Chapter I

INTRODUCTION

The Judo maxim, "The best use of Energy" has been the guiding principle in applying science of Judo. Originally, one of the characteristics of Judo was the emphasis placed upon intuition and personal experience and the individuality of the technique resulting from hard practice and experiment. However, modern Judo is based upon the methods inherited from the early days. These methods were offered by advanced sciences whereby a general and theoretical system of technique is arrived at on the basis of a thorough analysis and rationalization. In the recent years, the application of science to Judo has increased greatly and research on the technique has made a considerable progress. Since Judo has been adopted as an Olympic event, methods of training and conditioning have also been greatly developed.

Technique is the correct and efficient performance of Judo movement. It is not a mechanical process in its true aspect. It is developed by an intelligent practice. These specific actions are effected without conscious effort. Perhaps 75% or more of the completed Judo technique of throwing is in the Kuzushi (unbalancing) of the opponent without kuzushi, judo can

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not be effected. A thorough study of the principles of Kuzushi must be made by all Judo exponents regardless of its level of proficiency. This study is not a "one-time" affair, but rather a constant study and reappraisal to improve and apply the methods of unbalancing the opponent. It is usually performed along with one or two lines. The first of these is a direct method in which the opponent is brought into unbalance by the attacker applying a form of Happo no Kuzushi (eight forms of Kuzushi), imparting it by action of one's body forces against the opponent's weak line of balance. The second case is termed as Hando no Kuzushi (reaction forms of Kuzushi), and is an unbalance that the opponent imposes on himself by his body reactions to one's diversionary attack. Each individual technique has to be studied to determine the most efficient manner of obtaining the unbalance of the opponent. One should make use of both types of Kuzushi, Happo no Kuzushi and Hando no Kuzushi at every training session, and one's Judo technique will improve. If the Judo exponent has not met these requirements of posture, movement, body turning, grasping, and unbalancing of the opponent, he has yet to effect the Tsukuri (blending action). This implies the blending of the attacker's body to that of the opponent while the opponent is in the state of unbalance. The use of Tsurikomi (lift-pull) is a force applied to the opponent's body, using the entire body forces in unison to effect a state of unbalance. Beginners are apt to apply the Tsurikomi with the arm's alone, neglecting the
major source of body power which lies in the trunk proper. True Tsurikomi makes use of the entire body, with the arms acting as a connecting link to bring the body forces against the opponent. tsukuri cannot be effected properly without good Tsurikomi. Trainees should strive for effective Tsurikomi during the practice of Tsukuri. The actual Tsukuri varies somewhat from the technique being applied. This entry is termed Hairikata (method of entry), and can only be learned by competent instructions and constant practice. The proper use of the body is essential, and the mere use of strength is to be discouraged. However, strength applied properly will bring more effective Judo to develop patterns of entry based upon the basic movements of the technique being applied. The final stage of a Judo technique, Kake (execution) is an automatic condition of the proper application of Judo fundamentals already discussed. The true Judo Waza (technique) shows no distinct separation of Kuzushi, Tsukuri, and Kake but rather a blend of these stages into a smooth motion is faster than the eye.  

The coach plays an important role in motivating the athlete. The coaching is mainly an art and like the artist the coach must have two attributes. The first is creative flair, that marriage of aptitude and passion which enables him to draw an

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athlete's dream towards realization. The athlete, moved to express himself within a social mosaic, chooses to do so in the pursuit of competitive excellence in sport. The coach creates expressions and motivates the athletes in proper direction. The second attribute is technical mastery of the instruments and materials used. The athlete is the instrument and the material with which the coach works. Structurally, he is a system of levers, given movement by the pull of muscle, and obedient to the laws of physics. Functionally, he is a dynamic integration of adaptive system. But more than that, he is a reasoning being.

To accept the full weight of this responsibility, the coach must move towards a deeper appreciation of those sciences which relate to the athlete. This is not to say that pragmatism is dead because there will continue to be situations where the coach 'knows' a practice is correct, according to his 'feel' for coaching athletes. This is, of course, a part of the coach's art and it should stimulate the athlete. If the underlying principles are not defined and practiced, proper application of these will not result in fruitful communication skills³.

When analyzing movement, it is tempting to focus one attention on a single joint action. However, it is basic to all

studies of movement that it is the most efficient compromise which must be sought. Moreover, one must be constantly aware of a joint action relative to other joint actions, movement and all actions relative to mechanical laws. Consequently, it is suggested that the students should establish a technical model for a given event in sport. This technical model will represent the most efficient compromise. It will embrace broad principles of movement. Whether principles grow from theory or from experience, one is always drawn to the same conclusion that our system of levers must be considered in its entirety when creating technical models. The sciences of Kinesiology and Biomechanics have grown from applied anatomy and mechanics. It is recommended that the coach should take time to study these sciences.

Papcsy studied the effectiveness of the "principle inclusion method" (PIM) in contrast with the "practice method" (PM) in the learning of a motor skill. The activity learned was a bunting skill, both of which involve the same mechanical principles. He concluded that the subjects who learned an appropriate mechanical principles learned the skills faster and retained it, having higher IOS.

