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Abstract

The study obtained performance results for a total of 93 men’s hammer throwers who participated in major championships (Olympic Games or International Association of Athletics Federations [IAAF] World Championships) between the years 2008–2017. Data was analyzed to find performance trends in the finals of these championships relative to age, number of previous major championship appearances, seasonal best, and the average of the three best competition results for a given season. Downward trends were found for all of these metrics in the time period studied. Correlations coefficients were generated for six different variables (age, number of major championships appearances, seasonal best, best three-meet average, result in qualifying, and performance quotient of qualification round [PQ_{qualification}]) in relation distance thrown in the final and PQ_{final}. The strongest correlations to finals performance were found be with actual distance thrown in the qualifying round (r = .6493, p < .00001), the average of the three best competition results of the year leading in to championships (r = .5682, p < .00001), and the seasonal best performance (r = .5244, p < .00001). There was also a strong correlation found between the PQ_{qualification} and the PQ_{final} (r = .5317, p < .00001). Results from this study may be useful in guiding coaches, athletes, and federations in their preparation for future major championships in men’s hammer throw.

Keywords: hammer, prediction, Olympics, championship, men
Introduction

The hammer throw is one of four throwing events (hammer, shot put, discus, and javelin) that is regularly contested in the event program for the sport of track and field. The Olympic Games and International Association of Athletics Federations (IAAF) World Championships are considered the two most important competitions for the hammer throw at the sports highest level (Mack, 2016). In both of these events, the world’s top 32 competitors are invited to compete for the gold medal, which is considered the sport’s highest honor. There have been a number of studies that have examined various aspects of throwing performance in all four of these throwing events with many of these investigations having directed their effort on determining what performance metrics are correlated with throwing performance. The majority of these studies have been focused on the relationship between biomechanical factors, such as release speed, release angle, and height of release, to describe the elements of throwing performance (Badura, 2010; Gutierrez, Soto, & Rojas 2002; Isele & Nixdorf, 2010; Morriss, Bartlett, & Fowler, 1997; Murakami, Tanabe, Ishikawa, & Ito, 2017). Additionally, a number of researchers have also examined the correlation between throwing performance and weight lifting exercises (Judge & Bellar, 2012; Judge, Bellar, McAtee, & Judge, 2010; Judge et al., 2011), or specific strength exercises (Bondarchuk, 2007; Bondarchuk, Ivanova, & Vinnichuk, 1977; Karampatos, Korfias, Zara, Georgiadis, & Terzis, 2017). However, there is a paucity of research relative factors that may predict performance specifically in the Olympic Games or World Championships.

With regard to elite competitions (World Championships and Olympic Games) there is only a small amount of research that has attempted to quantify variables associated with success, or identify predictors of performance outcomes. In one of the initial pieces of research on quantifying variables for success, Ward, Morrow, Omizo, and Michael (1979) reported that self-report personality measures showed little benefit as predictors of success for Olympic level athletes in the four throwing disciplines. In another study focusing on performance prediction, Pilianidis, Mantzouranis, Kyriakoulakis, Proios, and Kotzamanidis (2012) used regression analysis to chronicle high prediction of performance accuracy in the men’s throwing events at the Mediterranean Games. The intent of this research was to provide coaches with information to help design training programs for success at the subsequent Mediterranean Games in 2013. The researchers reported that the men’s hammer throw specifically had the highest prediction validity of all the throwing events. With a similar focus on performance prediction, Zhang, Qin, Xu, and Zeng (2011) used document and mathematical statistics to predict the gold medal winning performance for the women’s shot put in the 2012 Olympic Games, based on gold medal performances from the previous five Olympic Games between 1992–2008. As with the case of Pilianidis et al., the motivation for this study was to provide information to guide a planning model for Chinese shot putters in preparation for the 2012 London Olympics. In retrospect, this study underestimated the winning throw by nearly 70 cm, but with a subsequent doping disqualification for the winner, it was adjusted to 33 cm.

In a different line of investigation, Pavlovic and Idrizovic (2014) undertook a study to determine the difference in results between


male and female javelin finalists at the London Olympic Games in 2012. The researchers also sought to see if the performances in the qualifying rounds were significantly related to results in the final rounds for both genders. No statistical differences were found for each gender’s performance from the qualifying to final rounds, however, it was observed that, surprisingly, only 33% of the competitors threw better in the final than in qualifying. This led the researchers to suggest that further investigation into the cause for this drop in performance was warranted.

There are some unique factors to the men’s hammer throw’s development that make the nature of the future performance prediction distinctly different from the other men’s throwing events. Over the past five decades, hammer throw technique has evolved significantly as an event with the advent of “modern” hammer technique pioneered by the throwers of the Soviet Union in the 1970’s and 1980’s (Babbitt, 2003). Men’s hammer performance levels reached a crescendo in the late 1980’s and early 1990’s with throwers such as Iouri Sedykh and Sergey Litvinov throwing in excess of 86 meters. Top standards remained well above the 80-meter level through the 1990’s and into the early 2000’s. However, unlike the majority of the men’s throwing events, hammer performance levels have begun to decline over the past decade, and it is now a rare exception to have a thrower performing over the 80-meter level.

