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Seed advantage in sport competitions: the case of professional judo

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ORIGINAL PAPER

Abstract

The aim of this paper was to quantify the advantage granted to seeds in the case of professional judo knockout competitions. We used Monte-Carlo simulations to compute statistics including the probability of winning the competition, reaching the final or winning a medal in a standard draw compared to a random draw. We showed that the advantage given to seeds is often significant. As a result, misclassification in the ranking list is at a great disadvantage for top athletes that are not seeded. Interestingly, the advantage given to seeds appears robust as a function of parameters, such as sex or number of athletes, and modelling assumptions. Simulation is a flexible tool for athletes to take decisions in managing their position in the ranking list and to optimize their probability of success in major events.
Keywords: Martial arts; combat sports; judo; ranking; Monte-Carlo simulation; competition; seed.

Ventaja de ser cabeza de serie en competiciones deportivas: el caso del judo profesional

Resumen

El objetivo de este trabajo fue cuantificar la ventaja de ser cabeza de serie en competiciones de judo profesional disputadas por sistema de eliminatorias. Utilizamos simulaciones Monte-Carlo para la estadística, incluyendo la probabilidad de ganar la competición, llegar a la final o ganar una medalla, a partir de un sorteo de competición estándar o aleatorio. Mostramos que la ventaja de los cabeza de serie es, a menudo, significativa. Como resultado, una clasificación errónea en el ranking supone una gran desventaja para los mejores atletas que no son cabeza de serie. Curiosamente, la ventaja de los cabezas de serie es sólida al considerar variables como sexo, número de atletas y suposiciones del modelo. La simulación es una herramienta flexible que permite a los atletas tomar decisiones relativas a la gestión de su posición en el ranking y optimizar sus probabilidades de éxito en grandes competiciones.
Palabras clave: Artes marciales; deportes de combate; judo; clasificación; simulación Monte-Carlo; competición; cabeza de serie.

Vantagem do cabeça-de-chave nas competições desportivas: o caso do judo profissional

Resumo

O objetivo deste trabalho foi quantificar a vantagem de ser cabeça-de-chave em competições profissionais de judo disputadas pelo sistema eliminatório. Usamos simulações de Monte-Carlo para calcular estatísticas, incluindo a probabilidade de vencer a competição, chegar à final ou ganhar uma medalha num sorteio de competição padrão ou aleatório. Mostramos que a vantagem semeada é muitas vezes significativa. Como resultado, a classificação incorreta no ranking coloca os melhores atletas não cabeça-de-chave em grande desvantagem. Curiosamente, a vantagem do cabeça-de-chave é robusta ao considerar parâmetros como sexo, número de atletas e suposições do modelo. A simulação é uma ferramenta flexível que permite aos atletas tomar decisões quanto à gestão de sua posição no ranking e otimizar as suas chances de sucesso em grandes competições.
Palavras-chave: Artes marciais; desportos de combate; judo; ranking; simulação de Monte-Carlo; concorrência; semeando; cabeça-de-chave.

1. Introduction

The outcome of a match between a champion and a challenger is always random and subject to the laws of probability. Uncertainty of the outcome is the reason why sport is so exciting to watch and to practice. Technical errors, injuries or simply a bad day may benefit the challenger when he or she faces the champion. As a result, prediction is often poorly accurate (Franchini & Julio, 2015).

Ranking positions are essential to understand performance in judo because they are used to qualify athletes for major championships such as Olympic Games and World Championship and are the basis for seeding athletes in international tournaments. Krumer (2017) has estimated contest

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winning probabilities from the ranking of athletes and other features such as home advantage and history in head-to-head fights. Other studies (Breviglieri et al., 2018; Courel-Ibáñez et al., 2018; Julio et al., 2013) have confirmed that the judo world ranking was a key predictor of individual judo contests. Daniel and Daniel (2013) have shown that the top eight athletes in the ranking list were predicting medal winners at the 2012 London Olympic Games with an accuracy as high as 81%. Recently, Maçaneiro et al. (2021) have also confirmed that the judo world ranking was a good predictor for mixed team match outcomes.