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4 ibid. p. 45

One of the main tasks of biomechanics in sports is to support development of better motor dynamics for individual sports. By measuring motor characteristics and by comparing them with data from motor dynamics of athletes who have achieved good results, raw data helps in the findings. The value of these data is increased and the findings are deepened if methods of mathematical statistics are used in the analysis. Such an approach, however, has its limitations. The fact that in the motor characteristics measured the efficiency of the motor process as well as the existing level of motor abilities are included. Therefore, specific criteria are necessary for analyzing the efficiency of the motor process. Such criteria do exist more or less in all sports. They are derived from the large fund of experience of sport practice and they have (in most cases only afterwards) been theoretically investigated. Thus, in different sports events theories on the efficiency of motor processes have been established. These made essential contributions to the techniques in sports. There are several examples where a new technique was found in practice by trials, which was much better than a previously used technique and which soon replaced the old technique. This is true, for example, for the shot-put technique applied first by O’ Brien. An essentially better path of acceleration of the shot can be implemented by this technique. Looking at the obvious progress in the development of technique in sports and investigating it more in detail from biomechanical points of view, we generally find
starting points for objective criteria in an analysis of the efficiency of motor dynamics. We thus found some starting points for the Biomechanical principle of the optimal path of acceleration in the shot put technique. More than other sport scientific disciplines, biomechanics must orient to the specifics of sport events if it is to remain productive. This is necessary because motor dynamics themselves are the subject of Biomechanical investigations. Findings of generally valid levels are, however, only possible to a certain extent because of the differences of motor dynamics and aims of sport events. The degree of coincidence between motor structure and the aim is very important.

During the twentieth century, advances in the science of human motion seem to have been not only due to improvements instrumentation, but also to the development of better and more creative methods of using these instruments. Fundamental to the study of human motion is measurement of the displacement of the body and its segments. To date, advances in kinematic analysis have been greater than in most other aspects of research.


Traditionally, cinematographic analysis of relative high speed films has been the technique used to obtain kinematic data. However, the raw displacement of data thus acquired usually contain inherent error that can cause large inaccuracies in the velocities and accelerations determined by direct differentiation. For this reason, various methods of smoothing the displacement data have been employed. The two most successful are digital filtering \textsuperscript{8,9}, and the use of spline functions by McLaughlin, Dillman and Lardner\textsuperscript{10}, Wood and Jennings\textsuperscript{11}, Zernicke, Caldwell and Roberts\textsuperscript{12}. Methods of three dimensional cinematographic analysis have been developed and refined during the 1970's to improve the accuracy of studying complex human

\textsuperscript{8} J.C. Pezzack, R.W. Norman and D.A. Winter, "An assignment of derivation determining techniques used for motion analysis" \textit{Journal of Biomechanics} 10 (1977) 377-382.


\textsuperscript{10} T.M. McLaughlin, C.J. Dillman and T.J. Lardner "Biomechanical Analysis with Cubic Spline Turnetions" \textit{Research Quarterly} 48 (December 1977): 569-582.


motions. But these techniques have not yet been implemented according to Miller\textsuperscript{13}. The use of optoelectronic devices to acquire displacement data is a particularly promising development that may replace cinematography in the near future. Among these new techniques that have emerged in recent years are (1) polarized light goniometry by Grieve\textsuperscript{14}, Reed and Reynolds\textsuperscript{15}. (2) automatic image analysis in which a television image or a cine film is scanned by computer to determine the $x$ and $y$ coordinates of anatomical landmarks: and (3) light spot position measurement, which uses optoelectronic devices such as the Selspot to obtain the information about the three-dimensional coordinates of small, active light sources attached to the human body. Although considerable progress has been made in the descriptive (Kinematic)-analysis of human motion, the area of kinetics has received relatively limited attention. Miller\textsuperscript{16} expressed the belief that future research must expand its concern with the kinetic analysis of human motion and must include not only an

\textsuperscript{13} Miller, Canadian Journal Of Applied Sport Sciences 3 (1978): 229-236.

\textsuperscript{14} D.W. Grieve, "A Device called the the Polygon for the Measurement of the Orientation of Parts of the Body Relative to a Fixed External Axes"Journal Of Physiology 201 (1969): 70.


\textsuperscript{16} Miller, canadian journal of applied sport sciences (1978): 229-236.
nation of external forces but also a delineation of contributions of individual body segments in producing coordinated movement. Accuracy in the measurement of external forces between the ground and the foot has improved during the past decade due to advances in force platform equipment and methodology by Payne, Slater and Telford\textsuperscript{17}. Recent promising developments include a method of analyzing center of pressure location in conjunction with horizontal and vertical components of ground reaction and a technique of plotting vector diagram which represent the changing magnitude and direction of the ground reaction force. Analysis of the relative roles of the body segments in producing the ground reaction force, when combined with supporting electromyographic data, can provide the basis for estimating resultant muscle and moments and joint reaction forces. Miller\textsuperscript{18} has described the progress and some of the problems in this area of research and stated that the potential of this type of kinetic analysis for sport activities has hardly been tapped. While kinematic and kinetic analysis permit the explanation of the dynamics of human motion researchers often are interested in solving specific problems.


human mechanics such as determining how a given sport skill or movement can be improved. Several sophisticated methods have been developed to aid in solving such problems (modeling, computer simulation, optimization and other statistical approaches). Use of a computer is essential to the efficient implementation of these methods. Also specific data on body segment parameters are critical in this area of research, modeling, a topic reviewed recently by Miller\textsuperscript{19} permits a mathematical representation of the body to be modified so that the effect of changing a certain aspect of its structure or motion can be determined. Use of the model in the simulation of a motor skill can be paired with numerical or graphical output from the computer programme. Boyesen, Francis and Thomas\textsuperscript{20}. One approach to modeling is based on principles of optimization theory, the underlying assumption being that the performer follows an optimizing criterion in executing the movement Ayoub, Ayoub and Walvekar\textsuperscript{21}.

