifters who were in India camp and preparing themselves for National and International competition. The subjects for the study were selected from the India camp at Netaji Subhash National Institute of Sports (NIS) Patiala. The data was collected during the trails of Youth World

Weightlifting Championship 2017 on dated 20-2-2017 at national camp, Patiala. The championship was held at Bangkok, Thailand from 3rd to 10th April, 2017.

For the measurements of body dimensions anthropometric rod, weighing machine and steel tape was used. Data collection and biomechanical analysis demand specific tools and equipment's to capture and analyse the data. For the biomechanical analysis videography was used. The subject's snatch movements were recorded using Casio exilim (high speed, 1200/fps) camera in a field/arena setting.

Prior to the administration of the data collection, the investigator called the concern authority to explain in detail the purpose of the study. Investigator called upon biomechanical expert Dr. Suhel Raza, Asst. Prof. in P.P.N. College, Kanpur,U.P. India with his camera team for the biomechanical data collection. He held a position of video analyst in various sports academics for the improvement of techniques and skills of players. Prior permission was taken from the Indian team chief coach Mr. Vijay Sharma, India Camp, NIS, Patiala for the data collection. The data was collected with the consent from the higher authority of NIS Patiala. The coaches and lifters were informed about the purpose of the study.

One advanced camera was situated on the stage a way off of 5.28 m from the lifting arena, shaping a roughly 45° angle with the sagittal plane. The lifts were recorded utilizing 1 computerized camera (Casio exilim), which caught pictures at 1200 fields for every second. The camera was set at sports mode and the inspecting pace of the camcorder was sixty fields for each second. A quick screen speed can freeze the movement of a quick subject and moderate shade paces can obscure the subject to give the impression of the movement. Consequently, the screen speed of the camera was fixed at quick speed (1/4000 quick shade speed permit quick subject to catch each edge in turn clearly) to wipe out the haze while video recording.

For the analysis of data SPSS version 22 was used. In order to examine the association of body dimensions, kinematic variables with performance, a product moment correlation method was used.

5.2 Conclusions of the study:

Based upon the findings following conclusions has been drawn: -

1. Performance has shown significant and positive correlation with lower leg length among the elite weight lifters. However, others body dimensions height, weight, sitting height, arm length, leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with performance among elite weightlifters.

2. During first phase of snatch skill, all the selected angular kinematic variables ankle joint angle, knee joint angle, hip joint angle, shoulder joint angle and elbow joint angle have shown insignificant correlation with performance of elite weightlifters.

3. During first pull of snatch skill only shoulder joint angle has negatively and significantly correlated with performance of elite weight lifters. However, all others angular kinematic variables ankle joint angle, knee joint angle, hip joint angle and elbow joint angle have shown insignificant correlation with performance of elite weight lifters.

4. During transition phase of snatch skill, shoulder joint angle has negatively significantly correlated, and elbow joint angle has positively significantly correlated with performance of elite weight lifters. However, all others angular kinematic variables ankle joint angle, knee joint angle and hip joint angle have shown insignificant correlation with performance of elite weight lifters.

5. During second pull of snatch skill, only knee joint angle has negatively and significantly correlated with performance of elite weight lifters. However, all others angular kinematic variables; ankle joint angle, knee joint angle, hip joint angle and elbow joint angle have shown insignificant correlation with performance of elite weight lifters.

6. During turn over under the barbell in snatch skill, all the selected angular kinematic variables; ankle joint angle, knee joint angle, hip joint angle, shoulder joint angle and elbow joint angle have shown insignificant correlation with performance of elite weightlifters.

7. During catch phase of snatch skill, all the selected angular kinematic variables; ankle joint angle, knee joint angle, hip joint angle, shoulder joint angle and elbow joint angle have shown insignificant correlation with performance of elite weightlifters

8. The performance has shown significantly negative correlation with velocity during first pull, and positive correlation with velocity during second pull among the elite weight lifters. However, others linear kinematic variables; barbell displacement till first pull, barbell displacement till second pull and maximum vertical height of barbell have shown insignificant correlation with performance of elite weight lifters.

9. Sitting height has shown significant and positive correlation with ankle joint angle during first phase of snatch skill. However, other body dimensions such as height, weight, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with ankle joint angle among elite weight lifters.

10. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with knee joint angle during first phase of snatch skill among elite weight lifters.

11. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during first phase of snatch skill among elite weight lifters.

12. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle during first phase of snatch skill among elite weight lifters.

13. Height and sitting height have shown significant and negative correlation with elbow joint angle during first phase of snatch skill. However, other body dimensions such as weight, arm length, leg length, lower leg length, chest girth,

thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with ankle joint angle among elite weight lifters.

14. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle during first pull of snatch skill among elite weight lifters.

15. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with knee joint angle during first pull of snatch skill among elite weight lifters.

16. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during first pull of snatch skill among elite weight lifters.

17. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle during first pull of snatch skill among elite weight lifters.

18. Height has shown significant and positive correlation with elbow joint angle during first pull of snatch skill. However, other body dimensions such as weight, sitting height arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle among elite weight lifters.

19. Thigh girth and calf girth have shown significant and positive correlation with ankle joint angle during transition phase of snatch skill. However, other body dimensions such as height, weight, arm length, leg length, lower leg length, chest girth, pelvic girth, BMI and waist hip ratio have shown insignificant correlation with ankle joint angle among elite weight lifters.

20. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with knee joint angle during transition phase of snatch skill among elite weight lifters.

21. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during transition phase of snatch skill among elite weight lifters.

22. Lower leg length has shown significant and negative correlation with shoulder joint angle during transition phase of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle among elite weight lifters.

23. Weight, lower leg length and thigh girth has shown significant and positive correlation with elbow joint angle during transition phase of snatch skill. However, other body dimensions such as height, sitting height, arm length, leg length, chest girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle among elite weight lifters.

24. Weight, sitting height, pelvic girth and BMI have shown significant and positive correlation and pelvic girth has shown significant and negative correlation with the elbow joint angle during second pull of snatch skill among elite weightlifters. However, other body dimensions such as height, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth and waist hip ratio have shown insignificant correlation with ankle joint angle among elite weight lifters.

25. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with knee joint angle during second pull of snatch skill among elite weight lifters.

26. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during second pull of snatch skill among elite weight lifters.

27. Leg length has shown significant and negative correlation with shoulder joint angle during second pull of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle among elite weight lifters.

28. Pelvic girth has shown significant and positive correlation with elbow joint angle during second pull of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle among elite weight lifters.

29. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with ankle joint angle during the turn over under the barbell phase of snatch skill among elite weight lifters.

30. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with knee joint angle during the turn over under the barbell phase of snatch skill among elite weight lifters.

31. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during the turn over under the barbell phase of snatch skill among elite weight lifters.

32. Thigh girth has shown significant and positive correlation with shoulder joint angle during the turn over under the barbell phase of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, lower leg

length, chest girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle among elite weight lifters.

33. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle during the turn over under the barbell phase of snatch skill among elite weight lifters.

34. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with ankle joint angle during the catch phase of snatch skill among elite weight lifters.

35. Waist hip ratio has shown significant and positive correlation with knee joint angle during the catch phase of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, lower leg length, chest girth, pelvic girth, thigh girth, calf girth and BMI have shown insignificant correlation with knee joint angle among elite weight lifters.

36. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with pelvic joint angle during the catch phase of snatch skill among elite weight lifters.

37. Chest girth has shown significant and negative correlation with shoulder joint angle during the catch phase of snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, lower leg length, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with shoulder joint angle among elite weight lifters.

38. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with elbow joint angle during the catch phase of snatch skill among elite weight lifters.

39. Lower leg length has shown significant and negative correlation with linear kinematic variable barbell distance from the floor to first pull in snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, chest girth, pelvic girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with linear kinematic variable barbell distance from the floor to first pull among elite weight lifters.

40. Weight, lower leg length and BMI has shown significant and positive correlation with barbell distance at the end of second pull in snatch in snatch skill. However, other body dimensions such as height, sitting height, arm length, leg length, chest girth, thigh girth, pelvic girth, calf girth and waist hip ratio have shown insignificant correlation with linear kinematic variable barbell distance at the end of second pull in snatch among elite weight lifters.

41. Pelvic girth has shown significant and negative correlation with linear kinematic variable maximum distance covered by barbell in snatch skill. However, other body dimensions such as height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with linear kinematic variable maximum distance covered by barbell among elite weight lifters.

42. All the selected body dimensions; height, weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth, calf girth, BMI and waist hip ratio have shown insignificant correlation with linear kinematic variable, the maximum vertical velocity during first pull in snatch among elite weight lifters.

43. Height has shown significant and positive correlation with linear kinematic variable, the maximum the maximum vertical velocity during second pull in snatch in snatch skill. However, other body dimensions such as weight, sitting height, arm length, leg length, lower leg length, chest girth, thigh girth, pelvic girth calf girth, BMI and waist hip ratio have shown insignificant correlation with linear kinematic variable, the maximum the maximum vertical velocity during second pull in snatch among elite weight lifters.

5.3 Suggestions

1. Present study has been confined to the elite level weightlifters under the age of 18. Similar, type of study can be carried out on other age groups also.
2. The scope of the study can be expended by incorporating other variables.
3. The present research was delimited to female weightlifters. In future similar kind of study on male weightlifters can be executed.
4. The similar examination might be led by choosing bigger number of subjects having a place with various degree of execution, for example, Inter-university, Nationals and Internationals competitions.
5. The similar study may be conducted on the male and female weight lifters belonging to different regions of the country.
6. The similar kind of study can be conducted in weightlifting on Clean & Jerk technique.
7. As this analysis was conducted in two dimensions only. For that reason, the author suggests that the use of three dimensions techniques will be more helpful for the coaches and sports related people. With kinematic variables, study can also be conducted on kinetics variables of weight lifting performance for the better understanding of the motion of barbell.

5.4 Recommendations

1. The present study might be helpful in understanding the relationship of anthropometric measurements with performance.
2. The current study may be helpful in sports where the encouraging to youngsters/children can be giving to which games and sports they are well reasonable by looking at their physique.

3. The coaches, players and the experts of Snatch technique of Weightlifting were greatly profited with the response provided of the existing method execution the Snatch skill.

4. The present study might be supportive in comprehension the relationship of Kinematic variables with performance.

5. The present study might be helpful in indulgent the relationship of Body dimension with performance in each phase of snatch.

6. This present study might be helpful in considerate the significant role of Angular kinematic in snatch skill.

7. This present study might be supportive in understanding the important role of linear kinematics of barbell in snatch skill.