In judo, a knockout draw serves as the structure of competitions. Because seeds cannot fight each other before the quarterfinal, they have an increased probability to reach this level of the tournament. We used Monte-Carlo simulations to compare the probability distributions of the performance of each athlete in both standard and random draws, and then to quantify the advantage given to seeds. The impact of seeding systems on tournament outcomes has already been the focus of several studies. For instance, Searls (1963) computed numerical values of tournament winning probabilities for each athlete. He could then compare the effect of the initial draw on these probabilities, and the impact of misclassification of the players. Schwenk (2000) emphasized the flaws of standard seeding procedures and proposed a fair seeding system. Based on pairwise winning probabilities proposed by Jackson (1993), Marchand (2002) provided comprehensive numerical results comparing the standard draw and the random draw. He showed that seeding had a rather limited impact on tournament winning probabilities. More recent papers (Daniel & Daniel, 2013; Guilheiro & Franchini, 2017) analysed the probabilities that seeds win a medal in major judo tournaments.

There is a need to explore the advantage given to seeds and better understand the consequences of not being ranked conveniently. For instance, two Olympic gold medallist Teddy Riner was not seeded at the 2020 Tokyo Olympic Games, and he failed to win his third Olympic gold medal. Is this result the consequence of not being seeded? Nobody would say so but Riner was clearly at a disadvantage by not being seeded. As seeding is based on ranking, seed advantage quantification is likely to help athletes build their tournament participation strategy across the season, in particular prior to a major event. For instance, an athlete may be a seed in a Grand Prix tournament (awarded 700 points for the ranking list to the winner) and not in a Grand Slam (awarded 1000 points for the ranking list to the winner). There is a trade-off between points awarded in each tournament to climb the ranking list and probabilities to get these points. The decision to participate to the first tournament or to the second (or to both tournaments) depends on physiological or health criteria, as well as expected rewards based on winning probabilities.

The main goal of this study was to quantify the benefit given to seeds in the standard draw compared to the random draw. We also computed the disadvantage given to some top athletes that are not seeded. Finally, as our statistics were based on modelling individual contest winning probabilities, we assessed the robustness of the seed advantage estimation relative to modelling assumptions. We computed our analytics in the context of professional judo. The main hypothesis of this paper was to assume that contest outcomes in the simulation were independent Bernoulli random variables with parameters of winning probabilities given by Krumer (2017).

2. Material and method

Modelling sport outcomes with probabilities leads to a better understanding of the interplay between the main factors of performance. In the field of tennis, Carter and Crews (1974) have computed match winning probabilities as a function of point winning probabilities. Other studies have focused on tournament winning probabilities computed from Monte-Carlo simulations such as Clarke and Dyte (2000) in the context of tennis and Ross and Ghamami (2008) in a general context.

We performed two Monte-Carlo simulations, one with a standard draw, another one with a random draw. We estimated the probability of any kind of competition outcome (for instance athlete ranked number 5 wins a bronze medal) by running many simulations. This was done in a three-step approach:

- the first step was to generate the draw. A random draw is the result of sampling the athletes at random without replacement. If athletes are seeded, the draw is a standard draw and is generated so that seeds cannot fight each other before the quarterfinal, as described in subsection 2.1.

- the second step consisted in generating the outcomes of each individual contest as described in subsection 2.2.
- the third step was to compute for each simulation the outcomes of the tournament and the statistics of these outcome as described in subsection 2.3.

