**Correlation of High Jump Performance and Selected Angular Kinematical Variables at Final Take-off of Fosbury-Flop** **Technique**

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**Abstract**

The Purpose of the study was to find Correlation between Dependent Variable (High Jump Performance) and Independent Variables (Selected Angular Kinematical Variables at Final Take-off of Fosbury-Flop Technique. **Selection of Subjects:** Universe of the Study: The study was confined to India only. Sampling Frame: Subjects were selected as a sampling frame from India only and their age was ranging from 16 to 28 years. Sampling Methods: Subjects were selected on the basis of purposively random sampling method. Sampling Size: A total of 8 male professional High Jumpers (who had been participating regularly and who have attained the performance level of 1.95 meters) from India were selected for the study. **Selection of Variables: Anthropometrical Variables:** Age, Height, Weight, Hand Length, Fore Arm Length, Upper Arm Length, Fore Leg Length, Upper Leg Length and Foot Length. **Angular Kinematical Variables:**  Ankle Joint (Angle of left & Right ankle joint), Knee joint (Angle of left & Right knee joint), Hip joint (Angle of left & Right hip joint), Shoulder joint (Angle of left & Right shoulder joint), Elbow joint (Angle of left & Right elbow joint), Wrist joint (Angle of left & Right wrist joint), Angle of trunk inclination and Angle of Head Inclination. **Criterion Measures:** Age of subject was measured by Chronological Age in year, Height of the subject was measured by Anthropometric Rod in meter, Weight of the subject was measured by Lever Balance/Weighing Machine in kilogram, Height of bar/highest performance of the subject was measured by Non Stretchable Tape in meter and Angle of angular kinematical variables of different phases of take-off skill in Fosbury-flop technique was measured by Max Traq 2D / Silicon Coach Pro-7 Motion Analysis Software in degree. Max Traq 2D / Silicon coach pro-7 motion analysis software was use for Kinematical analysis of take-off in Fosbury-flop techniques. The centre of gravity of the subject at the time of different phases of take-off skill in fosbury- flop technique by segmentation method as suggested by Games G. Hay was recorded. **Statistical Technique:** To Kinematical analyze of Fosbury-flop technique in high jump and to determine the key components of Fosbury-flop technique, descriptive statistic was used. To find out correlation between dependent variable (high jump performance) and independent variables (selected angular kinematical variables) at Final Take-off of Fosbury-flop technique in high jump, Pearson correlation was used. The level of significance was set at 0.05. **Conclusions:**

Finally, mean, standard deviation, scores of angular kinematics variables in degree at Final Take-off in Fosbury-flop Technique have been found as follow: Left Ankle Angle (132.87 ±7.64), Right Knee Angle (92.368 ± 13.30), Left Knee Angle (162.88 ± 5.91), Right Knee Angle (62.88 ± 9.28), Left Hip Angle (167.62 ± 10.21), Right Hip Angle (99.63 ± 11.27), Left Shoulder Angle (104.00 ± 13.31), Right Shoulder Angle (83.38 ± 10.76), Left Elbow Angle (110.38 ± 27.58), Right Elbow Angle (77.75 ± 9.60), Left Wrist Angle (200.88 ± 51.44), Right Wrist Angle (185.00 ± 5.04), Trunk Inclination Angle (21.13 ± 6.53), Head Inclination Angle (27.75 ± 8.00) respectively. Significant correlation was found between Right Elbow Angle (degree) at final Take-off of Fosbury-flop technique with High Jump Performance of subjects in case of angular kinematic variables.

Key Words: **Kinematical Analysis, Fosbury-Flop** **Technique**

**INTRODUCATION**

When a coach is confronted with the problem of detecting and correcting the faults, it is not difficult for an experienced eye to find the faults in the movement performed by the athlete but the most difficult aspect is to locate the cause of the fault. In such a situation, a coach may try to correct the effect (fault), may be without being able to discover the underlying cause. Such a corrective approach may lead to further deterioration of an athlete’s performance. It is very difficult to analyze and evaluate the dynamic aspects of human movement precisely by the naked eye observation alone. In these days of automation, the coach has to go beyond the stage of subjective analysis. It is here that procedures of biomechanics come to the help of the coach to evaluate various motor actions. With the application of biomechanical procedures, we can discover whether the existing technique fulfils the theoretical requirements of mechanics. Furthermore, a new approach to technical problem may emerge or a new technique is conceptualized which fulfils the requirement of mechanics, which may be simpler to learn, simpler to execute and may result in a better performance than that of the existing technique.

