# BODY MECHANICS OF TAI CHI CHUAN

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The purpose of this study was to analyse the fundamental movements of Tai Chi and to identify their correct execution, so as to increase their effectiveness, by using modern motion analysis techniques. In this preliminary study, we focused on the power generated from the forward push movement. The process, which involved the subject pushing a punch bag using stands of different lengths and widths, was videotaped. Reflective markers were placed on essential joints of the subject to allow the creation of a spatial model using motion analysis software. The results demonstrated that the length of the stand had more effect than its width on the power generated, and the standard as recommended by certain schools of Tai Chi might not be optimum.

**KEY WORDS:** tai chi, push hand, body mechanics, power generation, spatial model .

**INTRODUCTION:** Tai Chi is a form of traditional Chinese martial arts practised by all age groups. Its movements are slow and flowing, requiring a high level of concentration and coordination of the whole body [1]. It differs from most martial arts in that it emphasizes the principle of exploiting the opponent's own force to overcome themselves. In this way, "the weak can beat the strong and the slow can beat the fast." To do so, though, requires a good understanding of body mechanics, a high level of sensitivity and precise execution of movements involving the whole body. In Tai Chi, these skills are developed and refined through the Push Hand exercise (Fig. 1), which involves two persons practising the basic attacking and defensive movements in a cyclic manner. Again, the emphasis is on the precision, timing and coordination of the movements, rather than on the use of force [2].
The main objective of this study is to analyse the fundamental movements in Tai Chi using modern motion analysis techniques. Comparison will be made between the performances of practitioners with different levels of skills. The results will provide scientifically based guidelines on the correct execution of Tai Chi movements, thereby increasing their effectiveness.

Fig. 1 Tai Chi Push Hand exercise

Fig. 2 Forward Push

**METHOD:** In this first series of tests, we focused on the power generated from the forward push movement. To eliminate differences in biomechanics between different subjects, only one subject (Tai Chi beginner) was recruited for this series of tests. From the sitting back position (see the person on the right hand side of Fig. 1), the subject moved forward and

pushed a punch bag (39kg) with both hands (Fig. 2). Reflective markers were placed on all the important joints of the subject as well as the punch bag, and the process was videotaped. This was repeated by changing the longitudinal and lateral distances between the feet. A motion analysis software (Peak Motus 8.3) [3] was used to first create a spatial model of the subject (Fig. 3) using the video images and then analyse the results. The effectiveness of each stand was assessed by considering the peak acceleration of the punch bag. The importance of the turning of the waist in enhancing the power was also investigated.
Six points were marked on the floor (Fig. 4), giving five different stands. The left foot was always placed onto the 'a' position, while the right foot occupied one of the remaining five points b, c, d, e and f. Point b was the baseline position for the right foot which was calculated using the lengths of the lower limbs and the shoulder width, as recommended by certain schools of Tai Chi [1]. The other points are ±20% from the baseline position in both the longitudinal and lateral directions.

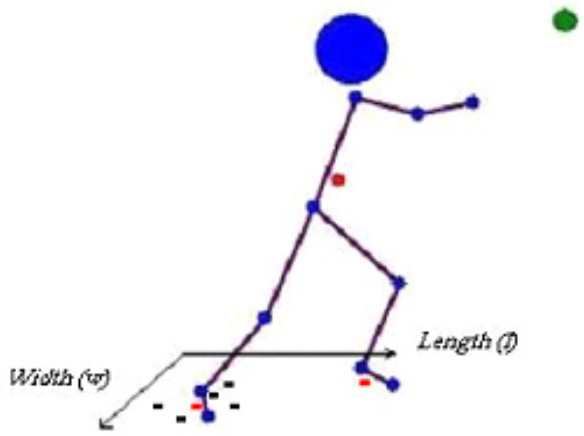


Fig. 3 Spatial model

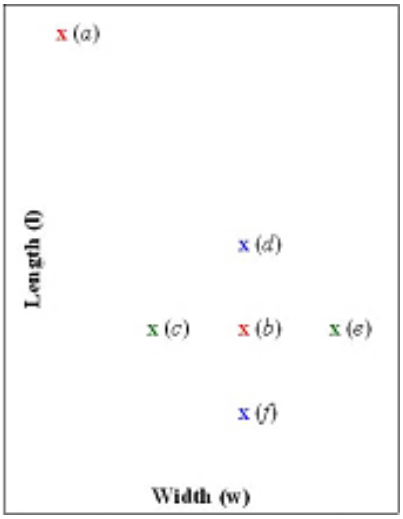


Fig. 4 Position of the feet during testing

**RESULTS:** The acceleration of the punch bag for different stands is shown in Figs. 5 & 6. The results are given for 10 attempts per stand. These, together with their average values, are summarized in Tables 1 & 2.

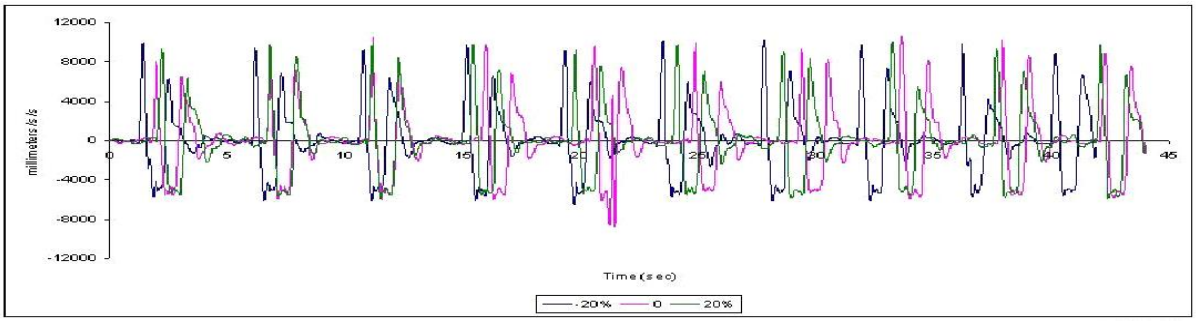


Fig. 5 Time histories of punch bag with changing width (w)