2.1. Generating the elimination draws

The direct knockout draw is the most common elimination bracket in sport competitions. The winner of each contest of round one is qualified for the next round. This elimination system divides the number of competitors by a factor 2 at each round up to the final where the two finalists compete for gold. In judo competitions, additional repechage draws allow competitors that loose at an early stage to continue and fight for a bronze medal. In the grand slam tournaments, continental, World and Olympic Championships, the International Judo Federation has now chosen a direct knockout system up to the quarterfinal and the athletes defeated in the quarterfinal enter two repechage draws (IJF, 2019).

The initial draw is not set at random. The top eight athletes in each weight category are seeded based on their IJF position in the world ranking order (or Olympic ranking list for the Olympic Games). Seeding aims at separating the strongest competitors, so that they do not fight each other at an early stage of the tournament. Athletes seeded number 1 and 8 are part of pool A, number 4 and 5 in pool B, number 2 and 7 in pool C, number 3 and 6 in pool D. For example, the best two players should not fight each other until the final, the top four until the semi-finals and the top eight until the quarterfinals. The other athletes are sampled at random in the initial draw (IJF, 2019).

Contrary to the standard draw, top athletes in a random draw may be opposed as soon as first round. In this study, we generated the standard draw by positioning the 8 seeds as described above and sorting all the other athletes at random. Athletes were all sorted at random in the random draw.

2.2. Generating individual contest outcomes

In judo, the statistics of victories between two given athletes are scarce and many of them have never fought each other. A model is then necessary to infer winning probabilities from observations; this is what Krumer (2017) has achieved. He calibrated a logistic formula upon a database of 1,902 male and 1,400 female judo fights. He found that the winning probability of *judoka* ranked r_1 against *judoka* ranked r_2 was given by Equation 1:

$$P(r_1, r_2) = \frac{1}{1+e^{-\beta(\log_2 r_2 - \log_2 r_1)}} = \frac{1}{1+\left(\frac{r_1}{r_2}\right)^{\beta/\ln 2}} \qquad (1)$$

Krumer estimated the parameter $\beta = 0.509 \pm 0.027$ for male and $\beta = 0.533 \pm 0.032$ for female. The parameter β is smaller for male than for female, meaning that the level of athletes in male competitions is more homogeneous than for female. Krumer provided other formulas including additional features such as home advantage, number of previous head to heads or weight category. In this study, we used the model of Equation 1 for individual winning probabilities. The winner of a fight for each simulation was the trial of a Bernoulli random variable with parameter $P(r_1, r_2)$, where r_1 and r_2 were the ranks of the respective opponents. As a competition involves many fights, we assumed that all the trials were independent to each other. Such assumptions have already been done in other papers to address performance in competitions, for instance in Maçaneiro et al. (2021)

2.3. Generating tournament outcomes

The third step was to simulate all the bouts of the competition. A similar approach has already been implemented by Clarke and Dyke (2000) in the case of tennis. Appleton (1995) also implemented a Monte-Carlo simulation to assess the ability of various croquet tournament structures to make the best player win the tournament.

By running enough of such simulations, we estimated the probability of several types of events. The estimate $\hat{p}_A$ of the probability of event A equals the number of times event A is observed in the simulations divided by the total number N of simulations (Equation 2).

$$\hat{p}_A = \frac{1}{N}\sum_{k=1}^{N} 1_{\{A_k\}} \qquad (2)$$

where $(A_1, \dots, A_N)$ is a sample drawn along the law of the random event A. The variance of $\hat{p}_A$ is of order $\hat{p}_A(1-\hat{p}_A)/N$; then, the statistical error on the estimated probability of event A is upper bounded by $1/2\sqrt{N}$. In sports, we can consider that an accuracy of 10^{-3} is enough for probability estimation, meaning that the number of simulations does not need to be larger than $N = 10^6$ to reach the required accuracy of the estimates. All the simulations of this paper were run with $N = 10^6$.