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\textsuperscript{19} ibid. \\
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The problem is then one of selecting an appropriate optimum strategy for the particular skill. Among the optimizing criteria that have been applied are: minimum energy, minimum time, and minimal tensile stress in ligaments. To identify the kinematic and anthropometric variables that were important to the successful performance of a skill, a statistical approach was employed and strongly recommended for multivariate statistical biomechanics by Zatziorsky.\(^{22}\)

As far as Biomechanics research is concerned, very few studies have been conducted on Judo, particularly on Judo throwing techniques. In India no bio-mechanical study has yet been conducted on Judo. Therefore, in India evaluation is mainly limited to the experience of the coach, which is based entirely on his observations. This limits only to the qualitative aspect of judgment and from which no quantification of any kind can be made. Moreover, bio-mechanics itself is a relatively new science. It is being used to study the sport movements.

Initial attempts to understand the mechanics of a sports skill usually involve a subjective evaluation of the performance by a trained observer. Seldom, however, does this type of qualitative analysis furnish sufficiently accurate information for research purposes. Top investigate the temporal,
kinematic and kinetic factors adequately, electronic and/or photo-instrumentation must be called into play. Such scientific approaches to the study of mechanical characteristics of human motion have gained wide acceptance and continue to provide much needed descriptive data.

Sports anthropometry has become fully integrated into sport science as an object-related subject during the past years. It describes the structure of the human body and its components, and thereby provides a data basis for approaches to the physical improvement of human beings and their athletic performances. Anthropometry deals quantitatively with those structural elements. These act as determinants of athletic performances. On the other hand, body forms and their phenotypes do not derive automatically from a genetic totality, but they must enjoy a logical functional relation. Functional analogues may then relate skeletal data either in terms of liver action that is length of extremities. Thus, the functional analogue of skeletal muscle expressed in force values that is power, maximal strength, strength, endurance is only one of the active elements. These can be determined by anthropometric methods and procedures dependent on the total mass that is force-load-correlation. An important part of the individual specification can best be illustrated

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by an appropriate metric determination of the body type. The wide-spread theoretical concept of describing physical aptitude for individual sports events by means of anthropometry based upon this view becomes progressively more difficult. The more complex the character of athletic performances, the better the results. It is obvious that the various features of body type possess the closest relations functionally to the physical capabilities of strength, speed and endurance. This can be substantiated most significantly by those sports events in which the distinctiveness of the required physical abilities are high. The question is therefore raised whether mere profound insights and understanding are blocked by looking for the athlete's single sports event only, even when the technology of measurement is continuously improved and computer programs or data processing equipments are more commonly used. There is little practical value in establishing a "Footballer-type", a "Swimmer", a "High-jumper" or a "100 m.-runner type". It seems more reasonable from the performance prognosis point of view. Reflections of this kind are more justified since the attempts to categories sports events according to the functional effects of body-type characteristics show that the various events may be combined in three large groups relating to their common features and respecting their differences: The first group comprises those sports events in which the movements are directed from the extremities towards the centre of gravity whether the mass to be
elerated is concentrated, the direction of force is a centripetal one. Second group comprises of those sports events in which the movement is directed from a probably earlier accelerated centre of gravity via the extremities towards an external resistance, for example apparatus or partner, the direction of force is a centrifugal one. The sports events of the third group should strictly speaking be included in groups 1 or 2. However, in these the elements of motor co-ordination or control (technique or intellectual postulates) tactics dominate. They can however be implemented only on the basis of an optimal effect of centripetally or centrifugally directed force that is quantity and quality of physical abilities. For each of the group cited further quite natural possibilities for differentiation arise which take into account particularities of athletic performances. Amongst others, the athlete’s attitude towards the apparatus and partner as well as the external condition under which the movement is made which include gravity, air-resistance, viscosity of water, the friction of ice and snow, etc. Thus at the level of actual athletic activity new anthropometric findings may be derived from practice-related research work itself. Sports anthropometric investigation should always start from the basis of the actual athletic movement and seek for functional representation in morphological values. It is impossible to cover the complex make-up of athletic performances with only one single body measurement. In this manner the role of sports-
anthropometry is changing and at the same time improving its practical efficiency.  

Jegaray, Levine and Carter after intensive study of anthropometric measurements of athletes concluded that the top level performance require a particular type of body size and shape, other aspects are being similar. They established a strong relationship between the structure of an athlete and specific task (event) in which he excelled and clear Physical prototype exist for optimal performance at the level of Olympic games. So emphasis should be given to find out the relationship between the anthropometric measures and the specific task (event) of an athlete for high level of performance.

The above discussion points out that an athlete (be in judo or karate) needs an aggregate of all the developed will qualities. Therefore, an all-round installment of such qualities must be the main part of an athlete's training. The coach tries to motivate the athletes by installment of these qualities.


