# BIOMECHANICAL ANALYSIS OF THE MEN'S HAMMER THROW IN THE ATHENS 2006 I.A.A.F. WORLD CUP IN ATHLETICS*

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## Introduction

The purpose of the present research was to present the time analysis of the technique phases of the men's hammer throw in the 10th I.A.A.F. World Cup in Athletics (Athens, Greece; 17 Sept. 2006) and the relation of the time components with the hammer throw performance.

The technique of the hammer throw consists of the preparation, transition, two-legged (i.e. double) and one legged support (i.e. single support) phases and the release phase [1]. It is necessary to consider the movement structure of the athlete in order to evaluate the training process [2]. Research concerning the throws in major track and field competitions includes time analysis (i.e. the duration) of the above mentioned phases as useful information concerning the technique of the hammer throw [3-9].

## Methods

All four trials of the nine participants were recorded (right side view) with a JVC GR-DVL9600E (Victor Company, Japan) digital video camera. The best attempt of the throwers was selected for further study (Table 1).

**Table 1.** The participating athletes, the result, their personal best (PB) and the result as percentage (%SB) of the season best record (SB@2006) before the competition [10].

| Rank | Athlete | Nation | Result (m) | Trial | PB (m) | SB@2006 (m) | %SB |
|---|---|---|---|---|---|---|---|
| 1 | MUROFUSHI | JPN | **82.01** | 3 | 84.86 | 81.77 | 100.3 |
| 2 | TIKHON | BLR | **80.00** | 3 | 86.73 | 81.12 | 98.6 |
| 3 | KONOVALOV | RUS | **77.14** | 2 | 82.28 | 78.23 | 98.6 |
| 4 | KRUGER | USA | **75.53** | 4 | 79.29 | 78.52 | 96.2 |
| 5 | PAPADIMITRIOU | GRE | **74.13** | 2 | 80.45 | 77.00 | 96.3 |
| 6 | STEACY | CAN | **74.04** | 2 | 75.96 | 75.96 | 97.5 |
| 7 | HARMSE | RSA | **73.94** | 1 | 80.63 | 77.55 | 95.3 |
| 8 | RENDELL | AUS | **71.99** | 1 | 79.29 | 77.53 | 92.9 |
| 9 | EPALLE | FRA | **71.43** | 1 | 81.79 | 76.09 | 93.9 |

As widely used in time analysis studies during athletics competitions, the sampling frequency was set at 50 frames per second. Therefore, the accuracy of the present time analysis was ±0.01sec.

Data processing was accomplished using the APAS-XP software (Ariel Dynamics Inc., Trabuco Canyon, CA). In order to examine the relation between the phases of the throw and the hammer throw performance, a two-tailed Pearson Correlation was conducted using SPSS 10 (SPSS Inc, Chicago, IL).

## Results

In the 2006 I.A.A.F. World Cup in Athletics, all participating athletes utilized 4 turns for the throw, with the exception of Konovalov (RUS), who used 3 turns. Table 2 presents the time analysis for the best throw of each athlete.

**Table 2.** Duration of the single (S) and the double (D) support phases in the 1st, 2nd, 3rd and 4th turn (in seconds).

| Rank | Athlete | Result | S1 | D1 | S2 | D2 | S3 | D3 | S4 | D4 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MUROFUSHI | 82.01 | 0.30 | 0.32 | 0.24 | 0.22 | 0.22 | 0.18 | 0.24 | 0.24 | **1.96** |
| 2 | TIKHON | 80.00 | 0.32 | 0.32 | 0.22 | 0.28 | 0.22 | 0.18 | 0.26 | 0.24 | **2.04** |
| 3 | KONOVALOV | 77.14 | 0.36 | 0.28 | 0.28 | 0.20 | 0.26 | 0.26 | - | - | **1.64** |
| 4 | KRUGER | 75.53 | 0.30 | 0.36 | 0.28 | 0.24 | 0.26 | 0.20 | 0.28 | 0.24 | **2.16** |
| 5 | PAPADIMITRIOU | 74.13 | 0.34 | 0.32 | 0.24 | 0.24 | 0.26 | 0.22 | 0.24 | 0.28 | **2.14** |
| 6 | STEACY | 74.04 | 0.28 | 0.34 | 0.22 | 0.26 | 0.24 | 0.20 | 0.24 | 0.28 | **2.06** |
| 7 | HARMSE | 73.94 | 0.34 | 0.26 | 0.30 | 0.24 | 0.24 | 0.18 | 0.30 | 0.22 | **2.12** |
| 8 | RENDELL | 71.99 | 0.34 | 0.34 | 0.30 | 0.30 | 0.24 | 0.24 | 0.22 | 0.30 | **2.28** |
| 9 | EPALLE | 71.43 | 0.40 | 0.36 | 0.36 | 0.16 | 0.34 | 0.20 | 0.28 | 0.32 | **2.42** |

The 1st place athlete completed the 4 turns in the fastest time (1.9 sec), while the 9th in the slowest (2.4 sec). A strong negative correlation ($r$= -.82; $p$= .01) was revealed between the official distance and the total duration of the 4 turns (Figure 1). Strong negative correlation was also observed between the official distance and the duration of the 3rd ($r$= -.89; $p$< .01) and the 4th turn ($r$= -.74; $p$< .05).