8. The outcomes of the study were evolving new methods for refining the performance of Indian Weightlifters.

9. The obtained results can provide valuable information for lower-level lifters and coaches to achieve better competition performance by altering their training methods accordingly.

10. On the basis of the finding of the current analysis, the coaches and physical educationists should prepare the weightlifters in snatch technique may be developed to achieved the high performance in sports.

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APPENDICES 1- RAW DATA OF RESULT SHEET, ANTHROPOMETRIC VARIABLES AND KINEMATIC VARIABLES

RESULT SHEET OF SNATCH IN WEIGHTLIFTING

DATE- 20 feb, 2017

NAME	WEIGHT CATEGORY	1ST ATTEMPT	2ND ATTEMPT	3RD ATTEMPT	TOTAL	BEST LIFT
K. ORMILA DEVI	44	51 ✓	53 ✓	56 ✓	56	56
Y.S. CHANU	58	65 ✓	69 X	69 X	65	65
Trupit Mane	58	71 ✓	73 ✓	75 ✓	75	75
P. U. Devi	63	70 ✓	73 ✓	74 ✓	74	74
W. Sapna Devi	69	62 ✓	65 ✓	67 X	65	65
Nikita Kale	69	68 ✓	72 ✓	75 ✓	75	75
A. Anju Devi	+75	68 X	68 ✓	70 ✓	70	70

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BODY DIMENSIONS MEASUREMENT RESULT OF WEIGHTLIFTERS   DATE- 20 Feb 2017

NAME	WEIGHT CATEGORY	HEIGHT (C.M.)	WEIGHT (KG)	TORSO HEIGHT	ARM LENGTH	LEG LENGTH	LOWER LEG LENGTH	PELVIC GIRTH	THIGH GIRTH	CALF GIRTH	CHEST GIRTH	WAIST- HIP RATIO	BMI
Armila	44	145cm	43.100kg	60cm	60.8cm	80.3cm	40.3cm	60.8cm	40.8cm	30cm	80.3cm	0.75	21.37 kg/m²
Y.S Channu	58	154cm	57.882	60.3cm	70cm	90cm	50cm	80cm	50.5cm	30.5cm	90cm	0.88	24.45 kg/m²
Trupit Mane	63	158cm	56.900	60cm	70.4cm	90cm	50.4cm	70.4cm	50.5cm	30.3cm	90cm	0.78	22.79 kg/m²
P.Umeshwri Devi	63	157cm	62.040	60.9cm	70.2cm	80.6cm	50.1cm	80.3cm	50.8cm	30.4cm	90cm	0.80	25.17 kg/m²
W.Sapna Devi	69	149cm	63.960	60cm	70cm	90cm	50cm	90.4cm	60cm	40cm	1mth	0.99	28.81 kg/m²
Nikita Kale	69	151cm	63.320	60.3cm	60.4cm	80.5cm	50cm	70.6cm	6ccm	40cm	80.6cm	0.67	27.86 kg/m²
A.Anju Devi	+75	159cm	83.200	60.8cm	70.3cm	80.8cm	50.3cm	1m.6cm	60.4cm	40.3cm	110cm	1.00	32.91 kg/m²

RAW DATA OF KINEMATIC VARIABLES

1. ANGULAR KINEMATIC VARIABLES OF WEIGHT LIFTERS IN EACH PHASE

FIRST PHASE	Ankle joint	Knee angle	Hip angle	Shoulder angle	Elbow angle
Subject 1	96	88	48	47	182
Subject 2	86	86	54	46	180
Subject 3	87	103	48	51	177
Subject 4	113	98	48	51	173
Subject 5	87	78	50	50	180
Subject 6	89	96	57	63	178
Subject 7	100	85	50	57	174
Mean	94	90.57143	50.71429	52.14285714	177.7142857

FIRST PULL	Ankle angle	Knee angle	Hip angle	Shoulder angle	Elbow angle
Subject 1	115	145	97	52	180
Subject 2	99	125	75	54	180
Subject 3	93	145	90	43	181
Subject 4	100	135	99	44	181
Subject 5	110	139	92	54	180
Subject 6	108	142	111	39	180
Subject 7	112	143	85	47	181
Mean	105.2857143	139.142857	92.71429	47.57142857	180.4285714

THE TRANSITION PHASE	Ankle angle	Knee angle	Hip angle	Shoulder angle	Elbow angle
Subject 1	89	95	131	181	33
Subject 2	90	102	159	18	190
Subject 3	82	121	128	8	183
Subject 4	87	127	150	12	180
Subject 5	107	147	161	24	180
Subject 6	105	120	143	22	182
Subject 7	99	125	132	35	203
Mean	94.14285714	119.571429	143.428571	42.85714286	164.4285714

SECOND PULL	Ankle angle	Knee angle	Hip angle	Shoulder angle	Elbow angle
Subject 1	132	175	179	38	174
Subject 2	132	180	186	26	180
Subject 3	130	152	178	18	179
Subject 4	136	160	185	31	180
Subject 5	132	159	181	28	180
Subject 6	135	150	181	32	181
Subject 7	146	158	182	38	158
Mean	134.7142857	162	181.714286	30.14285714	176