3. Results

To address the question of the advantage given to seeds, we have estimated the probabilities that a given event A occurs under the standard draw and the random draw. We called these estimated probabilities $\hat{p}_S(A)$ and $\hat{p}_R(A)$ respectively. The advantage given by the standard draw was then equal to the difference $\hat{p}_S(A) - \hat{p}_R(A)$. When this quantity was negative, it was the sign of a disadvantage.

3.1. Size of the advantage given to seeds

For the athlete ranked number k, we computed the probabilities to get a gold medal (event called G_k), to reach the final (event called F_k), to reach the semi-final (event called SF_k), to reach the quarterfinal (event called QF_k), to get a bronze medal (event called B_k), to reach the fifth place of the tournament (event called 5_k) or to get a medal (event called M_k).

The number of athletes in international tournaments is generally around 32, sometimes less. However, they are often above 64 and up to 100 in World Championships. In this paper, we considered that the number of athletes in a tournament was either equal to 32, 64, or 128.

Table 1 gives the probabilities for the top 10 athletes in a male tournament with 32 *judokas* in a standard draw and Table 2 gives the probabilities in a male tournament with 32 *judokas* in a random draw. We see that $\hat{p}_S(G_1) = 39.7\%$ and $\hat{p}_R(G_1) = 36.6\%$. The advantage given to the top ranked athlete is equal to 3.1%. This probability drops to 1.5% for the athlete ranked number 2. The winning probabilities of *judokas* ranked 5 to 8 decrease under the standard draw (for instance $\hat{p}_S(G_7) = 2.8\%$ whereas $\hat{p}_R(G_7) = 3.0\%$). However, these *judokas* benefit from the seeding system if we consider the probability to get a medal (for instance $\hat{p}_S(M_7) = 19.2\%$ whereas $\hat{p}_R(M_7) = 17.5\%$). Figure 1 shows the advantage generated by seeding is shaped with the rank of the athletes. This figure is obtained from the results exhibited in Tables 1 and 2. It reveals the low impact for winning the gold medal (blue curve). Conversely, the advantage to reach the quarterfinal is quite stable for all seeded athletes and drops suddenly to negative values for non-seeded athletes (orange curve). Finally, the advantage to win a medal decreases almost linearly with the rank of the athlete.

Table 1. Statistics for male standard draw tournaments with *N*=32.

Rank	G (%)	F (%)	SF (%)	QF (%)	B (%)	5th (%)	M (%)
1	39.7	55.0	68.5	79.7	19.2	3.7	74.1
2	19.2	36.2	54.0	69.7	21.6	7.6	57.9
3	11.1	24.0	42.5	62.4	21.3	10.9	45.3
4	7.4	14.9	37.5	56.7	22.2	12.9	37.1
5	5.0	13.0	27.1	52.1	15.6	13.9	28.5
6	3.8	8.8	25.8	48.2	15.8	14.4	24.6
7	2.8	8.3	17.9	45.0	11.0	13.4	19.2
8	2.1	5.6	11.4	42.2	9.8	12.9	15.3
9	1.4	4.1	10.9	25.0	6.5	7.6	10.6
10	1.1	3.5	9.6	23.2	5.7	7.2	9.2

Note. G=gold, F=finalist, SF=semi-finalist, QF=quarterfinalist, B=bronze, M=medallist.

Table 2. Statistics for male random draw tournaments with N=32

Rank	G (%)	F (%)	SF (%)	QF (%)	B (%)	5th (%)	M (%)
1	36.6	47.8	59.9	72.8	10.3	2.0	58.1
2	17.7	29.4	43.6	60.1	12.1	3.7	41.5
3	10.7	20.5	34.2	51.9	12.1	4.9	32.6
4	7.3	15.4	28.1	46.0	11.6	5.7	27.1
5	5.2	12.1	23.7	41.3	10.9	6.3	23.0
6	3.8	9.7	20.5	37.7	10.2	6.7	19.9
7	3.0	8.0	17.8	34.6	9.5	6.9	17.5
8	2.4	6.8	15.8	32.0	8.9	7.1	15.7
9	1.9	5.7	14.1	29.7	8.3	7.3	14.0
10	1.6	5.0	12.7	27.8	7.8	7.3	12.8

Note: G=gold, F=finalist, SF=semi-finalist, QF=quarterfinalist, B=bronze, M=medallist.