The laws governing motion indicate that motion is modified by a number of external environmental forces. Whether these forces are of help or these are hindrances, depends upon the prevailing conditions and the nature of motion. The problem in sports is to learn how to take maximum advantage of these external environmental forces under prevailing condition.

Ultimately, there emerged one term that gained much wider acceptance than any other. That term was biomechanics. The term biomechanics has been variously defined as:

“The mechanical bases of biological, especially muscular activity and the study of the principles and relations involved.”

**Objectives of the Study:**

1. First objective of the study was to Kinematical analyze the Fosbury-flop technique.

2. The objective of the study was to find out the correlation between dependent variable (high jump performance) and independent variables (selected angular kinematical variables) at Final Take-off of Fosbury-flop technique.

**RESEARCH METHODOLOGY**

**Coverage/ Selection of Subjects**

* + - 1. Universe of the Study: The study was confined to India only.
      2. Sampling Frame: Subjects were selected as a sampling frame from India only and their age was ranging from 16 to 28 years.
      3. Sampling Methods: Subjects were selected on the basis of purposively random sampling method.
      4. Sampling Size: A total of 8 male professional High Jumpers (who had been participating regularly and who have attained the performance level of 1.95 meters) from India were selected for the study.

**Selection of Variables / Units of Observation**

The followingAnthropometrical and kinematic(Linear) variables were selected for the purpose of this study:-**Anthropometrical Variables:** Age, Height, Weight, Hand Length, Fore Arm Length, Upper Arm Length, Fore Leg Length, Upper Leg Length and Foot Length. **Angular Kinematical Variables:**  Ankle Joint (Angle of left & Right ankle joint), Knee joint (Angle of left & Right knee joint), Hip joint (Angle of left & Right hip joint), Shoulder joint (Angle of left & Right shoulder joint), Elbow joint (Angle of left & Right elbow joint), Wrist joint (Angle of left & Right wrist joint), Angle of trunk inclination and Angle of Head Inclination.

**Criterion Measures**

Criterion Measures adopted for the study were as follows:Age of subject was measured by Chronological Age in year, Height of the subject was measured by Anthropometric Rod in meter, Weight of the subject was measured by Lever Balance/Weighing Machine in kilogram, Height of bar/highest performance of the subject was measured by Non Stretchable Tape in meter and Angle of angular kinematical variables of different phases of take-off skill in Fosbury-flop technique was measured by Max Traq 2D / Silicon Coach Pro-7 Motion Analysis Software in degree.

Max Traq 2D / Silicon coach pro-7 motion analysis software was use for Kinematical analysis of take-off in Fosbury-flop techniques. The centre of gravity of the subject at the time of different phases of take-off skill in fosbury- flop technique by segmentation method as suggested by Games G. Hay was recorded.

**Statistical Technique**

The following statistical technique was employed: To Kinematical analyze of Fosbury-flop technique in high jump and to determine the key components of Fosbury-flop technique, descriptive statistic was used. To find out correlation between dependent variable (high jump performance) and independent variables (selected angular kinematical variables) at Final Take-off of Fosbury-flop technique in high jump, Pearson correlation was used. The level of significance was set at 0.05. The data was analyzed by applying SPSS19-Version.

**RESULT AND DISCUSSION**

Descriptive statistics was computed to determine and analyze the angular kinematical variables at different phases of take-off of Fosbury-flop technique in high jump and result pertaining to same has been presented in table no – 1.