TURNOVER UNDER THE BARBELL	Ankle angle	Knee angle	Hip angle	Shoulder angle	Elbow angle
Subject 1	93	108	133	82	135
Subject 2	95	117	138	61	166
Subject 3	79	95	152	71	163
Subject 4	79	96	132	78	167
Subject 5	83	117	165	48	142
Subject 6	107	132	201	43	174
Subject 7	101	111	146	67	140
Mean	91	110.8571429	152.4285714	64.28571429	155.2857143

THE CATCH/HOLD PHASE	Ankle angle	Knee angle	Hip angle	Shoulder angle	Elbow angle
Subject 1	70	45	63	153	188
Subject 2	81	50	53	174	182
Subject 3	73	33	69	159	181
Subject 4	82	36	63	162	157
Subject 5	80	47	71	206	182
Subject 6	81	33	63	180	181
Subject 7	79	50	67	148	181
Mean	78	42	64.1428571	168.8571429	178.8571429

RAW DATA OF LINEAR KINEMATIC OF BARBELL

	Barbell height at first pull	Barbell height at second pull	Max. Barbell height	Time taken in first pull	Time taken in second pull	Max vertical velocity of b. At first pull	Max vertical velocity of b. At second pull
Subject 1	0.68	0.68	1.17	4.64	6.41	0.146551724	0.106084243
Subject 2	0.5	0.77	1.04	4.24	6.37	0.146551724	0.120879121
Subject 3	0.47	0.75	1.04	3.77	5.77	0.117924528	0.129982669
Subject 4	0.56	0.82	1.19	3.94	5.74	0.124668435	0.142857143
Subject 5	0.52	0.8	1.08	5.97	7.94	0.14213198	0.100755668
Subject 6	0.5	0.76	1.06	3.77	6.04	0.087102178	0.125827815
Subject 7	0.58	0.84	1.3	4.67	6.74	0.132625995	0.12462908
Mean	0.544285714	0.774286	1.125714	4.428571429	6.43	0.128222366	0.121573677

APPENDICES 2-

CONSENT LETTER FROM

COACH
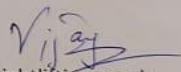
DATE- 20 Feb., 2017

The data is collected during the weightlifting trails of Youth world on 20, February, 2017 from the India camp at Netaji Subhash Institute of sports (NIS) Patiala. After discussion with the coach, officials and biomechanical expert one best lift is selected for further analysis. The names of the female lifters selected for the further analysis are as follow:-

1. K. Osmila Devi
2. Y.S. Chanu
3. Trupit Mane
4. P. U. Devi
5. W. Sapna Devi
6. Nikita Kale
7. A. Anju Devi

Weightlifting coach

NIS Patiala.

Ph. No. -8284859071

APPENDICES 3-

BIODATA OF

BIOMECHANICAL EXPERT,

OFFICIALS AND

WEIGHTLIFTERS

NAME- Dr. Sohel Razi

ADDRESS- 112/351 Swaroop Nagar Kanpur (U.P)

DATE OF BIRTH- 18/02/1980

EMAIL- SU·HELL·RAZA@GMAIL·COM

PHONE NO- 9336184977

LOVELY
PROFESSIONAL
UNIVERSITY

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
2010	Ph.D	L.N.I.P.E GWALIOR (M.P)	

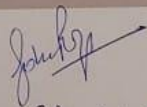## DETAILS ABOUT THE CAMERA-

① CASIO EXILIM (HIGH SPEED) 1200 FPS

PROFESSIONAL EXPERIENCES

① Video Analyst at MA Cricket Academy New Delhi since last six years

② Consultancy firm Sports Biomech. established in 2010

③ ~~Sports~~ www.sportsbiomech.com (website)

EXTRA CURRICULAR ACTIVITY
-
-

Deceleration – Above statement given by me is true.

(Dr. Sohel Razi)

NAME- POONAM TIWARI
ADDRESS- In Front of Sports stadium Hardoi.
DATE OF BIRTH- 07-08-1976   9415436495
EMAIL- Rajdhar mishra.rml@gmail.com
PHONE NO- 9415436495 (UP.)

LOVELY PROFESSIONAL UNIVERSITY

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
2001	NIS	NIS Patiyala	

PROFESSIONAL ACHIEVEMENTS

International Refree class II
South Asian games 2016 Gowhadi, commonwealth champinship
Puney 2015

SPORTS ACHIEVEMENTS

1. International Power-lifting south Asian champion ship 'Silver medal'. South Korea
2.
3. National champion in Power lifting 1996-1998
4.
5.

EXTRA CURRICULAR ACTIVITY
-
-

Deceleration – Above statement given by me is true.

Poonam Tiwa.

22

NAME- Amarnath Tyagi
ADDRESS- T116 Palanpurram phase 2 Modipuram Meerut U.P
DATE OF BIRTH- 11-10-1971
EMAIL- ANTyagi.India@gmail.com
PHONE NO-
8988778899

L OVELY
P ROFESSIONAL
U NIVERSITY

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
1996	NIS	Patiala NIS	

PROFESSIONAL ACHIEVEMENTS

official in Indian weї. Association

Class one refree

SPORTS ACHIEVEMENTS

1. World Army games 1994 [Sumalia moghadeshu (Africa)
2.
3.
4.
5.

EXTRA CURRICULAR ACTIVITY
•
•

Deceleration – Above statement given by me is true.

NAME- Nirlep Singh
ADDRESS- 42, Raghubirganj, U.P., India.
DATE OF BIRTH- 1-1-1973
EMAIL- Nirlepsingh100@gmail.com
PHONE NO- 7500921100

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
1993	B.A.	Meerut University (CCSU)	70%

PROFESSIONAL ACHIEVEMENTS

Class one Refree weightlifting.