There are numerous factors which are responsible for the
performance of a sportsman. The physique and body composition,
including the size shape and form which are known to play a
significant role in this regard. At present, sportsmen for
superior performance in any sport is selected on the basis of
physical structure and body size he possesses. This has proved to
be appropriate for high performance in the given
sports 27,28,29,30.

At the championship level, contributory factors in
performance, such as skill, opportunity, intelligence, motivation
and training may be assumed to be close to optimal for the
particular sport.

There is ample evidence to demonstrate that in some
sports, the Biomechanical demands are such that there are
specific prerequisites for physique.

27 H.S. Sodhi and L.S. Sidhu, Physique and Selection

28 J.M. Tanner, The Physique of the Olympic Athlete (London

29 V.S.S.M. Rao, "New Frontiers of Identifying Top Sportsmen"
Abstracts : International Congress of Sports Sciences, Patiala :

30 Encyclopedia of Sports Sciences and Medicine, S.
"Values" by William A.R. Orlan.
Size is often a prime selective factor. It is evident from mean values for selected size parameters of the participants in the 1968 Olympics in Mexico in relation to unisex reference human that there are often unique size characteristics associated with various events. It appears to be secular in trends when interpreting sports performance from biomechanics viewpoint. These may reflect in differing genetic pools of talent, charging technique and differing opportunity for participation. The athletes of the modern era are taller in those events in which height appears to have a Biomechanical advantage, (basket ball, rowings and weight throwing events). Also the sprint and middle distance runners since 1960 appear to be taller and heavier than their counterparts in 1928. This trend was not evident in those sports in which increased height has no Biomechanical advantage (gymnastics). In viewing any of the traditional height weight ratios, it is noted that following male modern competitors are "shorter" than their 1928 counterparts. Sprinters and 400m. runners, long jumpers, high jumpers, triple jumpers, discus throwers, shot putters, hammer throwers and throwers, except in 1972 had become "leaner" the trend to increasing stoutness appears to be continuing the decathlon and in all the throwing events. In both male and female swimmers, the trend is toward leaners. These changes in size have some
implication for sport biomechanics.

Judo is a body contact game where the structural measures of a Judoka play an important role in his performance. The main techniques in Judo are Throwing, Holding, Locking and Choking. A Judoka having the required anthropometric measurements such as length, girth and various proportions of the body parts compared to his opponent is supposed to have the better advantage in executing the above mentioned skills. While performing the sweeping and other major throwing techniques, the Judoka with a longer lower limbs can attain a better reach, range of movement, leverage etc. It is same in the case of a Judoka having long upper limbs and its proportions have better advantage in throwing holding, locking and choking. Similarly, the girth and lean body mass helps to have better control during the ground work over his opponent.

An athlete has a better technique when with the same Physical fitness achieves a better power output that is, strength, speed and endurance during physical exercise. Biomechanics of sport deals only with those parameters which are determined by the interaction of movement system with the control

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or supply systems, that is physical fitness and technique 32.

There are countless judo techniques but they can be roughly divided into three categories: Nage Waza (throwing techniques) Katame Waza (grappling techniques) and Atemi Waza (striking techniques). Only throwing techniques and grappling techniques are allowed in judo competitions, striking techniques are handy for self-defense.

It has been evidenced from all Japan high school contest statistics since 1952 to 1969, the throwing techniques applied 45.4 percent and grappling techniques applied 16.2 percent for the victory. Among the throwing techniques application of inner thigh throw 20 percent, shoulder throw 12 percent, Major outer reaping 12 percent. Hip sweep 5.6 percent. Hip spring throw 7.4 percent were superior pet techniques than any other throwing techniques 33.

Matsumoto, Takeuchi and Nakamura in their analytical studies on the contests performed at the all Japan Judo Championship 1970 and 1971 reported that seoi nage was applied 38


times out of 535 times i.e. 71 percent and 31 times out of 634 times i.e. 3.6 percent in the year 1970 and 1971 respectively which was quite low than Uchimata, Osotogar Ouchigari, Kouchiqari and Taiotoshi respectively.\textsuperscript{34}

35 Ogata and his associates surveyed the fact of juvenile judo for two years from 1979 to 1980. The contents of questionnaires were classified roughly into 5 items: (1) Concerning the trainers; (2) Concerning the instructions; (3) Concerning the instruction plans; (4) Concerning the contents of construction; (5) Concerning the facilities. It was found that seoi nage having the highest frequency of instructions and practice as well as, top priority in the order of instruction among all the considered techniques in the study.


According to IJF contest rules the throw in Judo must be effected with control largely on the back, with considerable force and speed for scoring full point.

The coaches can no more afford to waste their time with athletes who fail to exceed when faced with tough competitive situations. Realizing the importance of Seoi-nage in Judo performance and practice, which is greatly dependent upon specific biomechanics in relation to anthropometry and motor fitness, whereas the research scholar has never came across to an appropriate cumulative study on the same and at the same time feasible criteria for evaluating techniques in Judo is not available, motivated the research scholar to undertake biomechanical study relating to Anthropometry and motor fitness on two variations of shoulder throw, they are one arm shoulder throw and both arm shoulder throw on the basis of selected kinetic and kinematic parameters related to effectiveness in throwing by developing suitable and feasible criteria for evaluation as well as to find out the contributing biomechanical Anthropometric and motor fitness factors for effective execution of different variations of Seoi-Nage.

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**Statement of the Problem**

The purpose of this study were

(i) To develop suitable and feasible criteria for evaluating different variations of Seoi Nage.