**Table-1: Descriptive Statistics of Male High Jumpers in Relation to Angular Kinematical Variables at Final Take-off in Fosbury-flop Technique**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variable** | **Mean** | **Std.**  **Deviation** | **Std.**  **Error** | **Range** | **Min.** | **Max.** | **Sum** |
| **Left Ankle Angle in degree** | 132.87 | 7.64 | 2.70 | 21 | 123 | 144 | 1063 |
| **Right Ankle Angle in degree** | 92.368 | 13.30 | 4.70 | 35 | 77 | 113 | 739 |
| **Left Knee Angle in degree** | 162.88 | 5.91 | 2.09 | 20 | 154 | 174 | 1303 |
| **Right Knee Angle in degree** | 62.88 | 9.28 | 3.28 | 25 | 52 | 77 | 503 |
| **Left Hip Angle in degree** | 167.62 | 10.21 | 3.61 | 31 | 154 | 185 | 1341 |
| **Right Hip Angle in degree** | 99.63 | 11.27 | 3.99 | 30 | 87 | 117 | 797 |
| **Left Shoulder Angle in degree** | 104.00 | 13.31 | 4.71 | 45 | 77 | 122 | 832 |
| **Right Shoulder Angle in degree** | 83.38 | 10.76 | 3.80 | 28 | 68 | 96 | 667 |
| **Left Elbow Angle in degree** | 110.38 | 27.58 | 9.75 | 68 | 83 | 151 | 883 |
| **Right Elbow Angle in degree** | 77.75 | 9.60 | 3.40 | 28 | 62 | 90 | 622 |
| **Left Wrist Angle in degree** | 200.88 | 51.44 | 18.19 | 155 | 120 | 275 | 1607 |
| **Right Wrist Angle in degree** | 185.00 | 5.04 | 1.78 | 13 | 180 | 193 | 1480 |
| **Trunk Inclination in degree** | 21.13 | 6.53 | 2.31 | 20 | 9 | 29 | 169 |
| **Head Inclination in degree** | 27.75 | 8.00 | 2.83 | 27 | 11 | 38 | 222 |

It is evident from table - 1 that mean, standard deviation, scores of angular kinematics variables in degree at Final Take-off in Fosbury-flop Technique have been found as follow: Left Ankle Angle (132.87 ±7.64), Right Knee Angle (92.368 ± 13.30), Left Knee Angle (162.88 ± 5.91), Right Knee Angle (62.88 ± 9.28), Left Hip Angle (167.62 ± 10.21), Right Hip Angle (99.63 ± 11.27), Left Shoulder Angle (104.00 ± 13.31), Right Shoulder Angle (83.38 ± 10.76), Left Elbow Angle (110.38 ± 27.58), Right Elbow Angle (77.75 ± 9.60), Left Wrist Angle (200.88 ± 51.44), Right Wrist Angle (185.00 ± 5.04), Trunk Inclination Angle (21.13 ± 6.53), Head Inclination Angle (27.75 ± 8.00) respectively whereas standard Error and Range of scores was found as follow: Left Ankle Angle (2.70 & 21), Right Ankle Angle

(4.70 & 35), Left Knee Angle (2.09 & 20), Right Knee Angle (3.28 & 25), Left Hip Angle (3.61 & 31), Right Hip Angle (3.99 & 30), Left Shoulder Angle (4.71 & 45), Right Shoulder Angle (3.80 & 28), Left Elbow Angle (9.75 & 68), Right Elbow Angle (3.40 & 28), Left Wrist Angle (18.19 & 155), Right Wrist Angle (1.78 & 13), Trunk Inclination Angle (2.31 & 20) and Head Inclination Angle (2.83 & 27) respectively.

To determine the relationship of angular kinematical variables with the performance of high jump at different phases of take-off in Fosbury-flop technique. The data collected was analyzed by using the correlation (Pearson Correlation) and result pertaining to that has been presented in table - 2.

