## 04 - POWER ANALYSES OF A YAU-MAN KUNG FU STRIKE

OSMAR PINTO NETO, MARCELO M. F. SABA, MARCIO MAGINI
Universidade do Vale do Paraíba, São José dos Campos, São Paulo, Brasil
osmar@univap.br, msaba@dge.inpe.br, magini@univap.br

**Introduction**

During the past 1500 years, many different styles of martial arts were developed in India and China and several of them are still being taught nowadays. Most of these styles were developed as a progression of the styles created in the ancient schools of martial arts (Reid and Croucher, 1983). The two main Chinese ancient schools of martial arts were located at two philosophical/religious centers, The Shaolin Temple (Buddhist) and the Wudang Mount (Taoist) (Despeux, 1981).

The Yau-Man style was developed from the collective knowledge of several other styles, during the Ch'ing Dynasty (1644-1911). This style is famous for its handle of the staff, as well as the combination of short hand and foot movements, sometimes coupled with a weapon (the Chinese traditional knife for example). A Yau-Man adept develops martial arts and Chinese traditional medicine and lives by a code of five principles: fidelity and friendship; piece and character; intelligence, reasoning and discipline; helping the needy, and avoidance of greed.

Since the movements of the Yau-Man Kung-Fu are generally short and fast, a study of their power is relevant.

In the past decades some studies were done trying to comprehend different aspects of martial arts (Wilk et al., 1983; Hodge and Deakin, 1988; Massanari, 2001; Wu et al., 2004). The paper "The Physics of Karate," published in 1983, in the American Journal of Physics, is very important among other factors because it relates terms as "kinematical studies" and "biomechanical aspects" applied to martial arts (Wilk et al., 1983). None of these studies however calculates the power of martial arts movements.

Despite the importance of power production in human movement analyses, this is one of the least examined biomechanical parameter. This fact can be attributed to the difficulty in measuring this parameter and its abstract nature (Enoka, 2000).

Giving a muscle the appropriate neural impulse, the determinant factors on power production are the number of activated muscle fibers, in parallel, and the speed by which the myofilaments can convert chemical energy into mechanical work (Enoka, 2000).

The number of activated muscle fibers, in parallel, depends on the neuromuscular coordination of motor units recruitment. This capacity can be improved by proper training. (Ghorayeb e Neto, 1999)

The speed by which the myofilaments can convert chemical energy into mechanical work depends on the type of muscle fiber. Based on examination of the myosin ATPase enzyme muscle fibers can be classified as Types I, IIa, and IIb (Frankel e Nordin, 1990). The fiber Type II can produce tension faster than the Type I; therefore, it is more capable of power production (Hall, 1993).

All people preset different proportion of muscle fibers Type I and II in most of their muscles. These proportions are determined fundamentally by the genetics of the individual (Wilmore e Costill).

Taking into consideration these physiological aspects, it can be speculated that an individual can improve the power of its strikes with training. It may also be speculated that individuality is as a determinant factor as the number of years of training to the magnitude of the power of the strikes from different martial arts practitioners.

The present paper examines values of muscles power of individuals performing a Kung Fu Yau-Man strike. It shows higher values for martial artists compared to the control group. It also shows that after two years of practice the magnitude of power values are determined more by individuality than number of years of training.

**Methodology**

Materials and Methods

Seven individuals, five Yau-Man practitioners, and two non-practitioners (control group) were selected to participate in the experiment. The participants were requested to perform 5 strikes known in the Kung Fu Yau-Man as "palm". During this strike the lower body remains almost static in a position called "mabu". In the initial position the trunk is slightly rotated projecting forward the non-striking (or defense) hand. The arm is flexed in the shoulder joint (80 degrees) and in the elbow joint (160 degrees), and it is slightly adducted. The wrist is fully extended. The striking arm is also flexed in the shoulder joint (50 degrees) and in the elbow joint (100 degrees). The wrist is semi-extended (Fig. 1). The "palm" consists in a fast rotation of the trunk projecting now the striking hand forward and inverting the position of the arms. The upper body final position is symmetrically opposite of the initial position (Fig. 2).



*Fig. 1. Initial position of the Yau-Man "palm".*



*Fig 2. Final position of the Yau-Man "palm".*

All the strikes were aimed to hit a high-density rubber surface, and the participants were instructed to hit it as hard as they could. The fact that the strikes were analyzed in a real impact situation is important to take into account psychological aspects that can interfere in the movement, and possibly help differentiate more experienced practitioners Vos e Binkhorst (1966). During the collision the impact area in is the lower extremity of the palm (carpals).

All collisions were recorded by the High Speed Digital Imaging System (or High Speed Camera) "MotionScope PCI" from Red Lake, model 8000S. This camera belongs to the ELAT (Atmospheric Electricity Group) from INPE (Brazilian

Space Research Institute). It is based in a CCD (Charge Couple Device) sensor to capture and record a sequence of digital images with a temporal resolution ranging from 60 to 8.000 fps. These images are saved as a computer file. For this study the acquisition rate was adjusted to be 1000 fps. Fig. 3 shows an image of the experiment recorded by the High Speed Camera.