SPORTS ACHIEVEMENTS

1. National level weightlifter.
2. Inter university Gold Medalist.
3. Participated in National weightlifting championship.
4.
5.

EXTRA CURRICULAR ACTIVITY
-
-

Deceleration – Above statement given by me is true.

Nirlep Singh

NAME- K. Ormila Devi
ADDRESS- Langthel Leikom bazar. Manipur.

DATE OF BIRTH- 20/3/2002
EMAIL-
PHONE NO- 842 7535 802

LOVELY PROFESSIONAL UNIVERSITY

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
2016	8th	Utlou High School, Manipur	58·1

PROFESSIONAL ACHIEVEMENTS

SPORTS ACHIEVEMENTS

1. Youth National Gold Medal 44kg class 2016
2. Youth National Bronze medal in Patna 2015
3.
4.
5.

EXTRA CURRICULAR ACTIVITY

- North East Game Gold Medal in 44kg 2015
-

Deceleration – Above statement given by me is true.

K. Ormila Devi

NAME- Trupit Mane
ADDRESS- Maharashtra

DATE OF BIRTH- 20-09-2001
EMAIL-
PHONE NO- 9822371909

LOVELY
PROFESSIONAL
UNIVERSITY

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
2017	10th	Maharashtra	Pursuing

PROFESSIONAL ACHIEVEMENTS

SPORTS ACHIEVEMENTS

1. Gold Medal in School National 2015
2. Youth National Gold Medal 2016
3. 3 Times participated in National weightlifting Championship.
4.
5.

EXTRA CURRICULAR ACTIVITY
-
-

Deceleration – Above statement given by me is true.

NAME- YUMNAM SHILHEINGANBI CHANU
ADDRESS- MANIPUR

DATE OF BIRTH- 01-04-2000
EMAIL-
PHONE NO- 9856528252

LOVELY PROFESSIONAL UNIVERSITY

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
2015	8th	MANIPUR	64-1.

PROFESSIONAL ACHIEVEMENTS National School Games 2013

SPORTS ACHIEVEMENTS

1. Youth National Silver medal in 58 kg class 2016
2. Youth National Participate in 58 kg class - 2015-216
3.
4.
5.

EXTRA CURRICULAR ACTIVITY
- North East Game Gold - in 58kg - 2015
-

Deceleration – Above statement given by me is true.

Y. Shilheinganbi C

27

NAME- Potshangbam Umeshwori Devi
ADDRESS- Manipur

DATE OF BIRTH- 28/7/2002
EMAIL-
PHONE NO- 7085969634

LOVELY
PROFESSIONAL
UNIVERSITY

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
2015	8th	Sanskrit School	54.1.

PROFESSIONAL ACHIEVEMENTS

SPORTS ACHIEVEMENTS

1. Youth National Gold Medal in 63kg (2016)
2. Youth National Participation in Patna 63kg (2015)
3.
4.
5.

EXTRA CURRICULAR ACTIVITY
- •
- •

Deceleration – Above statement given by me is true.

P. Umeshwori Devi

28

NAME- Nikita Kale
ADDRESS- Maharashtra

DATE OF BIRTH- 22-7-2000
EMAIL-
PHONE NO- 9270721518

**LOVELY
PROFESSIONAL
UNIVERSITY**

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
2016	10th	Maharashtra	58%

PROFESSIONAL ACHIEVEMENTS

Five National participation in weightlifting.

SPORTS ACHIEVEMENTS

1. Gold in School National 2016.
2. Gold in School National 2015
3. Gold in School National 2014.
4.
5.

EXTRA CURRICULAR ACTIVITY
-
-

Deceleration – Above statement given by me is true.

NAME- W. Sapna Devi
ADDRESS- Manipur

DATE OF BIRTH- 15-1-2003
EMAIL-
PHONE NO- 9615352926

**LOVELY
PROFESSIONAL
UNIVERSITY**

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
2017	9th	Manipur	pursuing

PROFESSIONAL ACHIEVEMENTS

SPORTS ACHIEVEMENTS

1. Gold Medal in Sub-Junior and Junior National 2016-
2. Participated in School National 3 times.
3.
4.
5.

EXTRA CURRICULAR ACTIVITY
- •
- •

Deceleration – Above statement given by me is true.

W. Sapana Devi

Weight Category - +75

NAME- Arambam Anju Devi
ADDRESS- Manipur

DATE OF BIRTH- 18-07-2001
EMAIL-
PHONE NO- 9615352926

LOVELY
PROFESSIONAL
UNIVERSITY

ACADEMIC QUALIFICATIONS

Year	Degree	Institute	CGPA / Percentage
2016	10th	Ultoul High School	68·/.

PROFESSIONAL ACHIEVEMENTS

SPORTS ACHIEVEMENTS

1. Gold Medal in National 2016
2. Sub Junior Silver Medal in National 2016.
3. 2 Times participated in National competition.
4.
5.

EXTRA CURRICULAR ACTIVITY
•
•

Deceleration – Above statement given by me is true.

