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# Kinematic comparison of selected identical phases of close leg press handstand performing on different apparatuses in artistic gymnastics

**Rajpoot YS, Ghai Guru Datt and Joshi Hem Chandra**

**Abstract**
A press handstand is a gymnastic term referring to the slow and controlled elevation of a gymnast's body from an initial stationary position to a handstand position. The purpose the study was to kinematically analyze and compare each phases of the same skill (close leg press handstand) performing on three different apparatuses used in artistic gymnastics separately. A total of seven (n = 7) best male gymnasts from L.N.I.P.E., Gwalior (M.P.); who had the good mastery over the skill on all selected apparatuses were purposely selected for the present study as subjects. To acquire kinematical data, a digital Sony HDR cx-200 video recording camera with a frame rate of 60 frames per second, were used during the execution by placing it right side of the subjects(gymnasts) and perpendicular to the sagittal plane. The digitization of the skill by converting raw data into numeric values was done with the help of kinovea software to obtain selected kinematic variables. The repeated measure ANOVA was used for the kinematic comparison of all three repeated group at each apparatus. The level of significance was set at 0.05. The results showed the significant difference was found when compare all identical phases of the skill case of both the selected variables ($p$<.05) on the basic discussion it is concluded that the phase 2 plays as a dominant role in terms of angular velocity of hip joint as well as the temporal variable.

**Keywords:** Technique, close leg press handstand, gymnastics, sagittal plane, hip joint velocity

## 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) [8]. 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. 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. 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.

Gymnastics are currently training close to their bio-physical limits and with evolving code of point and desire to continually strive for complex and innovation moments. A press handstand is a gymnastic term referring to the slow and controlled elevation of a gymnast's body from an initial stationary position to a handstand position. The body configuration between initial and final positions can vary, making certain variations of the skill more difficult than others. However, accomplishment of any variation requires a continuous change in body configuration brought about by muscular torques acting at the wrist, shoulder, and hip joints.

Although handstands in general and press handstands in particular are frequently discussed qualitatively in gymnastics books (Brown, 1980 [2]; Faria, 1972 [4]; Fukushima & Russel, 1980 [5], related quantitative research consists of a single study. Prassas *et al*. (1986) [11] investigated the relationship between shoulder joint strength, hip joint flexibility, and timing to the straight arm/flexed hips press handstand on the parallel bars. They concluded that increased levels of shoulder joint strength at the later stages of shoulder joint flexion might be one of the Prerequisites for proper execution of the skill, and that utilization of an increase in existing hip

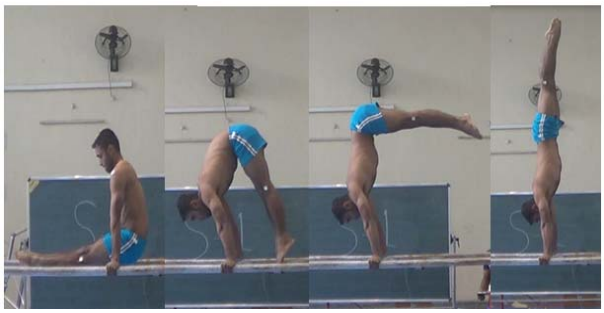
joint flexibility could reduce the demands placed upon the shoulder joint musculature.

The purpose the study was to kinematically analyzed and compare each identical phases of one of the mounting skill (close leg press handstand) on different apparatuses uses in artistic gymnastics. So, therefore, the researchers tested the hypothesis that there might be the significant difference in all selected identical phases of the skill in case of both selected kinematics variables while performing on different apparatuses (Two tail hypothesis).

## Methodology

For the purpose of the study, the total 7 national level right handed male gymnasts of 18 to 23 years with minimum deviation from their demographic characteristics (Age, Height, Weight, Fat %, Arm Dominance and Experience) and those performed the particular skill (press to handstand) in their practice routine in all selected apparatuses were purposely selected. There range of mean age, mean height and mean weight was 21.4±.97 years, 166.8±2.61 cm and 61.8±4.83 kg respectively. The gymnasts performed the close leg press handstand on three different apparatuses used in men's competitive gymnastics [Floor Exercise (FX), Parallel Bars (PB) and Still Rings (SR)]. The whole skill was analyzed in three sequential phases illustrated in figure 1. The Temporal Variable (time execution of the skill) and Hip Joint Velocity (angular velocity) was used as kinematic variables. The temporal data was recorded in seconds and hip joint velocity was recorded in degree/second.

Videography technique was employed in order to register the performance of close leg press handstand on all three apparatuses. Selected kinematics variables by dividing the whole skill in three sequential phases were analyzed and compare on three different apparatuses separately. The most appropriate identical positions of the skill i.e. Initial Position (IP), Greatest hip joint flexion position (GHJFP), Leg horizontal position (LHP) and Handstand position (HP) were taken out from the video by using snipping tool software and then synchronized in pre decided sequential phases (IP to GHJFP, GHJFP to LHP, LHP to HP & IP to HP) for analysis.