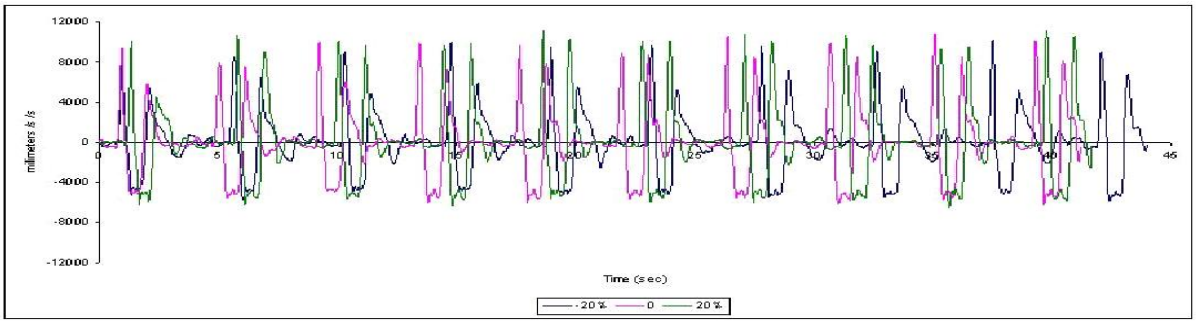


Fig. 6 Time histories of punch bag with changing length (l)

Table 1 Results (mm/s2) with changing width (w)

| Width (w) | -20% | 0 | 20% | Ratio |
|---|---|---|---|---|
| 1 | 9.962.182 | 8.060.009 | 9.329.699 | 1.23 : 1 : 1.16 |
| 2 | 9.404.296 | 9.062.951 | 9.687.084 | 1.04 : 1 : 1.07 |
| 3 | 9.257.849 | 10511.61 | 9.836.168 | 0.88 : 1 : 0.94 |
| 4 | 9.670.824 | 9.740.587 | 9.792.442 | 0.99 : 1 : 1.01 |
| 5 | 9.130.297 | 9.636.876 | 9.250.378 | 0.95 : 1 : 0.96 |
| 6 | 10096.22 | 9.924.278 | 9.690.489 | 1.02 : 1 : 0.98 |
| 7 | 10295.18 | 9.348.376 | 9.013.402 | 1.1 : 1 : 0.96 |
| 8 | 9.770.689 | 10580.16 | 9.983.604 | 0.92 : 1 : 0.94 |
| 9 | 9.850.121 | 10148.62 | 9376.83 | 0.97 : 1 : 0.92 |
| 10 | 8.872.009 | 8.832.348 | 9.666.539 | 1.01 : 1 : 1.09 |
| **Average** | **9.630.966** | **9.584.581** | **9.562.664** | **1.011 : 1 : 1.003** |

Table 2 Results (mm/s2) with changing length (l)

| Length (l) | -20% | 0 | 20% | Ratio |
|---|---|---|---|---|
| 1 | 8.674.364 | 9.412.096 | 10070.51 | 0.92 : 1 : 1.07 |
| 2 | 8.521.984 | 7.904.992 | 10715.95 | 1.08 : 1 : 1.36 |
| 3 | 8.945.946 | 9.928.233 | 10141.7 | 0.90 : 1 : 1.02 |
| 4 | 9.982.286 | 9.860.777 | 9.676.646 | 1.01 : 1 : 0.98 |
| 5 | 9.465.489 | 9.717.735 | 11100.59 | 0.97 : 1 : 1.14 |
| 6 | 9.693.896 | 8.884.862 | 10014.26 | 1.09 : 1 : 1.13 |
| 7 | 9.536.352 | 10517.32 | 10742.87 | 0.91 : 1 : 1.02 |
| 8 | 9.130.077 | 9.832.433 | 10626.74 | 0.93 : 1 : 1.08 |
| 9 | 10201.46 | 10787.91 | 9.287.401 | 0.95 : 1 : 0.86 |
| 10 | 8934.74 | 10060.84 | 11147.72 | 0.89 : 1 : 1.11 |
| **Average** | **9308.66** | **9690.72** | **10352.44** | **0.965 : 1 : 1.077** |

**DISCUSSION:** The results indicate that maximum power was generated by using a stand which was longer than that recommended by the standard. Increasing the length of the stand by 20% increased the power generated by about 8%, which was significantly greater than the 1% variation between the two sets of results for the same baseline stand. Changing the width of the stand seemed to have a negligible effect on the results. However, the experiments need to be recruited with more subjects to test the validity of this observation more generally. In the experiments carried out so far, we have focussed on the attacking aspect of Tai Chi. For future work, we will consider the defensive side of this martial art by examining the power absorption ability of the practitioners. We will also compare the performances of different practitioners, e.g. novice versus expert, and examine their movements and interaction with another person during the Push Hand exercise.

**CONCLUSION:** Motion analysis techniques have been used to study the power generated in a forward push movement of Tai Chi. This study which was based on one single subject has shown that the length of stand as recommended by certain schools of Tai Chi may not be optimum in terms of maximising the power generated. However, more subjects need to be recruited to repeat the tests. Future work will consider the defensive or power absorption aspect of Tai Chi.

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