A. Anju Devi

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APPENDICES-4
PHOTOGRAPHS

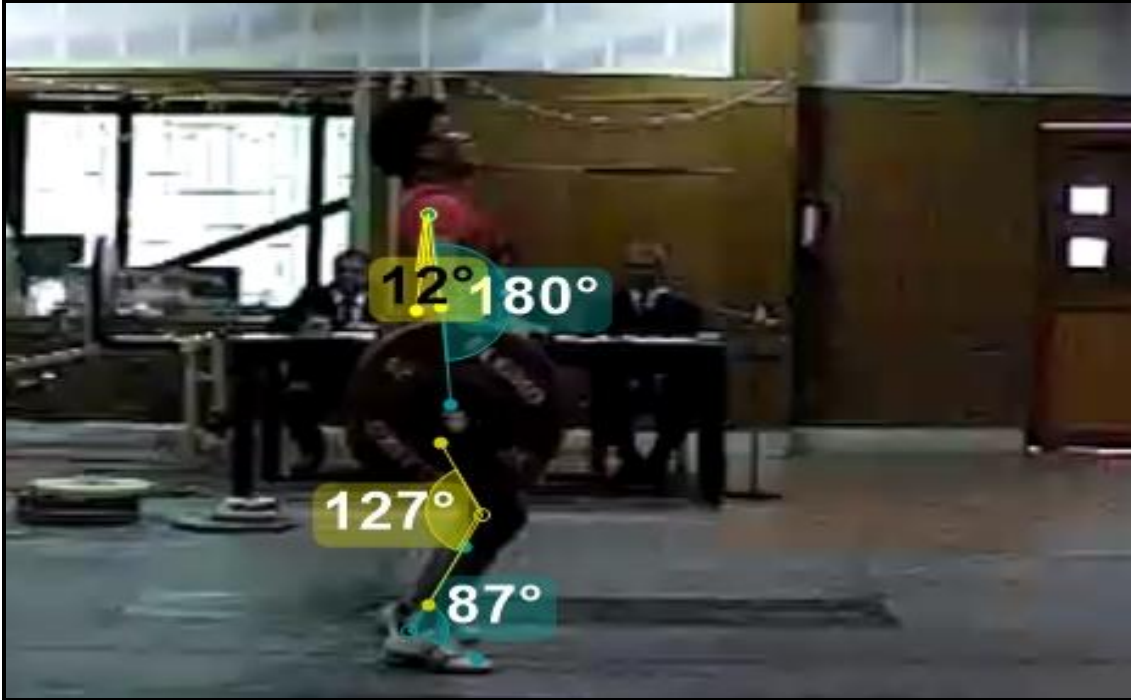# APPENDICES 4- PHOTOGRAPHS

ANGULAR KINEMATICS OF EACH PHASE