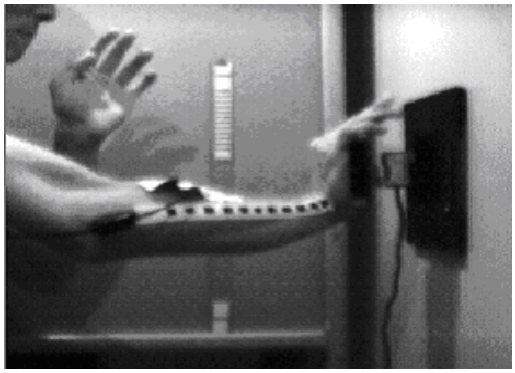

Fig. 3. Impact image taken by the High Speed Camera. The color contrasts in the forearm indicate the markers used in the analyses. The color contrasts in the ruler were used to determinate the conversion scale from pixels to centimeters.

***Physical Analyses***

The muscle power of one movement can be calculated based on how fast energy changes (Enoka, 2000). In the case of the strike the change in energy can be calculated as the kinetic energy at the instant before the impact minus the kinetic energy at the beginning of the movement. The kinetic energy at the instant before the impact can be calculated through equation (1) (Halliday et al., 1997).

$$K = \frac{1}{2} m s_b \qquad (1)$$

where, $\mathbf{s_b}$ is the hand speed just before the impact, obtained through video analyses. An instantaneous speed was approximate by the average speed in 5ms dues to limited spatial resolution (240 x 210 pixels). **m** represents the effective mass of the individual in the strike, which according to Pinto et al. (2005) is approximately 5% of the corporeal mass of the individual.

Since the initial kinetic energy is zero, we can obtain the value of the muscle power **P** with equation (2).

$$P = \frac{K}{t} \qquad (2)$$

where **t** is the change in time between the initial instant of the movement and the instant just before the impact. The values of t were obtained through video analyses.

**Results**

Table 1 summarizes the results obtained from the experiment. The number of years of training for the practitioners group ($\mathbf{t_t}$) were obtained the in the files of the martial arts school they attend. The values of corporeal mass ($\mathbf{m_c}$) were obtained in a mechanical scale with a precision of 500 grams. The mean power obtained for the trained group was 788W; the mean for the control group was 357W. The practitioners' group mean is higher than the control group with a $p= 7.10^{-6}$ obtained by the student t-test.

Table 1: Shows the averages and sample standard deviation obtained by each individual.

| Individuals | $\mathbf{t_t}$ **(years)** | $m_c$ (kg) | $\mathbf{S_b}$ **(m/s)** | t (ms) | **P (W)** |
|---|---|---|---|---|---|
| Control 1 | **0** | 92 | **4,5 +/- 0,4** | 157 +/- 4 | **400 +/- 59** |
| Control 2 | **0** | 98 | **5,0 +/- 0,3** | 150 +/- 14 | **314 +/- 74** |
| Practitioner 1 | **2** | 65 | **6,7 +/- 0,0** | 110 +/- 6 | **672 +/- 34** |
| Practitioner 2 | **2** | 80 | **8,2 +/- 0,1** | 114 +/- 4 | **1194 +/- 42** |
| Practitioner 3 | **9** | 70 | **7,4 +/- 0,1** | 115 +/- 8 | **843 +/- 88** |
| Practitioner 4 | **11** | 56 | **6,3 +/- 0,1** | 110 +/- 7 | **512 +/- 43** |
| Practitioner 5 | **19** | 82 | **6,9 +/- 0,1** | 136 +/- 3 | **718 +/- 30** |

**Discussion**

As it was expected, the power mean value for the practitioners' group was significantly greater than the control group mean value (788 W to 357 W, with $p= 7.10^{-6}$). This difference could be even more significant if the effective mass would not be standardized, since effective mass is subject to change with training (Pinto et. al., 2005). There was a significant difference between the values obtained by the two individual in the control group (p= 0,05, using student's t-test). The reason for that might be that individual Control 1 does weight lifting, and individual Control 2 is sedentary. It is clear by comparing the mean values obtained by the individual of the practitioners' group that there is no correlation between the magnitude of power values and years of training. This result indicates that, after two years of training, an individual is capable of achieving values of power (in a specific Kung Fu strike) that biologically distinguish him/herself from others.

**Conclusion**

The present methodology was efficient in obtaining power values for Yau-Man Kung Fu palm strike. The results show power values up to 1200 W and that Kung Fu adept practitioners obtained larger values compared to the control group. The paper also concludes that after a few years of training, individuality is the most determinant factor in the power magnitude of one's strikes.