**Table-2: Relationship of Angular Kinematical Variables with the High Jump Performance at Different Phases of Take-off in Fosbury flop Technique**

|  |  |  |
| --- | --- | --- |
| **Correlation Coefficient (r)** | | |
|  |  | **Final Take-off** |
| **Angular Kinematical Variables** | **Left Ankle Angle (degree)** |  |  | .127 |
| **Right Ankle Angle (degree)** |  |  | .240 |
| **Left Knee Angle (degree)** |  |  | .496 |
| **Right Knee Angle (degree)** |  |  | .125 |
| **Left Hip Angle (degree)** |  |  | .359 |
| **Right Hip Angle (degree)** |  |  | .280 |
| **Left Shoulder Angle (degree)** |  |  | -.029 |
| **Right Shoulder Angle (degree)** |  |  | .043 |
| **Left Elbow Angle (degree)** |  |  | -.416 |
| **Right Elbow Angle (degree)** |  |  | .730\* |
| **Left Wrist Angle (degree)** |  |  | .317 |
| **Right Wrist Angle (degree)** |  |  | .403 |
| **Trunk Inclination Angle (degree)** |  |  | -.226 |
| **Head Inclination Angle (degree)** |  |  | .075 |

**\*significant at 0.05 level**

**Coefficient of correlation required to be significant at 6 degree of freedom (.707)**

Further, Table -2 reveals that in case of Right Elbow Angle (degree) at final Take-off of Fosbury-flop technique obtained value (.730) is greater than tabulated value of (.707) therefore it has shown significant relationship of this independent variables with High Jump Performance of subjects. But In case of Left Ankle Angle (degree), Right Ankle Angle (degree), Left Knee Angle (degree), Right Knee Angle (degree), Left Hip Angle (degree), Right Hip Angle (degree), Left Shoulder Angle (degree), Right Shoulder Angle (degree), Left Elbow Angle (degree), Left Wrist Angle (degree), Right Wrist Angle (degree), Trunk Inclination Angle (degree)and Head Inclination Angle (degree) at final Take-off of Fosbury-flop technique obtained value are lower than tabulated values of (.707) therefore it has shown insignificant relationship of these independent variables with High Jump Performance of subjects.

**Discussion of finding**

The results of the study shows that mean, standard deviation, scores of angular kinematics variables in degree at Final Take-off in Fosbury-flop Technique have been found as follow: Left Ankle Angle (132.87 ±7.64), Right Knee Angle (92.37 ± 13.30), Left Knee Angle (162.88 ± 5.91), Right

Knee Angle (62.88 ± 9.28), Left Hip Angle (167.62 ± 10.21), Right Hip Angle (99.63 ± 11.27), Left Shoulder Angle (104.00 ± 13.31), Right Shoulder Angle (83.38 ± 10.76), Left Elbow Angle (110.38 ± 27.58), Right Elbow Angle (77.75 ± 9.60), Left Wrist Angle (200.88 ± 51.44), Right Wrist Angle (185.00 ± 5.04), Trunk Inclination Angle (21.13 ± 6.53), Head Inclination Angle (27.75 ± 8.00) respectively.

The correlation (Pearson Correlation) technique was applied to determine the relationship of angular kinematical variables with the performance of high jump at different phases of take-off in Fosbury-flop technique. In case of Right Elbow Angle (degree) at final Take-off of Fosbury-flop technique obtained value (.730) is greater than tabulated value of (.707) therefore it has shown significant relationship of this independent variables with High Jump Performance of subjects.

**Conclusions:**

On the basis of the findings of the study, the following conclusions are drawn:

1. Finally, mean, standard deviation, scores of angular kinematics variables in degree at Final Take-off in Fosbury-flop Technique have been found as follow: Left Ankle Angle (132.87 ±7.64), Right Knee Angle (92.368 ± 13.30), Left Knee Angle (162.88 ± 5.91), Right Knee Angle (62.88 ± 9.28), Left Hip Angle (167.62 ± 10.21), Right Hip Angle (99.63 ± 11.27), Left Shoulder Angle (104.00 ± 13.31), Right Shoulder Angle (83.38 ± 10.76), Left Elbow Angle (110.38 ± 27.58), Right Elbow Angle (77.75 ± 9.60), Left Wrist Angle (200.88 ± 51.44), Right Wrist Angle (185.00 ± 5.04), Trunk Inclination Angle (21.13 ± 6.53), Head Inclination Angle (27.75 ± 8.00) respectively.
2. Significant correlation was found between Right Elbow Angle (degree) at final Take-off of Fosbury-flop technique with High Jump Performance of subjects in case of angular kinematic variables.

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