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KINEMATIC COMPARISON OF TWO DIFFERENT TECHNIQUES OF FRONT FLIP TUCK (FORWARD SOMERSAULT TUCK) ON FLOOR EXERCISE IN MEN'S ARTISTIC GYMNASTICS

Joshi Hem Chandra, Research scholar, Department of Sports Biomechanics, L.N.I.P.E., Gwalior, Madhya Pradesh (India).

Ghai Guru Datt , Professor, HOD, Department of Sports Biomechanics, L.N.I.P.E., Gwalior, Madhya Pradesh, (India).

Abstract

Front flip (forward tuck somersault) is one of the fundamental skills taught in the early stage in the competitive Gymnastics career of a Gymnast. The purpose of this study was to investigate kinematic comparison of two different techniques (Russian technique V/s Japanese techniques) of front flip tuck on floor in men's artistic gymnastics. A total of five (n = 5) best male gymnasts of 18 to 23 years old from L.N.I.P.E., Gwalior (M.P.); who had mastery on both the techniques were selected for the present study as subjects. To acquire kinematical data, a digital Nikon D-3100 video recording camera with a frame rate of 30 frames per second, were used during the execution by placing it left side of the subjects(gymnasts) and perpendicular to the sagittal plane. From the video, the photograph of selected three phases (i.e. take off phase, flight phase and landing phase) were obtained by using snipping tool software. The digitization of the photographic sequence of selected phases was done with the help of kinovea software and the selected angular kinematic variables were obtained at take off phase, flight phase and landing phase. The centre of gravity of required phases was located by using segmentation method (Hey, 1993). The paired t-test was used for the kinematic comparison of both the techniques of front flip tuck at each phase. The level of significance

was set at 0.05. The results showed the significant difference in both the techniques in selected linear and angular kinematic variables (p< .025) (two tail hypothesis). On the basic discussion it is concluded that kinematically over arm technique (Japanese style) was quite better than the under arm technique (Russian style).

Key words: *kinematics, Front Flip Tuck on Floor Exercise, Technique, Sagittal Plane, joint point method, segmentation method.*

INTRODUCTION:

Correct execution of body movement leads to a successful sports performance. Biomechanics is "the study of the structure and function of biological systems by means of the methods of mechanics" (Hatze, 1974). It is most helpful in improving the performance in terms of correct body position in sports or activities where technique is the dominant factor rather than physical structure or physiological capacity. Since biomechanics is essentially the science of movement technique. In the recent years, greater stress has been laid on quality rather than quantity of training (Singh D. et al., 2011). The coaches and teachers of physical education want their athletes to extract maximum achievement from their training procedure without causing too much strain on them. (khalil, 1986). It may be necessary to develop programs of study for the training of technique in sports biomechanics, technicians who can provide the kind of services sought by sporting bodies. (Hay, 1984). Gymnastics are currently training close to their bio-physical limits and with evolving code of point (F.I.G, 2013) and desire to continually strive for complex and innovation moments. In gymnastics, every skill is having biomechanical orientation. In this context, the mechanical principles such as motion, speed, center of gravity, angle of take-off, push-off, landing angle play an important role related with the performance. The ultimate aim of the coaching biomechanics interface in gymnastics training is to make training more effective and efficient. The most of the part of floor routine is consist of variety of tumbling element. Front flip tuck also known as forward tuck somersault is one of the fundamental skills taught in the early stage in the competitive Gymnastics career of a Gymnast. Basically forward somersault is a balance over movement without intermediate support which comes under the swing group elements. Basically there are two different types of techniques for performing front flip that are in trend now-a-days. The one of the techniques is under arm front flip