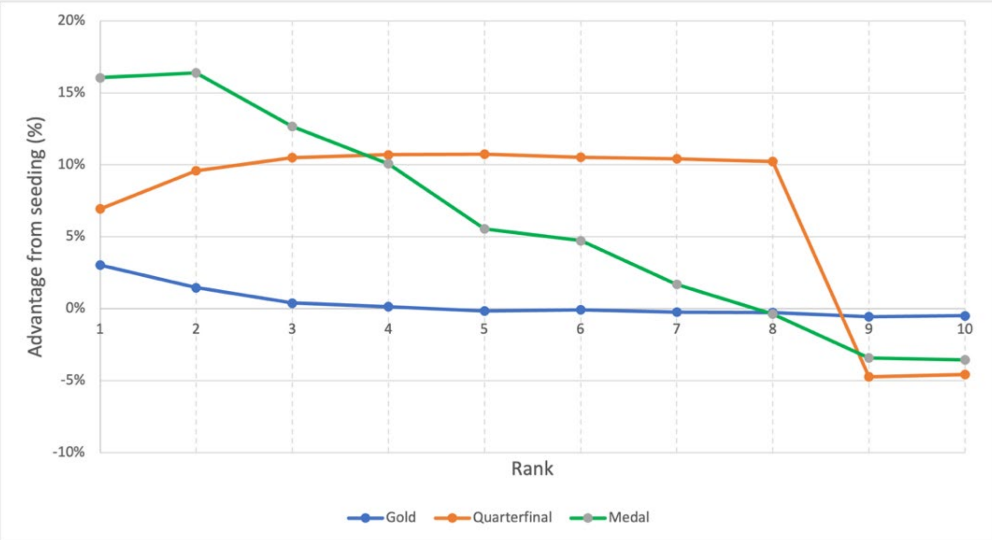

Figure 1. Advantage from seeding (%) to win the gold medal (blue curve), to reach the quarterfinal (orange curve) and to win a medal (green curve).

We observe that seeds have an advantage of order of 10% to reach the quarterfinals. The advantage may be even higher as illustrated in Figure 1 since it is above 15% for the two best athletes to win a medal.

3.2. Disadvantage in case of misclassification

The approach developed in this paper also helps to better evaluate the consequences of misclassifications in the ranking list on athlete performances. The seeded athletes are not always the eight best athletes. The ranking list is based on a set of rules involving past results in tournaments and may lead to ordering anomalies regarding the real quality of the athletes.

Teddy Riner, the leader of the heavy weight category, is a typical example of misclassification in the ranking list. Riner was ranked 24th only at the Olympic ranking list and 30th at the world ranking list of the International Judo Federation (source www.ijf.org, dated March 22nd, 2020). Despite he is the best *judoka* of the heavy weight category, seeding was a disadvantage for Riner; he had to fight Tamerlan Bashaev (ranked number one) as soon as in the quarterfinal. The probability for Riner to win the gold medal in Tokyo was significantly reduced because he was not seeded. We estimate this probability by running two sets of simulations of a tournament including the top 32 athletes. In the first set of simulations, we considered that Riner was number 1 and seeded number 1. His probability of winning the gold medal was equal to 39.7% in this case from the simulation. In the second set of simulations, Riner was ranked number 1 (he was the best *judoka* on the mat), but he was not a seed and his position in the initial draw was set at random. His probability of winning the gold medal dropped to 33.8% then. His probability of winning a medal was equal to 72% if Riner were seeded number 1 and dropped to 63.4% if he were not a seed. At the end, Riner won the bronze medal at the Tokyo Olympic Games.