(ii) To find out the contributing biomechanical, anthropometric, flexibility and motor fitness factors for effective execution of different variations of Seoi Nage.

**Delimitations**

The research scholar has delimited his study to the following:

(i) Criteria has been developed only for Ippon Seoi Nage (ISN) and Morote Seoi Nage (MSN) separately.

(ii) In this study the researcher has used cinematography for the collection of the following Kinematic Variables.

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<tr>
<th>S.NO.</th>
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<td>..</td>
<td>Angle of inclination from horizontal (H) of the joining right</td>
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shoulder (rt.sh) centre of foot (CF) when knee flexed (KF).

2. Angle of inclination from H of the line joining left shoulder (lt.sh) and CF when KF.

3. Angle of inclination from H of the line joining right hip (rt.hip) and CF when KF.

4. Angle of inclination from H of the line joining left hip (lt.hip) and CF when KF.

5. Angle of inclination from H of the line joining right knee (rt.knee) and CF when KF.

6. Angle of inclination from H of the line joining left knee (lt.knee) and CF when KF.

7. Angle of inclination from H of the line joining right ankle (rt.ank) and CF when KF.

8. Angle of inclination from H of the line joining left ankle (lt.ank) and CF when KF.

9. Angle of inclination from H of the line joining right centre of gravity (C.G) and CF when KF.

10. Angle of inclination from H of the line joining lt.C.G and CF when KF.

11. Angle of inclination from H of the line joining rt.sh and CF when knee extended (KE).

12. Angle of inclination from H of the line joining lt.sh and CF when KE.

13. Angle of inclination from H of the line joining rt.hip and CF when KE.
14. Angle of inclination from H of the line joining lt. hip and CF when KE. i14

15. Angle of inclination from H of the line joining rt. knee and CF when KF. i15

16. Angle of inclination from H of the line joining lt. knee and CF when KE. i16

17. Angle of inclination from H of the line joining rt. ankle and CF when KE. i17

18. Angle of inclination from H of the line joining lt. ankle and CF when KE. i18

19. Angle of inclination from H of the line joining rt. C.S and CF when KE. i19

20. Angle of inclination from H of the line joining lt. C.S and CF when KE. i20

21. Angle of inclination from H of the line joining rt. sh and CF when hip flexed (HF). i21

22. Angle of inclination from H of the line joining lt. sh and CF when HF. i22

23. Angle of inclination from H of the line joining rt. hip and CF when HF. i23

24. Angle of inclination from H of the line joining lt. hip and CF when HF. i24

25. Angle of inclination from H of the line joining rt. knee & CF when HF. i25

26. Angle of inclination from H of the line joining lt. knee & CF when HF. i26

27. Angle of inclination from H of the line joining rt. ankle & CF when HF. i27

28. Angle of inclination from H of the line joining lt. ankle & CF when HF. i28

29. Angle of inclination from H of the line joining rt. C.S & CF when HF. i29

30. Angle of inclination from H of the line joining lt. C.S & CF when HF. i30
31. Difference in the angle of inclinations (DAI) between knee flex & ext positions (KFE) at rt.sh