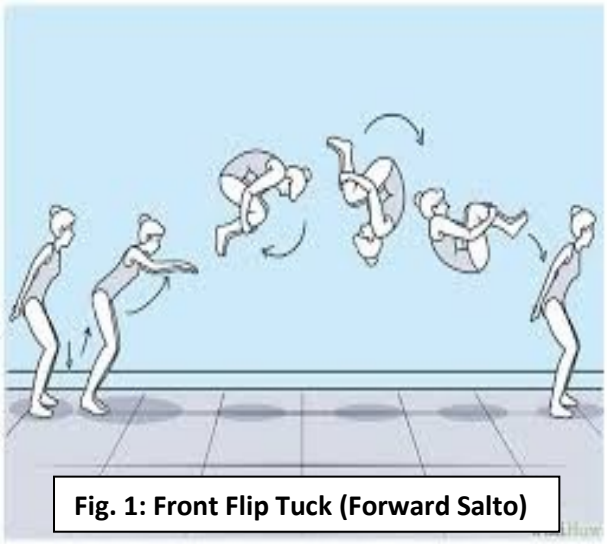


Fig. 1: Front Flip Tuck (Forward Salto)

developed by the Russians gymnasts and another is upper arm front flip developed by the Japanese gymnasts. The only difference between these two techniques is the arm action. Most of the researchers in artistic gymnastics have examined the takeoff, flight, & landing phase's characteristics of different skills and various types of somersault (Putatunda, 2013). (Hwang et. al., 1990) investigated take-off mechanics of three different types of forward somersaults performed at the 1988 Seoul Olympic Games including the contribution of the different body parts to the total angular momentum. , i.e. the required "spin" and found that, in all cases, the legs' contribution to the total angular momentum was dominant. Similar take-off mechanics were found by Kerwin, Webb & Yeadon (1998) who investigated the production of angular momentum in forward somersaults performed during the 1996 Olympics. Angular momentum and center of mass (CM) kinematics of single and double forward somersaults were investigated by Brüggemann (1983). (Brochado & Brochado, 2002) investigated Differences at the impulse phase for the front somersault on floor exercise and on different trampolines. Forward somersaults have received much attention. The Russian one, favored by the majority of gymnasts, has been studied by Knight, Wilson and Hay (1978) who concentrated mainly on the action of the arms. Ground reaction forces for the Russian type of somersaults were also examined by Miller and Nissinen (1987) in order to investigate their characteristics in relation to performance. In summary, there is a wealth of information and good understanding of somersaults' take-off requirements. But there are very

less information regarding the biomechanical comparison among the techniques of somersault at all possible phases of skill.

So, the present study hereby makes an effort to broaden the horizon of knowledge by bringing new facts and thoughts by investigating the comparison in various kinematic variables of two different techniques of front flip (forward somersault) on floor in men's artistic gymnastics. Therefore, I tested the hypothesis that there might be the significant difference in all selected kinematics variables between both the techniques. (two tail hypothesis).

Material and Methods

The methodology of the study consist of selection of subjects, selection of variables, criterion measures, filming protocol, testing procedure and the technique employed for analysis of data.

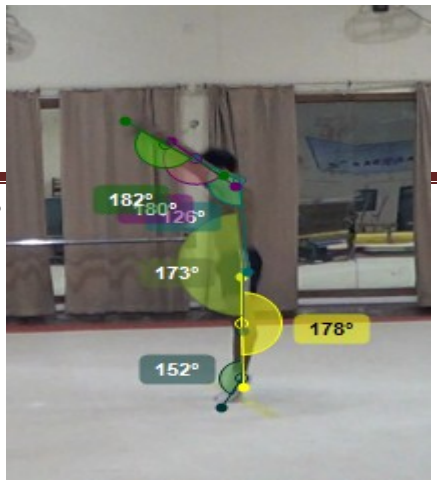
Selection of subjects:

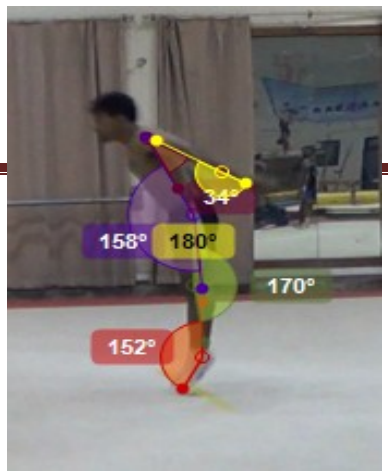
Five male gymnasts of Lakshmibai National institute of Physical Education, Gwalior from the gymnastics match practice group, who had a good control over the particular skill with both the techniques (forward somersault on floor), were selected as the subject for the present study and there range of mean age, mean height and mean weight was 21.4±.84 years, 166.8±4.60 cm and 61.8±6.45 kg respectively.

Experimental filming protocol:

Videography was employed for the biomechanical kinematics analysis of front flip tuck on floor. The camera that was used for this study was a standard Nikon D3100 (with motor drive). The video camera was mounted on the tripod stand at the height of 1.37 mts. from the floor arena. The video camera was placed perpendicularly at center in the line of inner bar and parallel to the sagittal plane at a distance of 4 meters. The frequency of the camera was 30 frames/second with HD quality of video. The subjects performed the skill three times and the best trail was used for the analysis.

Figure 2: segmental angles during take-off phase of front flip tuck (forward salto tuck) on floor exercise.





Over arm techniques under arm technique

Procedure of data collection:

Data were gathered in the standard testing procedure under the controlled condition. All testing was carried out in the standard gymnasium of L.N.I.P.E., Gwalior (M.P.). Videography technique was employed in order to register the performance of front flip tuck (forward salto tuck) in two different techniques i.e. over arm technique (Japanese salto) and under arm technique(Russian salto) for the study. Selected kinematics variables (table 1 to table 4) and three selected phases of whole skill i.e. take off phase, flight phase and landing phase were analysed. The most appropriate position from selected phases was taken out from the video by using snipping tool software. The digitization of the photographic sequence of selected phases was done with the help of kinovea software and the selected angular kinematic variables were obtained at take off phase, flight phase and landing phase. The centre of gravity of required phases was located by using segmentation method (Hey, 1993). The angles of selected joints were measured degree, time variable in seconds and linear kinematics variable were measured in centimeters.

Statistical technique:

Statistical analysis was done with SPSS (Statistical Package for the Social Sciences, 20.0, USA). Mean and standard deviation was calculated as a descriptive statistics and student's paired t-test was used if the mean change in scores was significant. Then obtained "t" value was tested at 0.05 level of significance. The assumptions for applying pair t-test were also taken into consideration. Effect size of each variable was calculated to find out the total magnitude of the mean differences along with its significance level.

Results and discussion of finding

The result of paired-t test which was obtained in order ascertains the difference of selected angular and linear kinematic variables of all three selected phases of both the techniques of front flip tuck have been presented below:

Table 1: Findings of angular kinematics of front flip tuck (Forward salto) at take off phase.

Variables (Angles in degree)	Over arm M ± S.D.	Under arm M ± S.D	t-value	Sig.	Effect size (Cohen's d)
Shoulder (°)	132.0 ± 8.75	38.0 ± 4.42	20.66*	.000	13.56
Elbow (°)	180.0 ± 0 .00	116.8 ± 4.44	1.61	.182	1.02
Wrist (°)	179.o ± 2.65	162.6 ± 3.39	4.59	.010	2.58
Hip (°)	164.2 ± 8.64	160.8 ± 3.70	0.67	.540	0.51
Knee (°)	179.2 ± 0.84	177.2 ± 4.14	1.27	.275	0.67
Ankle (°)	147.0 ± 3.77	144.0 ± 4.18	1.54	.199	0.76
Angle of release (°)	130.4 ± 12.13	132.0 ± 4.35	0.34	.750	0.10

*Significant at 0.05/2 level (two tail hypothesis).