IP GHJFP LHP HP

**Fig 1:** Illustration of Close Leg Press Handstand with Identical Positions

The camera that was used for this study was a standard Sony HDR cx-200. The frequency of the camera was 60 frames/second with HD quality of video. The video camera was mounted on the tripod stand at the vertical height of 1.06 meters in case of capturing action on floor exercise from the ground, 2.25 meters in case of capturing action on parallel bars from the ground and 2.93 meters in case of capturing action on rings from the ground. The video camera was placed perpendicularly at center in the line of the subjects to the sagittal plane at a distance of 5.90 meters in case of capturing action on floor exercise, 6.12 meters in case of capturing action on parallel bars and 5.97 meters in case of capturing action on rings and then the latest version of kinovea software (08.23) was used for digitizing the data and converting the raw data into numeric values. The subjects performed the skill with full of control and with proper technique. One best trail was taken into consideration.

**Fig 2:** Illustration of Experimental Filming Protocol

Statistical analysis was done with SPSS (Statistical Package for the Social Sciences, 20.0, USA). The descriptive analysis was done by computing mean and standard deviation in order to have an idea about the characteristics and variations of each phase of the close leg press handstand in case of all selected variables while performing on three different apparatuses and as the same group was tested in all sequential phases so, repeated measure ANOVA was used to find out the mean difference among the groups (within group) whether significant or not after fulfilling all the assumptions of selected parametric test. Then obtained "f" value was tested at 0.05 level of significance. Partial eta squared of each variable was calculated to find out the total magnitude of the mean differences along with its significance level (Effect Size).

## Results

The results of one way repeated measure ANOVA which were obtained in order to ascertain the mean difference in selected kinematics variables i.e. temporal variable as well as the hip joint velocity when compared each phase of the press handstand on three selected apparatuses gymnastics [Floor Exercise (FX), Parallel Bars (PB) and Still Rings (SR)]. The outcome of temporal variable has been presented in table 1:

**Table 1:** Findings of Temporal Variable at Each Phase of the Press Handstand on All Three Selected Apparatuses. (In Second)

| Phases | | M ± S.D | Mauchly's Test | F-value | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| FX | Phase 1 | 1.55 ± .26 | .374 | 93.180* | .000 | .940 |
| | Phase 2 | 1.30 ± .16 | | | | |
| | Phase 3 | 2.54 ± .11 | | | | |
| PB | Phase 1 | 1.21 ± .10 | .099 | 1532.589* | .000 | .996 |
| | Phase 2 | 1.09 ± .07 | | | | |
| | Phase 3 | 2.54 ± .08 | | | | |
| SR | Phase 1 | 1.09 ± .04 | .152 | 1102.472* | .000 | .995 |
| | Phase 2 | .63 ± .09 | | | | |
| | Phase 3 | 2.85 ± .10 | | | | |

*Significant at 0.05/2 level (Two Tail Hypothesis)

Note: Phase 1 = IP to GHJFP, Phase 2 = GHJFP to LHP, Phase 3 = LHP to HP

The presentation of results of temporal variable (total time taken in case of each phase) mentioned in tables table 1 includes outcome of mean (M) and standard deviation (SD) as descriptive statistics also illustrated in figure 3, Mauchly's test to check the violation of sphericiry assumption which was found insignificant (p =.374,.099 &.152) for all selected apparatuses, F- value to find out the mean difference while comparing each phase of the skill which was found significant ($F_{(2, 12)}$ = 93.180, 1532.589 & 1102.472, p =.000) for all selected apparatuses respectively at 0.05 level of significance, and the partial eta squared to find out the total effect size of the mean difference which was reported as very large (.940,.996 &.995) in magnitude.

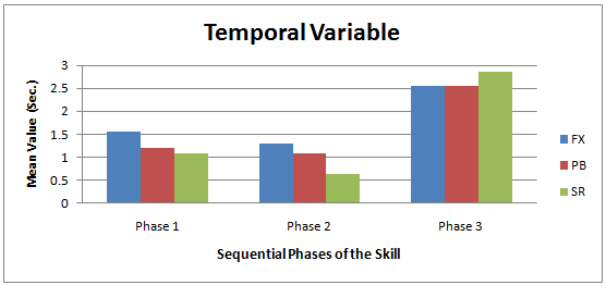



**Fig 3:** Graphical Representation of Temporal Variable at Each Phase of the Skill on Three Different Apparatuses.

The outcome of the hip joint velocity in terms of hip joint angular rotation while performing close leg press handstand is presented in table 2:

**Table 2:** Findings of Temporal Variable at Each Phase of the Press Handstand on All Three Selected Apparatuses. (In Degree/Second)

| Phases | | M ± S.D | Mauchly's Test | F-value | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| FX | Phase 1 | 6.00 ± 2.00 | .001* | 107.089* | .000 | .947 |
| | Phase 2 | 38.86 ± 6.01 | | | | |
| | Phase 3 | 29.29 ± 3.40 | | | | |
| PB | Phase 1 | 22.71 ± 5.21 | .510 | 18.498* | .000 | .755 |
| | Phase 2 | 41.71 ± 6.50 | | | | |
| | Phase 3 | 35.86 ± 4.38 | | | | |
| SR | Phase 1 | 28.71 ± 4.35 | .026* | 114.182* | .000 | .950 |
| | Phase 2 | 73.00 ± 11.20 | | | | |
| | Phase 3 | 26.57 ± 3.26 | | | | |