The purpose of this study was to identify the current performance trends for the men’s hammer throw at the major championships over the past 10 years, in order to contrast and compare with the body of research in this area, and to shed a brighter light on the impact of various performance metrics for the event. In addition, calculations were made to identify significant correlations between selected variables going into competition to assess any significant influence they had on performance. Given the apparent regression of men’s hammer performance over the past 10 years, it was hoped that key indicators, such as age, championship experience, and previous performance, could be tested so that coaches and athletes, alike, will be better able to predict, select, and prepare training for greater success in men’s hammer at the major championships. It is hypothesized that factors such as age, championship experience, and previous performance will be statistically significant predictors of major championship performance.

**Methods**

The study obtained performance results for a total of 93 men’s hammer throwers who participated in major championships (Olympic Games or IAAF World Championships) between the years 2008–2017. Performances by athlete’s who had failed doping tests at any of these competitions were not considered for the study. The performance data was derived from competition results from both the official IAAF (n.d.) and Tilastopaja (n.d.) websites. Data for each athlete who competed in the final of each championship were recorded for age, number of major championship appearances, qualification performance, final performance, season best, and the average for the three best competition results for that given year. Additionally, a performance quotient \((PQ)\) was calculated for both the qualification and final rounds for each major championship in order to quantify how well they performed to their potential based on their seasonal results going into the championship. \(PQ\) was calculated
by dividing the distance thrown in either the qualification round ($Q$) or final round ($F$) of the championship by the average of the three best competition results for that season ($X$) using the following formulas.

$$PQ_{\text{qualification}} = \frac{Q}{X} \text{; } (1)$$

$$PQ_{\text{final}} = \frac{F}{X} \text{. } (2)$$

Units for the $PQ$ would be expressed as a percentage. A score of 100% (expressed as 100.0) would be earned if the qualifying or final performance would be equal to the average of the three best competition results for the given season. The best three-meet average ($X$) was calculated by dividing the sum of the three best competition results ($x_1$, $x_2$, $x_3$) for a given season by the number of competitions (three) as shown in the following equation:

$$X = \frac{1}{3} (x_1 + x_2 + x_3). \text{ } (3)$$

Averages were then tallied for age, number of major championship appearances, qualification result, final result, season best ($SB$), best three-meet average ($X$), qualification $PQ$, and final $PQ$ for the competitor groups for each major championship for the years that were studied. Calculations of Pearson’s correlation coefficient for six different variables (age, number of major championships appearances, seasonal best, best three-meet average, result in qualifying, and $PQ_{\text{qualification}}$) in relation distance thrown in the final and $PQ_{\text{final}}$. A current statistical software package (IBM SPSS Statistics Version 25.0) was used to perform the analysis and statistical significance was set at $p < .05$.

## Results

Data collected (final result, qualifying result, age, major championship appearances, seasonal best, and the average of the three best competition results) from the results for the finalists in all the major outdoor track and field championships from 2008 to 2017 were averaged and presented in Tables 1 and 2. The performance quotients for both the qualification and final rounds were also calculated and averaged. These appeared to remain steady through this time period (see Tables 1 and 2). As could be expected, the performance quotients were slightly higher for the final round compared with the qualifying round due to the three extra attempts awarded in the final round for the top eight throwers, and the desire to achieve a maximum result by all finalists as opposed to a fixed qualifying result. Results for the average qualifying mark, final mark, and seasonal best were plotted on a chart and trend lines were calculated and presented in Figure 1 to show the downward trend in hammer performance over the past 10 years. The linear trend lines in Figure 1 clearly highlight a steady decline of nearly two meters for each performance category over the past 10 years for the average result of these three variables. Negative trend lines were also observed for age (Figure 2), major championship appearances (Figure 3), and $PQ_{\text{qualification}}$ and $PQ_{\text{final}}$ (Figure 4).

Tests were performed for Pearson’s correlation coefficient ($r$) for six different variables (age, number of major championships appearances, seasonal best, best three-meet average, result in qualifying, and $PQ_{\text{qualification}}$ in
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The results of the correlations were reported in Table 3 in descending order from highest to lowest correlation between variables. The strongest correlations to finals performance were found with actual distance thrown in the qualifying round ($r = .6493$, $p < .00001$), the average of the three best competition results of the year leading in to championships ($r = .5682$, $p < .00001$), and the seasonal best performance ($r = .5244$, $p < .00001$). There was also a strong correlation found between the $PQ_{qualification}$ and the $PQ_{final}$ ($r = .5317$, $p < .00001$). Positive correlations of statistical significance were also found between the number of major championship appearances and the performance in the final ($r = .3094$, $p < .01$) and the $PQ_{final}$ ($r = .3196$, $p < .01$). Conversely, statistically significant negative correlations were found between both the seasonal best ($r = - .2773$, $p <$
Figure 1. Trends in men’s hammer performance at major championships between 2008 and 2017.