Table 1 shows there was significant difference ($p < .001$) in the angle at shoulder joint during take-off phase while performing forward salto tuck from both the technique. Rest all other angular kinematics variables showed insignificant difference ($p > .025$) in both the summersault techniques. The descriptive results clearly indicating that the angle at shoulder joint (in relation to torso) during over arm (Japanese) technique of front flip is greater than the under arm (Russian) technique. That significant difference in the angle at shoulder joint may help the gymnasts to provide more range to execute front flip (forward salto) at the time

of take off and more range will give more time to generate optimum force to produce rotational effect when the body is in air at flight phase.

Table 2: Findings of angular kinematics of front flip tuck (Forward salto) at flight phase.

Variables (Angles in degree)	Over arm M ± S.D.	Under arm M ± S.D	t-value	Sig.	Effect size (Cohen's d)
Shoulder (°)	27.6 ± 7.12	23.8 ± 4.23	0.98	.381	0.64
Elbow (°)	108.4 ± 2.08	99.2 ± 7.19	2.76	.051	1.68
Wrist (°)	180.0 ± 0.00	175.8 ± 2.25	1.87	.135	1.18
Hip (°)	53.6 ± 4.04	35.2 ± 2.86	9.618*	.001	5.26
Knee (°)	70.8 ± 3.96	67.6 ± 3.98	0.74	.502	0.46
Ankle (°)	165.8 ± 4.08	132.4 ± 7.53	14.83*	.000	5.51

*Significant at 0.05/2 level (two tail hypothesis).

Table 2 showed the significant difference only in the angle of hip joint ($p = .001$) and ankle joint ($p < .001$) at the time of flight phase while performing front flip (forward salto) tuck from both technique. At the time of flight phase of forward salto when the gymnast's body travels in the air has to complete one forward rotation around frontal axis For completing the rotation the torque (force produce rotation) plays an key role and that rotational force (torque) with the help of arm action with the co-ordination of hip joint action. By reducing the angle at hip joint, the radius of rotation of the body decreases and mass of the body shifted towards centre and body starts rotating (Hall, 1995). In case of under arm forward salto, gymnasts flex more hip joint (35.2 ± 2.86) as compare to the over arm forward salto technique (53.6 ± 4.04) because of less arm action so while performing forward salto with under arm techniques gymnasts have to flex more hip so that they can decrease the radius of rotation of body quickly and the body can rotate properly in the air at flight phase. The significant difference in the angle at ankle joint may be because of poor execution as well as the poor aesthetic attention while performing front salto with under arm techniques. Rest all other variable at flight phase showed insignificant difference ($p > .025$) may be because of same nature of skill.

Table 3: Findings of angular kinematics of front flip tuck (Forward salto) at landing phase.

Variables (Angles in degree)	Over arm M ± S.D.	Under arm M ± S.D	t-value	Sig.	Effect size (Cohen's d)

Shoulder (°)	56.4 ± 4.71	31.2 ± 3.70	6.95*	.002	5.89
Elbow (°)	165.4 ± 5.27	157.2 ± 3.56	4.62*	.001	1.89
Wrist (°)	176.0 ± 1.51	179.2 ± 1.30	2.31	.080	1.83
Hip (°)	126.8 ± 3.76	167.0 ± 3.39	26.26*	.000	11.21
Knee (°)	107.0 ± 3.00	149.8 ± 2.16	30.72*	.000	16.35
Ankle (°)	93.0 ± 2.77	89.0 ± 3.16	2.26	.086	1.42

*Significant at 0.05/2 level (two tail hypothesis).