*Significant at 0.05/2 level (Two Tail Hypothesis)

The presentation of results of hip joint velocity (angular) mentioned in tables table 2 includes outcome of mean (M) and standard deviation (SD) as descriptive statistics also illustrated in figure 4, Mauchly's test to check the violation of sphericiry assumption which was found significant (p =.001,.026) in case of floor exercise (FX) and still rings (SR), F- value to find out the mean difference while comparing each phase of the skill which was found significant ($F_{(bonferroni\ correction\ applied)}$ = 107.089 & 114.182, p =.000) in case of floor exercise and still rings and ($F_{(2, 12)}$ = 18.498, p =.000) in case of parallel bars (PB) at 0.05 level of significance, and the partial eta squared to find out the total effect size of the mean difference which was reported as very large (.940,.996 &.995) in magnitude. As the assumption of sphericity has been violated [$\chi^2(2)$ = 14.942, p =.001 & $\chi^2(2)$ = 7.314, p =.026] in case of FX and SR. Therefore degree of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε =.51) as F statistics in repeated measure ANOVA.

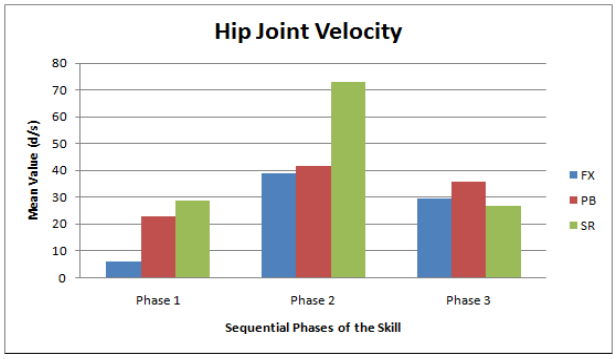



**Fig 4:** Graphical Representation of Hip Joint Velocity at Each Phase of the Skill on Three Different Apparatuses.

## Discussion of Finding

As far as the temporal variable (total time taken) is concern, the same pattern of executing the movement in terms of total time taken was reported in the descriptive table of the temporal variable when observed phase wise of the skill in case of all three apparatuses which shows that performing close leg press handstand on different apparatuses does not affect the nature of the skill in term of time execution.

The findings of all possible pair wise comparison showed that in term of time execution, the phase 3 took significantly more time to complete action than rest both of the phases of the skill in case of all three apparatuses. And along with this finding, phase 2 took significantly less time to complete its action than rest of the two phases of the skill in case of Parallel bars (PB) and still rings (SR). The reason of taking less time in execution by phase 2 may be because while performing the skill, phase 2 (GHJFP to LHP) acts as the connecting phase in between initial phase and final phase so the gymnasts have to be very conscious while executing this phase to reduce the chance of error (Failed Attempt). In gymnastics, the press handstand is a lifting form element of the strength structural group as the body has to lift against the gravitational force while performing and phase 2 plays key role while performing the skill. So time of execution should take into consideration at this phase. So many researchers had phase wise analyze the press handstand with its variation and used time of execution as a temporal variable in biomechanical study in their area of interest. (Prassas *et al*., 1986 [11]; Prassas, 1988 [12]; Prassas and Spiros, 1991; Niu *et al*. (2000); Tsai *et al*., 2006; Kong *et al*., 2011 and Joshi *et al*., 2016).

As far as the angular velocity while performing press handstand is concern, there was a huge significance of time history of hip joint can be called as joint velocity of hip angle. The post hoc test was applied to find the best dominance phase of the skill with the help of pair wise comparison of each phases while performing the skill on each apparatuses. The findings of all possible pair wise comparison showed that in term of hip joint velocity, phase 2 and phase 3 was having equally significant more angular velocity than the phase 1 in case of floor exercise (FX) and parallel bars (PB) and the findings of still rings (SR) reported only phase 2 having greater angular velocity the rest both of the phase of the skill. The findings again revealed the phase 2 as a key phase in terms of angular velocity (Prassas *et al.,* 1986) [11].

## Conclusion

The finding concluded that in case kinematic variables (Temporal variable and hip joint velocity), training of close leg press handstand by dividing into its identical phases could

be more effective to learn fast and perform efficiently as the results showed the significant difference, when observed the particular skill phase wise for all three apparatuses(FX, PB and SR). The findings of each identical phases revealed that performing close leg press handstand on different apparatuses does not affect the nature of the skill in term of time execution as the same pattern of executing the movement in terms of total time taken was followed by the gymnasts when observed phase wise of the skill. The findings also revealed the phase 2 as a key phase in terms of angular velocity of hip joint as well as the temporal variable

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