3.3. Impact of sex, number of athletes and modelling assumptions

In Tables A1-A4 (see Appendix A), we have computed similar probabilities for male and female tournaments in standard and random draws respectively with N=64. We see that the orders of magnitude of the seed advantage are the same notwithstanding the non-negligible impact of the value of the parameter β which is different for female compared to male on probabilities. Standard draws are more beneficial to top athletes when the tournament is unbalanced *i.e.,* when the parameter β is higher. In particular, the higher the value of β, the higher the benefit for top athletes in a standard draw. As an illustration with N=64, the advantage given on event G_1 for male is equal to 39.6% - 36.5% = 3.1% compared to 41.4% - 38.1% = 3.3% for female. A small change in the value of the parameter β results in different values of the probabilities for both random and standard draw. However, the value of the advantage remains quite stable in a wide range of values for the parameter β. We have illustrated this phenomenon in the case N=64 and $\beta = 0.4$. For instance, the estimated probabilities $\hat{p}_S(M_1)$ and $\hat{p}_R(M_1)$ differ quite substantially when $\beta = 0.4$ compared to $\beta = 0.509$. However, the advantage remains quite stable: $\hat{p}_S(M_1) - \hat{p}_R(M_1)$ is equal to 13.7% when $\beta = 0.4$ and equals to 16.5% when $\beta = 0.509$.

The number of athletes involved in a competition may vary from a weight category to another. Thus, the number of athletes tends to increase in World Championship: while the heavy weights category is usually less populated, some categories are likely to have more than 80 athletes and sometimes close to 100. We have run simulations with standard and random draws of 32, 64 and 128 athletes. The results for N=64 and N=128 are displayed in Appendix A and B respectively. We observe that the quantity $\hat{p}_S(A) - \hat{p}_R(A)$, measuring the advantage given to seeds remains quite stable when the number of athletes competing changes.

We observe that the advantage given to seeds is robust to some changes in the modelling assumptions. We have already observed that the advantage given to seeds was stable when the parameter β changed. This is also the case when β is itself a random variable to account for the random error made in the estimation of this parameter. We ran Monte-Carlo simulations to assess the impact of the uncertain value of β (convexity effect). For each simulation, the parameter β is a normal random variable with mean equal to 0.509 (same value as for the male winning probabilities parameter) and standard deviation equal to 0.05 (*i.e.* twice the estimation error measured by Krumer (2017) in his paper). We summarize the results of these simulations in Appendix C for the standard and the random draws in Table C1 and Table C2 respectively. We observe that the figures are very close to those of Tables A1 and A2 respectively, which shows that convexity effects are negligible.

3. Discussion

In this research, we ran Monte-Carlo simulations of professional judo tournaments to evaluate the advantage given to seeds in knockout draw competitions. It was observed that this advantage was limited to win the gold but might be significant to achieve other targets such as winning a medal. Conversely, the seeding system was at a significant disadvantage for misclassified athletes. Finally, we observed that the advantage given to seeds was not very sensitive to sex, number of athletes or modelling assumptions.

Using the results of tables 1 and 2, we observed that the advantage given to the top athlete for winning the gold medal was equal to 3.1% and is even lower for the other athletes. This advantage was rather limited as already observed by Marchand (2002). However, this advantage was much higher when considering other targets, such as reaching the quarterfinal or winning a medal. From Figure 1, the advantage to reach the quarterfinal was shown to be higher than 15% for the top two athletes. This impact is significant and is in line with what we observe in major tournaments: the seeding system allows top athletes to avoid each other in the first rounds. It can be shown for instance that the probability of having two seeds fighting each other in the first round of a random draw tournament with 32 athletes is as high as 68.7%. Conversely to what is expected, seeds do not systematically get an advantage from seeding. Athletes ranked above 4 are penalized in a standard draw compared to a random draw for winning the gold. The very reason for that is because the seeding system protects top athletes from an early elimination and, as the top 2 athletes have a higher probability to reach the final in a tournament with a standard draw, this lowers the probabilities of all athletes ranked 5 and under to get the gold, ranks 3 and 4 being the breakeven point of probability changes. Marchand (2002) has already observed that seeding was favourable to the top 1 and 2 athletes only for winning the gold medal. We generalize this observation to other events and Monte-Carlo simulations provide a general methodology to evaluate which athletes will benefit to a seeding system under any kind of assumption. As an example, the top 7 athletes benefit the seeding system for reaching the semi-finals, contrary to the athletes ranked 8 or under. Another interesting information is that the eight seeds benefit the seeding system to get a medal (gold, silver, or bronze) or reach the quarterfinal.