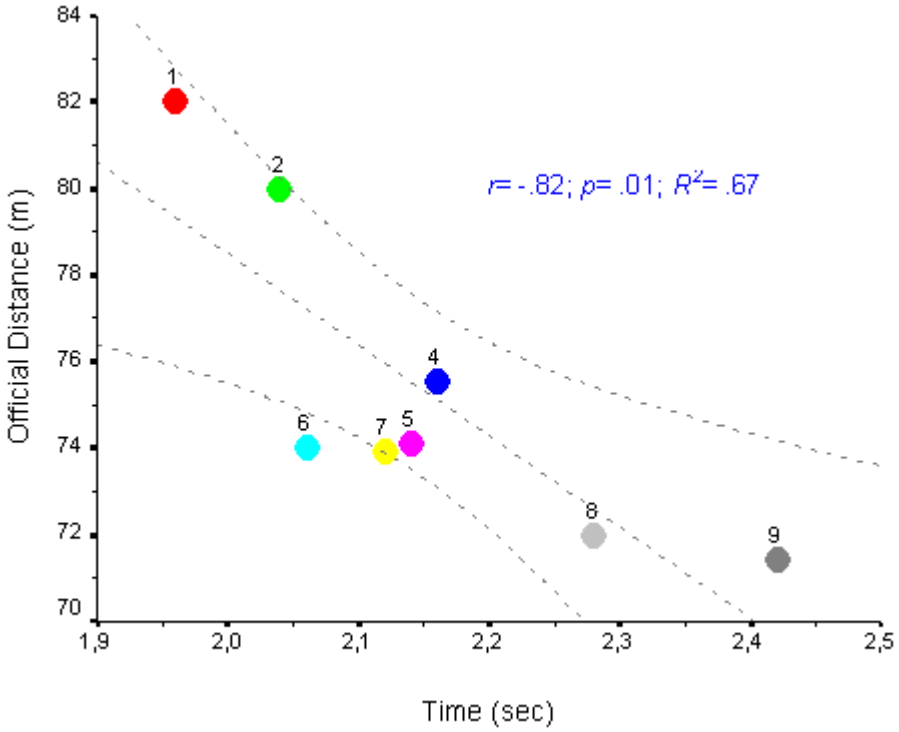


**Figure 1.** The relationship between hammer throw performance and the duration of the 4 turns. The slashed curves indicate the 95% confidence interval; the numbers in the graph indicate the ranking of the athlete.

Differentiations were noticed concerning the distribution of single and double support phases in each turn (Table 3). It can be documented that only the single support phase in the 3rd turn was longer for all the throwers using 4 turns. An average 55.9% vs. 44.1% was observed in the 3rd turn concerning the single and double support respectively.

**Table 3.** Percentage (%) of the double (D) support phases within the 1st, 2nd, 3rd and 4th turn.

| Rank | Athlete | Result | %D1 | %D2 | %D3 | %D4 |
|---|---|---|---|---|---|---|
| 1 | MUROFUSHI | 82.01 | 51.6 | 47.8 | 45.0 | 50.0 |
| 2 | TIKHON | 80.00 | 50.0 | 56.0 | 45.0 | 48.0 |
| 3 | KONOVALOV | 77.14 | 43.8 | 41.7 | 50.0 | - |
| 4 | KRUGER | 75.53 | 54.5 | 46.2 | 43.5 | 46.2 |
| 5 | PAPADIMITRIOU | 74.13 | 48.5 | 50.0 | 45.8 | 53.8 |
| 6 | STEACY | 74.04 | 54.8 | 54.2 | 45.5 | 53.8 |
| 7 | HARMSE | 73.94 | 43.3 | 46.4 | 40.9 | 42.3 |
| 8 | RENDELL | 71.99 | 50.0 | 50.0 | 50.0 | 57.7 |
| 9 | EPALLE | 71.43 | 47.4 | 30.8 | 37.0 | 53.3 |

Despite the differences in the total duration, a common pattern concerning time distribution among the turns was observed, since the throwers used approximately 31% of the time for the 1st turn, 24% for the 2nd, 21% for the 3rd and 24% for the 4th turn and the release of the hammer (Figure 2).