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End.:Osmar Pinto Neto - Instituto de Pesquisa e Desenvolvimento, IP&D, UNIVAP
Av. Shishima Hifumi, 2911 - 12.244-000, São José dos Campos, SP, Brasil
e-mail: osmar@univap.br Tel: (55-12) 39234254

*Marcelo M. F. Saba* - Departamento de Geofísica Espacial, DGE, INPE
Av. dos Astronautas, 1758 - 12227-010, São José dos Campos, SP
e-mail: msaba@dge.inpe.br Tel: (55-12) 39456768

*Marcio Magini* - Instituto de Pesquisa e Desenvolvimento, IP&D, UNIVAP
Av. Shishima Hifumi, 2911 - 12.244-000, São José dos Campos, SP, Brasil
e-mail: magini@univap.br Tel: (55-12) 39471084

**POWER ANALYSES OF A YAU-MAN KUNG FU STRIKE**

Despite the importance of power production in human movement analyses, this is one of the least examined biomechanical parameter. This fact can be attributed to the difficulty in measuring this parameter and its abstract nature (Enoka, 2000). The present paper examines power values of several people performing Kung Fu strikes. For that, seven individuals were requested to hit a high-density rubber surface, performing Yau-Man Kung Fu "palm" strikes. A high-speed camera at a 1000 fps rate recorded all strikes. The results show power values up to 1200 W and that Kung Fu adept practitioners obtained larger values compared to the control group. The paper also concludes that after a few years of training, individuality is the most determinant factor in the power magnitude of one's strikes. **Keywords:** Muscle Power, Kung Fu, High Speed Camera

**ANALYSE DE LA CAPACITE MUSCULAIRE DU COUP YAU-MAU KUNG FU**

Malgre l'importance de la capacite de production dans l'analyse du mouvement humain, ce critere est l'un des critere les plus negliges.Cela est certainement du au fait que il a une characterisitique difficile a mesurer et de nature abstraite. (Enoka 2000). Ici, nous examinons l'utilite de la capacite musculaire de plusieurs personnes executant un mouvement de kung Fu. Ainsi, nous avons demande a sept individus de participer a l'experimentation. Pour cela, chaque individu devait donner un coup du style Yau-Mau kung Fu sur une surface epaisse en caoutchouc, pendant qu'une camera filmait chaque etape du mouvement a une rapidite de 1000 quart de secondes. Le resultat montre une valeur de capacite allant jusqu'a 1200 W et porte a conclure que les adeptes de Kung Fu ont une capacite musculaire plus eleve que ceux qui ne sont pas adeptes du Kung Fu. L'analyse prouve egalement qu'avec un certain nombre d'annees d'entrainement, l'individu lui-meme est le facteur le plus determinant de sa capacite musculaire. **- mots cles:** capacite musculaire, Kung Fu, camera rapide

**ANALIZA DE LA POTENCIA DE UNO GOLPE DE KUNG FU YAU-MAN**

A pesar de la importancia de la producción de potencia para él analiza del movimiento humano, esto es uno de los parámetros biomecánicos menos examinados. Esto puede ser atribuido a la dificultad en la medición de este parámetro y su naturaleza abstracta (Enoka, 2000). Este artículo prueba los valores de potencia de varias personas que realizan golpes de Kung Fu. Para eso, siete individuos fueron solicitados a golpear una superficie de caucho de alta densidad, realizando golpes de "palma" del Kung Fu Yau-Man. Una cámara de alta velocidad en una tasa de 1000 fps registró todos los golpes. Los resultados muestran valores de potencia hasta 1200 W y que practicantes de Kung Fu obtuvieron valores más grandes do que lo grupo controle. El artículo concluye también que después de unos pocos años de la instrucción en Kung Fu, individualidad es el factor más determinante en la magnitud de potencia de uno golpe. **Las palabras clave:** Potencia Muscular, Kung Fu, Cámara de alta velocidad

**ANÁLISE DA POTÊNCIA MUSCULAR DE UM MOVIMENTO DO KUNG-FU YAU-MAN**

Apesar do papel importante da produção de potência, este é um dos parâmetros biomecânicos menos examinados na análise de movimento humano. Essa falta de atenção pode ser atribuída em parte à dificuldade associada com a medida da potência e da natureza abstrata do parâmetro (Enoka, 2000). O presente trabalho examina valores de potências musculares de indivíduos desenvolvendo um golpe do Kung-Fu Yau-Man. Para isso, sete indivíduos foram selecionados para participar do experimento. Os indivíduos foram requisitados a fazer um golpe de Kung-Fu para acertar uma chapa de metal revestida por uma espuma amortecedora; os golpes foram filmados por uma câmera rápida a 1000 quadros por segundo. Os resultados mostram valores de potência (chegando a aproximadamente 1200 W) mais elevados para pessoas treinadas em Kung-Fu em relação a pessoas que nunca treinaram. O trabalho também conclui que a partir de um certo tempo de treinamento este passa a não ter mais relação direta com a capacidade de gerar potência. **Palavras chave:** Potência Muscular, Kung-Fu, Câmera Rápida.