32. DAI between KFE at lt.sh

33. DAI between KFE at rt.hip

34. DAI between KFE at lt.hip

35. DAI between KFE at rt.knee

36. DAI between KFE at lt.knee

37. DAI between KFE at rt.ankle

38. DAI between KFE at lt.ankle

39. DAI between KFE at rt.C.G

40. AD between KFE at lt.C.G

41. Difference in the angle of inclination (DAI) between knee ext & hip fl. positions (KEHF) rt.sh

42. DAI between KEHF at lt.sh

43. DAI between KEHF at rt.hip

44. DAI between KEHF at lt.hip

45. DAI between KEHF at rt.knee

46. DAI between KEHF at lt.knee

47. DAI between KEHF at rt.ankle

48. DAI between KEHF at lt.ankle

49. DAI between KEHF at rt.C.G

50. DAI between KEHF at lt.C.G

51. Angle at ankle joint when knee flexed between rt.shin and horizontal (H) a1

52. Angle (A) at ankle joint when knee fl. (KF) between lt.shin and H a2

53. Angle at ankle joint when KF between rt.foot and H a3
<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Page</th>
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<tbody>
<tr>
<td>54.</td>
<td>Angle at ankle joint when KF between lt. foot and H</td>
<td>a4</td>
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<td>55.</td>
<td>Angle at rt. ankle total when KF</td>
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<td>Angle at lt. ankle total when KF</td>
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<td>57.</td>
<td>Angle at knee joint when KF between rt. lower leg and H</td>
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<td>58.</td>
<td>Angle at knee joint when KF between lt. lower leg and H</td>
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<td>59.</td>
<td>Angle at knee joint when KF between rt. thigh and H</td>
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<td>60.</td>
<td>Angle at knee joint when KF between lt. thigh and H</td>
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<td>Angle at rt. total knee when KF</td>
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<td>62.</td>
<td>Angle at lt. total knee when KF</td>
<td>a12</td>
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<td>63.</td>
<td>Angle at hip joint (HJ) when KF between rt. thigh and H</td>
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<td>64.</td>
<td>Angle at HJ when KF between lt. thigh and H</td>
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<td>65.</td>
<td>Angle at HJ when KF between rt. sh and H</td>
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<td>Angle at HJ when KF between lt. sh and H</td>
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<td>67.</td>
<td>Angle at rt. HJ total when KF</td>
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<td>68.</td>
<td>Angle at lt. HJ total when KF</td>
<td>a18</td>
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<td>69.</td>
<td>Angle at ankle joint (AJ) when leg ext. (LE) between rt. shin and H</td>
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<td>70.</td>
<td>Angle at AJ when LE between lt. shin and H</td>
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<td>Angle at AJ when LE between rt. foot and H</td>
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<td>72.</td>
<td>Angle at AJ when LE between lt. foot and H</td>
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<td>73.</td>
<td>Angle at rt. AJ total when LE</td>
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<td>74.</td>
<td>Angle at lt. AJ total when LE</td>
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<td>75.</td>
<td>Angle at knee joint (KJ) when LE between rt. lower leg and H</td>
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<td>76.</td>
<td>Angle at KJ when LE between lt. lower leg and H</td>
<td>a26</td>
</tr>
<tr>
<td>77.</td>
<td>Angle at KJ when LE between rt. thigh and H</td>
<td>a27</td>
</tr>
<tr>
<td>78.</td>
<td>Angle at KJ when LE between lt. thigh and H</td>
<td>a28</td>
</tr>
</tbody>
</table>
79. Angle at rt. KJ total when LE  
80. Angle at lt. KJ total when LE  
81. Angle at hip joint (HJ) when LE between rt. thigh and H  
82. Angle at HJ when LE between lt. thigh and H  
83. Angle at HJ when LE between rt. sh and H  
84. Angle at HJ when LE between lt. sh and H  
85. Angle at rt. HJ total when LE  
86. Angle at lt. HJ total when LE  
87. Angle at ankle joint when hip flexed (HF) between rt. shin and H  
88. Angle at AJ when HF between lt. shin and H  
89. Angle at AJ when HF between rt. foot and H  
90. Angle at AJ when HF between lt. foot and H  
91. Angle at rt. AJ total when HF  
92. Angle at lt. AJ total when HF  
93. Angle at knee joint when HF between rt. lower leg and H  
94. Angle at KJ when HF between lt. lower leg and H  
95. Angle at KJ when HF between rt. thigh and H  
96. Angle at KJ when HF between lt. thigh and H  
97. Angle at rt. KJ total when HF  
98. Angle at lt. KJ total when HF  
99. Angle at hip joint when HF between rt. thigh and H  
100. Angle at HJ when HF between lt. thigh and H  
101. Angle at HJ when HF between rt. sh and H  
102. Angle at HJ when HF between lt. sh and H  
103. Angle at rt. HJ total when HF
104. Angle at lt. HJ total when HF
105. Angle at AJ formed by rt. shin differences between KFE position
106. Angle at AJ formed by lt. shin differences between KFE position
107. Angle at AJ formed by rt. foot differences between KFE position
108. Angle at AJ formed by lt. foot differences between KFE position
109. Angle at rt. AJ total differences between KFE position
110. Angle at lt. AJ total differences between KFE position
111. Angle at KJ formed by rt. lower leg differences between KFE position
112. Angle at KJ formed by lt. lower leg differences between KFE position
113. Angle at KJ formed by rt. thigh differences between KFE position
114. Angle at KJ formed by lt. thigh differences between KFE position
115. Angle at rt. KJ total differences between KFE position
116. Angle at lt. KJ total differences between KFE position
117. Angle at hip joint formed by rt. thigh differences between KFE position
118. Angle at HJ formed by lt. thigh differences between KFE position
119. Angle at HJ formed by rt. shi differences between KFE position
120. Angle at HJ formed by lt. shi differences between KFE position
121. Angle at rt. HJ total differences between KFE position
122. Angle at lt. HJ total differences between KFE position
123. Angle at AJ formed by rt. shin differences between KEHF position
124. Angle at AJ formed by lt. shin differences between KEHF position
125. Angle at AJ formed by rt. foot differences between KEHF position
126. Angle at AJ formed by lt. foot differences between KEHF position
127. Angle at rt. AJ total differences between KEHF position
128. Angle at lt. AJ total differences between KEHF position
129. Angle at KJ formed by rt. lower leg differences between KEHF position
130. Angle at KJ formed by lt. lower leg differences between KEHF position
131. Angle at KJ formed by rt. thigh differences between KEHF position
132. Angle at KJ formed by lt. thigh differences between KEHF position
133. Angle at rt. KJ total differences between KEHF position
134. Angle at lt. KJ total differences between KEHF position
135. Angle at HJ formed by rt. thigh differences between KEHF position
136. Angle at HJ formed by lt. thigh differences between KEHF position
137. Angle at HJ formed by rt. shin differences between KEHF position
138. Angle at HJ formed by lt. shin differences between KEHF position
139. Angle at rt. HJ total differences between KEHF position
140. Angle at lt. HJ total differences between KEHF position
141. Angular velocity (AV) at AJ formed by rt. shin when knee extended completely from knee fl. (KEKF)
142. AV at AJ formed by lt. shin when KEKF
143. AV at AJ formed by rt. foot when KEKF
144. AV at AJ formed by lt. foot when KEKF
145. AV at rt. AJ total when KEKF
146. AV at lt. AJ total when KEKF
147. AV at KJ formed by rt. leg when KEKF
148. AV at KJ formed by lt. leg when KEKF
149. AV at KJ formed by rt. thigh when KEKF
150. AV at KJ formed by lt. thigh when KEKF
151. AV at rt. KJ total when KEKF
152. AV at lt. KJ total when KEKF
153. AV at HJ formed by rt. thigh when KEKF
154. AV at HJ formed by lt. thigh when KEKF
155. AV at HJ formed by rt. sh when KEKF
156. AV at HJ formed by lt. sh when KEKF
157. AV at rt. HJ total when KEKF
158. AV at lt. HJ total when KEKF
159. Angular velocity at ankle joint formed by rt. shin when hip flexed after knee ext. completely (HFK E)
160. AV at AJ formed by lt. shin when HFK E
161. AV at AJ formed by rt. foot when HFK E
162. AV at AJ formed by lt. foot when HFK E
163. AV at rt. AJ total when HFK E
164. AV at lt. AJ total when HFK E
165. AV at knee joint formed by rt. lower leg when HFK E
166. AV at KJ formed by lt. lower leg when HFK E
167. AV at KJ formed by rt. thigh when HFK E
168. AV at KJ formed by lt. thigh when HFK E
169. AV at rt. KJ total when HFK E
170. AV at lt. KJ total when HFK E
171. AV at hip joint formed by rt. thigh when HFK E
172. AV at HJ formed by lt. thigh when HFK E
173. AV at HJ formed by rt. sh when HFK E
174. AV at HJ formed by lt. sh when HFK E
175. AV at rt. HJ total when HFK E
176. AV at lt. HJ total when HFK E
177. Total time taken to execute the throw (TT)  
178. Execution time that is time of main phase (ET)  
179. Time of freely falling body from highest Y Coordinate (TFF)  
180. Ratio of ET and TFF  
181. Resultant velocity of freely falling body (RVFF)  
182. Time of knee fl. from start of throwing (TKNFL)  
183. TKNFL to Foot detachment of receiver (FD)  
184. TKNFL to Leg ext.  
185. TKNFL to Belt in vertical line of receiver (BVL)  
186. Time of FD to Leg ext.  
187. Time of FD to BVL  
188. Time of Leg ext. to BVL  
189. Displacement (Dis) of thrower (TH) at X coordinate  
190. Displacement of thrower at Y coordinate  
191. Displacement resultant of thrower  
192. Dis of receiver (RE) at X coordinate  
193. Dis of RE at Y coordinate  
194. Dis resultant of RE  
195. Final velocity of RE when contacts the mat (FVR)  
196. Final acceleration of RE when contacts the mat (FAR)  
197. Final force of contact of RE when contacts the mat (FFCR)  