The findings of table 5 clearly revealed that except the angle of wrist joint and ankle joint rest all other angular kinematics variables at landing phase had shown significant difference ($p < .025$) while performing forward salto tuck on floor exercise with two different techniques. In the time of landing lower limb's joints specially hip joints and knee joint plays an important role for providing more stability by recue from the shock (Ismail et. al., 2012; McNitt-Gray, 1991; Ferkolj, 2008; Devita et. al., 1991). In gymnastics, all situations where landing take place gymnasts immediately flex their hip and knee joint accordingly so that the landing forces generated by the body can be economize or neutralize in the process of shock observing. Gymnasts adjust to the landing impact by absorbing the landing forces over a long period of time suggested by Geiblinger et. al.,1995 at international symposium on biomechanics in sports. He had presented the role of hip and knee joint at the time of landing phase in his study. Along with hip and knee flexion, the center of gravity of the body goes down that provides the body more stability on the ground at the time of landing. descriptive outcomes of the present study showed the greater angles at hip and knee joint in over arm techniques which is considered ideal for good and soft landing suggested by Hou et. al., 2005. He had concluded from his study that among the moments of the three joints, the moment of hip is the greatest and the muscles of knee and ankle joint assist each other and are assisted by the hip muscles. The findings also showed the significant difference in shoulder and elbow joint ($p < .025$). While landing the arm positioning provides the additional stability to the moving body by countering the extra forces and depends upon the preparation of the body at the time of landing. Rest all other variable at flight phase showed insignificant difference ($p > .025$) may be because of same pattern of body position while performing the skill.

Table 4: Findings of linear kinematics of front flip tuck (Forward salto).

(CoM : Center of Mass)

Variables	Over arm M ± S.D.	Under arm M ± S.D	t-value	Sig.	Effect size (Cohen's d)
CoM at take off (cm.)	115.2 ± 4.08	107.8 ± 2.86	12.33*	.001	2.1
CoM at flight (cm.)	159.0 ± 6.59	158.2 ± 7.25	0.63	.556	0.1
CoM at landing (cm.)	80.6 ± 3.71	89.6 ± 3.36	10.75*	.000	5.54
Total flight length (cm.)	192.0 ± 4.47	184.6 ± 9.58	2.63	.058	0.90
Total flight time (sec.)	0.80 ± 0.03	0.87 ± 0.05	5.17*	.007	1.31

*Significant at 0.05/2 level (two tail hypothesis).

Outcome of table 4 showed the significant difference in following linear kinematics i.e. CoM at take off phase (height of the center of gravity), CoM at landing Phase and total flight time while performing forward salto from both the techniques. At the time of take off phase in case of over arm techniques the gymnasts bring their arms above where as in case of under arm technique gymnasts bring their arm backward upward direction resulting because of limited range of motion their arms remains below the head this may be one of the reason of showing difference in their height of center of mass (CoM) at this phase. Bringing arm backward and upward direction in while performing forward salto with under arm techniques, the inclination in the gymnast's body takes place resulting the mass of the body shifted download as compare to the over arm technique and this inclination may affect the flight phase of the forward salto.

At the time of landing, as the researchers has mentioned in table 3 that because of greater angle in hip joint and knee joint in over arm techniques, the center of gravity shifted downward which makes difference to the under arm technique in CoM's height at the time of landing. Lower height of CoM (center of mass) provides better stability as well as greater angle recue the body from the landing impact while landing on floor.

Table 4 also showed the significant difference in total flight time while performing forward salto (front flip) with both the techniques even there was no significant difference in maximum vertical displacement (CoM at flight phase) and maximum horizontal displacement (total flight length) so it can be concluded that the overall velocity of the body during over

arm technique is more (2.40 mt./sec.) than under arm technique (2.13 mt./sec.) and that makes difference in temporal (time) variable between both the techniques.

Conclusion

The ultimate aim of the study was to investigate kinematic comparison of two different techniques (Russian technique V/s Japanese techniques) of front flip tuck on floor exercise in men's artistic gymnastics and the findings provided the following information:

1. There was the significant difference in both the techniques after comparing each of the phases of front flip with selected kinematics variables.
2. On discussion of the finding it is concluded that kinematically over arm technique (Japanese style) was quite better than the under arm technique (Russian style).

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