The approach developed in this paper also helps to better evaluate the consequences of misclassifications in the ranking list on athlete performances. There is a clear correlation between ranking and performance which is demonstrated in number of papers such as Breviglieri et al. (2018), Courel-Ibáñez et al. (2018) or Julio et al. (2013). However, it is worth mentioning that ranking is only a proxy of the relative levels of the athletes because they all pursue distinct strategies, some aiming to climb the ranking list, others targeting a performance in major events only. Two Japanese athletes, Ono Shohei and Nagase Takanori, decided not to be seeds at the Olympics and won the gold medal; Riner won the bronze medal. We observed from simulations that, given the level of an athlete, being or not being a seed has a large impact on his/her winning probabilities. Being a seed has a reward but has a cost too: it requires to participate to more tournaments, generating a risk of injury among others. As shown by Franchini et al. (2017), there is an optimal time interval between two competitions to increase the chances of winning a medal. For Grand Prix, Continental Championship and World Championship, the authors show that a 10–13–week period of time is optimal for both male and female, and a period longer than 14 weeks is optimal for male to perform at the Olympic Games and Masters.

Our study's results clearly showed the limited sensitivity of the advantage given to seeds to parameters and modelling assumptions. One limitation of our study was to assume that fight outcomes in the Monte-Carlo simulations were sorted under the independent assumption. Psychological effects are indeed strong in judo because all the fights of a tournament occur over the same day and losers of a bout may continue the competition when they access the repechage draw. For instance, Cohen-Zada et al. (2017) show that winners in the repechage draw (who are usually lower ranked) have an increased winning probability when they fight against losers of the semi-finals (who are higher ranked on average). This result holds for men only, not for women. The authors argue that this is in line with evidence in the biological literature that testosterone increases following victory and decreases following loss only among men (see e.g., Wood & Stanton, 2012). Other studies in the field of judo (Filaire, 2001; Suay, 1999) show that winning is usually associated to a rise in cortisol rather than testosterone and that the hormonal response for an athlete may not be a consequence of winning or losing a fight only but may rather involve more complex processes. In any case, the independence assumption of the Bernoulli trials of the simulation is likely to fail especially for the bronze medal contest. In the field of tennis for instance, Newton and Aslam (2006, 2009) explored non *i.i.d.* assumptions; nonetheless, accounting for dependence in modelling is specific to each sport and measuring its impact on the advantage given to seeds is an open field of research.

6. Conclusions

Seeding has a direct impact on the performance of athletes and gives an advantage to top athletes in the ranking list. This advantage for winning gold is rather limited but is quite significant for reaching other targets such as winning a medal or qualifying to the quarterfinal. We observe that the advantage is not distributed uniformly across seeds; only seeds 1 and 2 get an advantage for winning the gold medal for instance. Weight category leaders are at a significant disadvantage when they are not seeded but may however choose to focus on a better preparation than climbing the ranking list to be seeded. The advantage given to seeds has a limited sensitivity to parameters such as sex and number of athletes, and to modelling assumptions.

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Appendices

In the following tables, we report the simulation results of the probabilities to achieve a given performance for athletes ranging between 1 and 10 in the ranking list.