(iii) The present study was delimited to the following anthropometric variables.
1. Total body weight. (kg) (AN1)
2. Stature (cm) (AN2)
3. Acromion height (cm) (AN3)
4. Sitting height (cm) (AN4)
5. Trunk length (cm) (AN5)
6. Upper arm length (cm) (AN6)
7. Fore arm length (cm) (AN7)
8. Sum of upper and fore arm length (cm) (AN8)
9. Trochanterion-Tibiae externum length (Thigh length) (AN9)
10. Lower leg length (cm) (AN10)
11. Sum of Thigh and lower leg length. (cm) (AN11)
12. Foot length (cm) (AN12)
13. Biacromial diameter (cm) (AN13)
14. Crural index (cm) (AN14)
15. Trunk leg length ratio (cm) (AN15)
16. Upper fore arm length ratio (cm) (AN16)
17. Ponderal index. (AN17)

(iv) The present study was delimited to the following flexibility and motor performance variables

1. Right grip strength (Isometric) in kg. (P1)
2. Left grip strength (Isometric) in kg. (P2)
3. Leg extension strength (isometric) in kg. (P3)
4. Back extension strength (isometric) in kg. (P4)
1. Bench press for maximum strength of arm extension (Isotonic) in kg. (P5)

6. Dips test for maximum arm and shoulder strength in kg (P6)
7. Sit up for abdomen (Isotonic max. strength) in kg. (P7)
8. Bench squat for legs and back isotonic max. strength in kg. (P8)
9. Vertical Arm Pull (Explosive strength) for upper extremity in cm. (P9)
10. Vertical jump (Explosive strength) for lower extremity in cm. (P10)
11. Reaction and speed of movement (cm) (P11)
12. Planter flexion in degree. (P12)
13. Dorsi flexion in degree. (P13)
14. Knee flexion in degree. (P14)
15. Wrist flexion in degree. (P15)
16. Wrist extension in degree. (P16)
17. Elbow flexion in degree. (P17)
18. Shoulder flexibility in cm. (P18)
19. Sit and reach Test (hip-Back flexion and hamstring extension) in cm. (P19)
20. Trunk and Neck extension in cm. (P20)
21. Right grip strength per kg. body weight. (P21)
22. Left grip strength per kg body weight. (P22)
23. Leg. extension strength per kg. body weight. (P23)

**Limitations**

(i) The researcher has used two dimensional cinematography method, but Judo movement takes place in three dimensions and is recognized as a limitation to the study.

(ii) In this study force of impact has been calculated by adopting indirect method because it requires bigger size force platform and is recognized as a limitation to the study.

(iii) For a better bio-mechanical analysis, to predict muscle action electromyography is needed but EMG has not been used. Hence it is recognized as a limitation to the study.