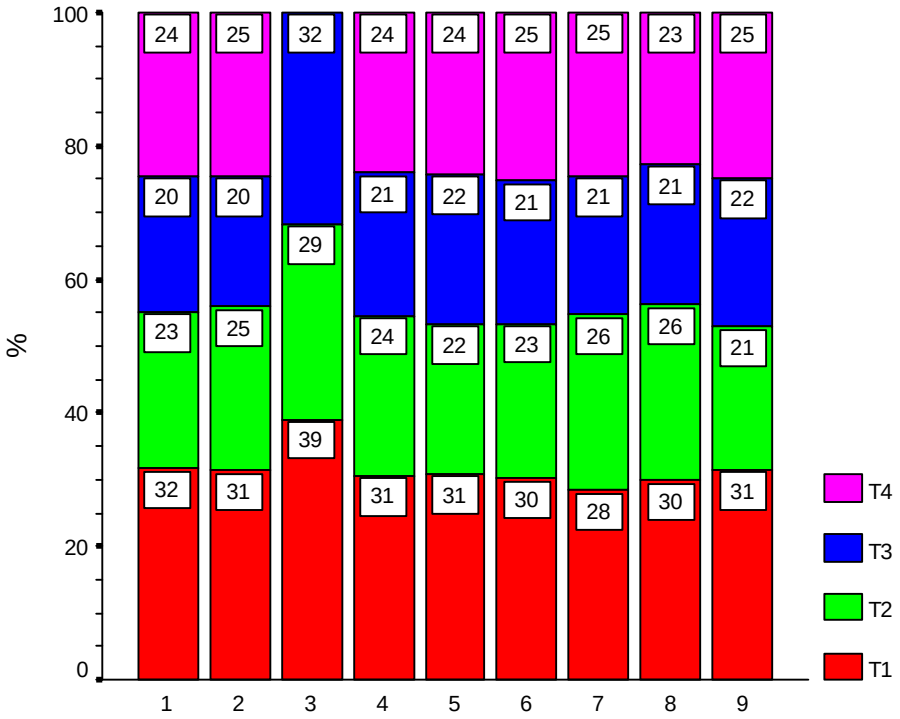


**Figure 2.** The duration of each turn (T) as percentage of the total duration of the turns. The athlete ranked 3rd (Konovalov, RUS) used 3 turns.

## Discussion

The total duration of the hammer throw in the present study (1.96 – 2.42 sec) was in agreement with those (1.81 – 2.50 sec) reported from the Athens 1982 European Championships [3], the Rome 1987 World Championships [4], the Seoul 1988 Olympic Games [5], the Göteborg 1995 World Championships [6], the Seville 1999 World Championships [8] and the Szombathely 2003 IAAF World Athletic Final [9]. With respect to the above mentioned studies, small

alterations were observed for the 2nd turn (1% shorter duration in 2006), the 3rd turn (1% shorter in 2006) and the 4th turn (2% longer in 2006).
The correlation between the throwing distance and the duration of the throw indicated that the better throwers could turn with greater speed, as reported by Morriss & Bartlett [11]. However, the correlation coefficient was lower in the present study (-.74 vs -.95 in the Morriss & Bartlett study).
On the other hand, it is worth mentioning that the duration of the double support phase within the first three turns, expressed as percentage of the duration of the turn, was smaller in the present study than in the previous studies mentioned. The analysed athletes (compared to the athletes reported above) were for an average 50.0% (53.3%) on double support in the 1st turn, 47.8% (48.6%) in the 2nd and 44.5% (47.0%) in the third. The athletes competed in 2006 had a larger percent for the double support only in the 4th turn (50.6% vs 48.1%). This difference can be attributed to the lower level of athletes analysed in this study (mean result: 75.58m±3.55), compared to the athletes analysed in 1982, 1987, 1988, 1995, 1999 and 2003 (80.29m±1.94). Due to the fact that the hammer is accelerated during the double support phases [1], this finding must be taken into consideration. A 55% ratio between the double support phase and the total turning time is recommended [12].
In conclusion, the athlete needs realizable guidelines for individual movement patterns for a positive orientation in technique training [2]. In order to fulfil this demand, track and field coaches must have in mind the following main technical requirements [3]:

1. Reduction of the duration of the single support phases by
   a) tilting backwards during the first half of the double support phase,
   b) using the second half of the double support phase for a fast rotation,
   c) rotating the free leg close to the support leg,
   d) placing the free foot behind and on the right of the supporting leg.
2. Use of the 4th turn for increasing the dynamic parameters of the athlete-hammer system by breaking the movement in the horizontal level.
3. The duration of the acceleration in the double support phase rather than the maximum acceleration is the factor that improves the final throwing distance.

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**Author's biography**

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**Figure 3a.** A.G. Kruger (USA, 4th; 75.53m, 4th attempt): From the preliminary swings to the single support phase in the 2nd turn.


**Figure 3b.** A.G. Kruger (USA, 4th; 75.53m, 4th attempt): From the single support phase in the 2nd turn to the single support phase in the 4th turn.


**Figure 3c.** A.G. Kruger (USA, 4th; 75.53m, 4th attempt): From the single support phase in the 4th turn to the recovery phase.