Figure 2. The trend-line for average age of the major championship finalists in men’s hammer from 2008 to 2017.
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Figure 3. The trend-line for the average number of previous major championship appearances of the major championship finalists in men’s hammer from 2008 to 2017.

Figure 4. The trend-lines for the performance quotients for the qualifying ($PQ_{\text{qualifying}}$) and final ($PQ_{\text{final}}$) rounds.
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.01) and the average of the three best competition results of the year leading into championships ($r = -.2582, p < .05$) and the $PQ_{final}$. The negative correlations would be expected given that athletes who are performing better going into the major championships would register a lower $PQ_{final}$ compared to an equal performance in the final from a competitor with a lower seasonal best or $X$. Finally, positive correlations were also found for an athlete’s age (r = .1615) and the distance thrown in the qualifying and the $PQ_{final}$ ($r = .2509, p < .05$). No statistical significance was found between a competitor’s age ($r = .1615$) or the $PQ_{qualification}$ ($r = -.0878$) and the performance in the final.

### Discussion

The purpose of this study was to highlight the current performance trends for the men’s hammer throw at the major championships over the past 10 years, and to test the significance of selected performance metrics for the event. More specifically, in depth analysis was conducted to uncover significant correlations between selected variables going into the major competitions in order to assess any significant influence they had on performance. A small portion of the overall analysis was conducted to see whether performance in the qualifying rounds would play a significant role in the performance in the final round.

Statistical analysis revealed the distance thrown in the qualifying round did have the highest correlation with performance in the final round of all the variables that were studied ($r = .6493$). In an analysis of similarly related variables, the relationship between the $PQ_{qualification}$ and the $PQ_{final}$ also displayed statistical significance. This supports the assumption that the competitors who were performing the best, both in terms of $PQ$ and actual distance thrown in the qualification rounds, would be more likely to produce the

<table>
<thead>
<tr>
<th>Relationship of correlation</th>
<th>$r$</th>
<th>$R^2$</th>
<th>$N$</th>
<th>Significance</th>
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</thead>
<tbody>
<tr>
<td>Distance in $Q$ vs. Result in final</td>
<td>.6493</td>
<td>.4222</td>
<td>93</td>
<td>$p &lt; .00001$</td>
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<tr>
<td>Best 3-meet average vs. Result in final</td>
<td>.5682</td>
<td>.3299</td>
<td>93</td>
<td>$p &lt; .00001$</td>
</tr>
<tr>
<td>$PQ_{in qualifying}$ vs. $PQ_{in final}$</td>
<td>.5317</td>
<td>.2827</td>
<td>93</td>
<td>$p &lt; .00001$</td>
</tr>
<tr>
<td>Seasonal best vs. Result in final</td>
<td>.5244</td>
<td>.2750</td>
<td>93</td>
<td>$p &lt; .00001$</td>
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<tr>
<td>Major championship appearances vs. $PQ_{in final}$</td>
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<td>Major championship appearances vs. Result in final</td>
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<tr>
<td>Age vs. $PQ_{in final}$</td>
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<td>.0706</td>
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<tr>
<td>Best 3-meet average vs. $PQ_{in final}$</td>
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<td>.0667</td>
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<td>Distance in $Q$ vs. $PQ_{in final}$</td>
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<tr>
<td>$PQ_{in qualifying}$ vs. Result in final</td>
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<td>.0077</td>
<td>93</td>
<td>NS</td>
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Note. $Q =$ qualifying round; $PQ =$ performance quotient; NS = not significant.

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In conclusion, this investigation showed that the variables of age, major championship experience, and seasonal performance (both SB and X) going into the major championship displayed a significant positive correlation with performance in the finals of the major championships. These results support the hypothesis that the factors of age, major championship experience, and seasonal performance would be statistically significant predictors of major championship performance. Given these results, federations may want to take these factors into account when selecting participants for a major
championship in the men’s hammer throw. While these may not be the only factors to consider, they could be among the most important when taking all variables into account. Beyond the statistical analysis of the various performance metrics with hammer performance at the major championships, it is striking how the performance trends for the actual throwing results project a downward slope. Since the 2008 Olympic Games, the average performance for the men’s hammer finalists in both the qualifying and final rounds has diminished by over 2 m (see Table 1). A corresponding drop of nearly 2 m has also been seen for both the seasonal best and the average for the three best meet results within a given season (see Table 2).

It is very clear that the overall level of elite hammer performance has dropped all together in the last 10 years. Potential causes for this drop could entail the followings: (1) less support for men’s hammer throwing from traditionally strong hammer throwing federations, (2) increased and stricter drug testing policies, (3) a retirement of a large number of high-level hammer throwers who have maintained a high standard for a long time, and (4) decreased interest and ability to stay in sport by high-level competitors due to the relegation of the hammer from the Golden/Diamond League, and fewer professional prize money opportunities. Further qualitative research will be necessary to study the comprehensive impact of these variables on men’s hammer performance worldwide. It is quite possible that a further decline in men’s hammer performance may continue if these developments are to continue. Member federations may want to take into account these trends when making high performance decisions and plan accordingly.

References

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