**Hypothesis**

Based on expert opinion and scholar's own understanding, it was hypothesized that one arm shoulder throw and both arm shoulder throw are influenced by certain biomechanical, anthropometric, flexibility and motor fitness variables.
Definition and Explanation of the Terms

Cine-Analysis

The term 'cine-analysis' implies that detailed examination of a film record is undertaken, generally to a stage beyond mere slow motion viewing. Proper Cine analysis begins when measurements or drawings of body motions are taken from the film. It may be sufficient for some purposes to plot these data directly in graphical form. Often, however, it is useful to put the measured data through a computational process to provide a more detailed analysis of the motion.\(^{37}\)

The term 'cine-analysis' refers to the whole process of taking film of the data and carrying out the necessary calculations.\(^{38}\)

Kinematics and Kinetic

**Kinematics** is that branch of bio-mechanics i.e., concerned with describing the motion of bodies. Thus Kinematics deals with such things as how far a body moves, and how consistently it moves. It

\(^{37}\) Grieve, *Techniques for the Analysis of Human Movement*, p. 3.
is not concerned at all with what causes a body to move in the way it does. This latter aspect of motion is preserve of Kinetics\textsuperscript{39}.

**Force**

Force is described as an external agency (i.e., push or pull) which produces or tends to produce motion or else destroys or tends to destroy motion in a body\textsuperscript{40}.

**Centre of Gravity**

The centre of gravity of any object that point at which all the weight of an object may be considered to be concentrated\textsuperscript{41}.

**Velocity**

Speed and velocity are commonly given the same meaning. In physics, speed and velocity have definite, separate meanings. The speed of an object indicates how fast it is moving, that is,


\textsuperscript{40} Harnam Singh et.al., *A Text Book of Physics* (Delhi: Frank Bros & Co., 1972), p.60

the distance the object will travel in a given time. It tells us nothing, however, the direction in which the object is moving.

Velocity may be defined as the rate of displacement, that is, the rate of motion in a particular direction.

**Acceleration**

The rate of change of velocity is called acceleration.

**Motor Fitness**

Ability to perform fundamental motor skills, involving physical fitness traits and other basic traits such as power, agility, speed and balance.

Clarke included following basic performance traits such as muscular power, agility, muscular strength, muscular endurance, circulo endurance, flexibility and speed.

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43 Ibid., p. 72


Anthropometric Measurements

Anthropometric measurements are dimensions of the structure of the human body taken at specific sites to give measures of length, girth and width.\textsuperscript{46}

Judo and Jujitsu

Judo means "the gentle way" and Jujitsu means "the gentle technique".\textsuperscript{47}

Significance of the study

In view of tremendous progress being brought about in the fields of games and sports, it has become essential to develop objective criteria for qualifying the techniques of sports person in order to determine the effectiveness of training programme. In addition to systematic training the physique of the sports person also plays a vital role in attaining high performances in games and sports. All factors i.e. physical fitness, techniques tactics


\textsuperscript{47} Interscholastic Committee of United State Judo Federation "Judo for High School, p.6."
and psychological preparation being equal, a sporteperson with better physique characteristics suited to a sports will excel.

The training programmes of sports person are to be so arranged that an individual is able to develop all the important factors of performance. To determine the effect of training models in the forms of indices are to be developed based on biomechanical, physical, physiological and psychological characteristics of sports person. These model then will serve as effective means for evaluating the performance of sports person.

The present study will be of immense benefit the coaches and the physical education teachers in the following ways.

(1) The findings of this study will help to form the basis of efficient structure of the shoulder throw for the competitive Judo performance.

(2) This study will help in effective organization of judo profession in terms of the process of development of required motor qualities.

(3) Many teachers and coaches attempt to correct the effect that they have detected and give little or no thought to the underlying causes. The scientific and sound logical basis
upon which the various techniques in seoi nage to connect observed effects with their underlying causes. The knowledge of the scientific basis of seoi nage will equip teachers and coaches to make sound judgments. Hence, the findings of this study will help in diagnostic teaching and coaching.

(4) As the learner progresses or gets older and more generally experienced, verbal directions and an analysis of movement can help more in increasing the meaning fullness of the skill and in giving new insights into it. Hence, the findings of this study will help not only the athletes themselves but coaches as well for self-evaluation and better understanding in the practice and learning process of seoi nage.

(5) The findings of this study will help in the selection of players in relation to the variation of shoulder throw and vice-versa in terms of athletes (Judoka) different anthropometric and motor fitness qualities by finding out the contributing biomechanical, anthropometric and motor fitness variables to different variations of shoulder throw.

(6) This study will provide suitable and feasible criteria or instrument for evaluating the one arm shoulder throw and both arm shoulder throw, which can be used in the field itself by the coaches without any sophisticated or costly equipment. Such feasible instrument will assist the physical
education teachers, researchers and coaches for evaluation of
training, camps and selection purposes.

(7) Statistical biomechanics is a special area of
biomechanical research. The use of multivariate statistics are
not common in biomechanical study. Thus the approach and model of
this study itself will be a primary resource to other
biomechanical researcher to take up such type of study in related
sports. The consideration of related motor and anthropometric
variables along with biomechanical criteria is a cumulative
approach, which will signify between the functional and potential
aspects of judoka in relation to ippon seoi nage and morote seoi
Nage.