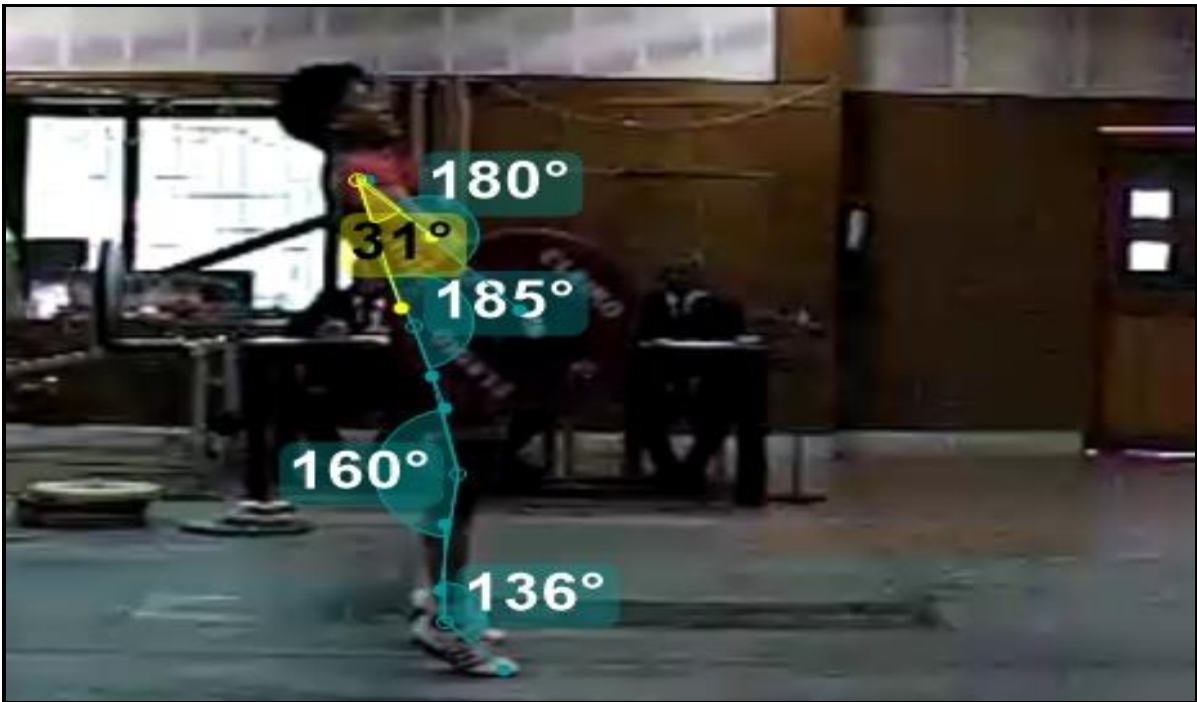**PHASE 1- The first phase/Lift off**
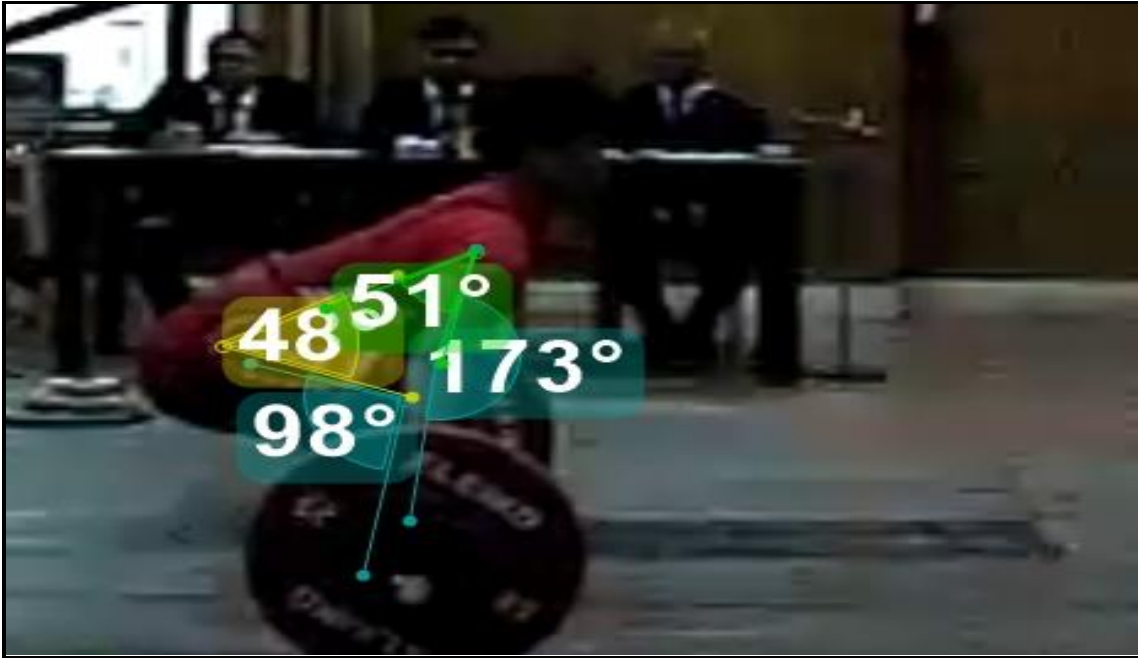
PHASE 2- The first pull
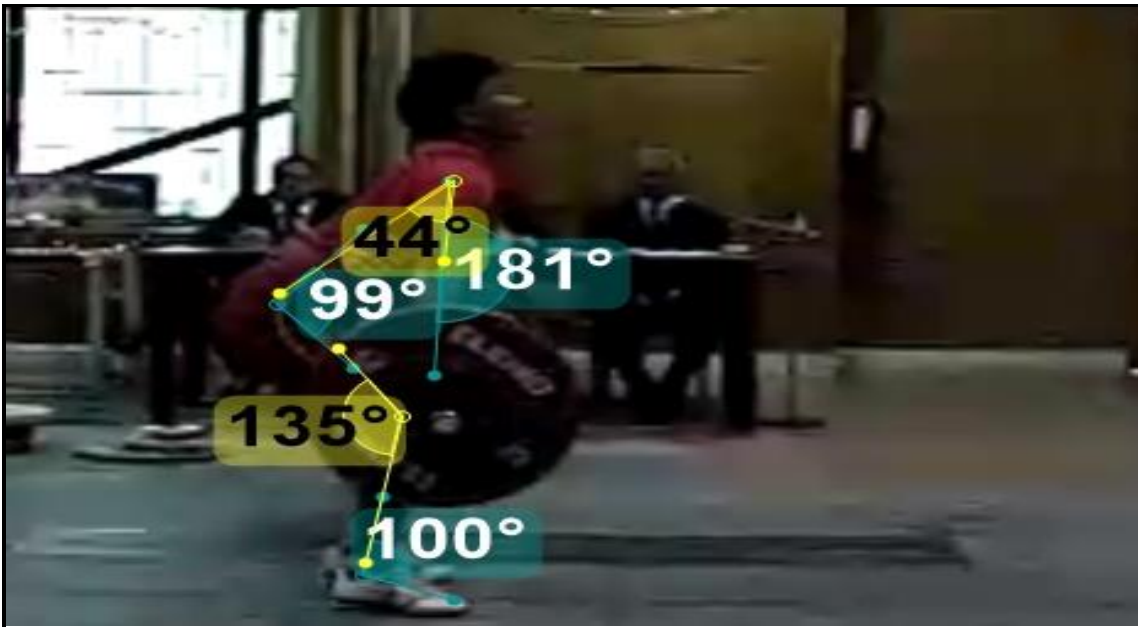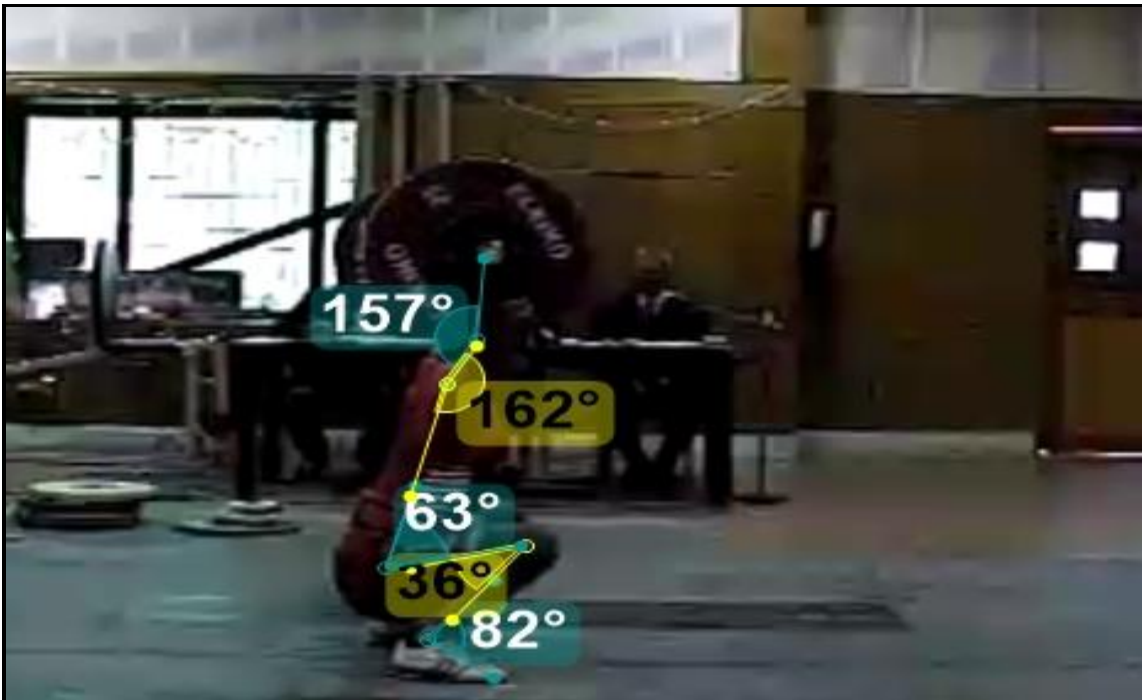
PHASE 3- The transition phase

PHASE 4- The second pull

PHASE 5- Turnover under the barbell

PHASE 6- The catch/hold phase
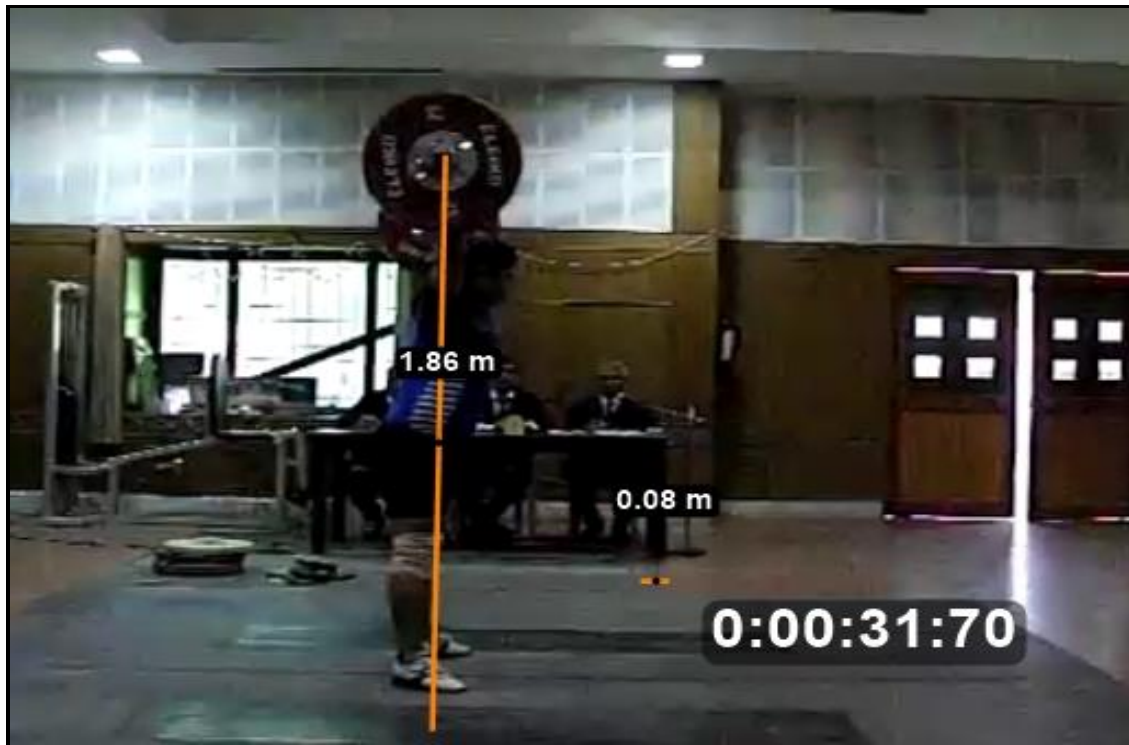
LINEAR KINEMATICS OF BARBELL

1. Barbell height at the end of the first pull

2. Barbell height at the end of the second pull

3. Maximum barbell height

4. The maximum vertical velocity of the barbell in the first pull= Distance/Time

5. The maximum vertical velocity of the barbell in the second pull=Distance/Time

0.84 m

0:00:06:74

Images of camera setting in Arena

Images of distance measured from floor to camera