Appendix A. Statistics for N=64

Table A1. Statistics for male standard draw tournaments with 64 athletes.

Rank	G (%)	F (%)	SF (%)	QF (%)	B (%)	5th (%)	M (%)
1	39.6	54.7	67.4	77.2	18.0	3.1	72.6
2	19.1	35.9	52.5	66.0	20.4	6.6	56.2
3	11.1	23.7	41.0	58.0	20.1	9.5	43.8
4	7.4	14.7	35.7	51.9	21.1	11.1	35.7
5	5.0	12.7	25.7	46.9	14.9	11.9	27.6
6	3.7	8.6	24.2	42.7	15.0	12.3	23.6
7	2.7	8.0	16.7	39.4	10.5	11.5	18.5
8	2.1	5.3	10.6	36.3	9.5	11.1	14.8
9	1.3	3.9	9.9	21.2	6.0	6.4	10.0
10	1.1	3.3	8.8	19.5	5.4	6.0	8.7

Note: G=gold, F=finalist, SF=semi-finalist, QF=quarterfinalist, B=bronze, M=medallist.

Table A2. Statistics for male random draw tournaments with 64 athletes.

Rank	G (%)	F (%)	SF (%)	QF (%)	B (%)	5th (%)	M (%)
1	36.5	47.1	58.3	69.5	9.0	1.4	56.1
2	17.7	28.8	41.8	55.8	10.4	2.7	39.2
3	10.7	20.1	32.5	47.1	10.3	3.5	30.5
4	7.2	15.0	26.3	40.8	9.7	4.1	24.8
5	5.1	11.6	21.9	36.1	9.2	4.4	20.8
6	3.8	9.4	18.7	32.4	8.6	4.6	18.0
7	2.9	7.7	16.2	29.2	7.9	4.8	15.6
8	2.3	6.4	14.1	26.6	7.4	4.8	13.8
9	1.9	5.4	12.5	24.5	6.9	4.8	12.3
10	1.5	4.6	11.2	22.5	6.4	4.8	11.0

Note: G=gold, F=finalist, SF=semi-finalist, QF=quarterfinalist, B=bronze, M=medallist.

Table A3. Statistics for female standard draw tournaments with 64 athletes.

Rank	G (%)	F (%)	SF (%)	QF (%)	B (%)	5th (%)	M (%)
1	41.4	57.0	69.7	79.1	17.9	3.0	74.9
2	19.5	37.3	54.6	68.1	21.0	6.7	58.3
3	11.1	24.3	42.5	59.9	21.1	9.8	45.3
4	7.2	14.7	37.1	53.7	22.3	11.6	37.0
5	4.8	12.7	26.3	48.5	15.4	12.7	28.1
6	3.6	8.4	24.9	44.2	15.7	13.1	24.0
7	2.6	7.9	16.7	40.7	10.7	12.2	18.5
8	1.9	5.1	10.3	37.5	9.6	11.6	14.8
9	1.2	3.7	9.7	21.3	6.0	6.5	9.8
10	1.0	3.1	8.6	19.6	5.3	6.1	8.5

Note: G=gold, F=finalist, SF=semi-finalist, QF=quarterfinalist, B=bronze, M=medallist.

Table A4. Statistics for female random draw tournaments with 64 athletes.

Rank	G (%)	F (%)	SF (%)	QF (%)	B (%)	5th (%)	M (%)
1	38.1	49.0	60.3	71.2	8.8	1.3	57.8
2	18.1	29.8	43.2	57.3	10.5	2.6	40.3
3	10.7	20.6	33.4	48.4	10.6	3.5	31.2
4	7.1	15.3	27.0	41.9	10.0	4.1	25.3
5	5.0	11.7	22.4	36.9	9.4	4.5	21.2
6	3.7	9.4	19.0	33.1	8.8	4.7	18.2
7	2.8	7.6	16.4	29.8	8.2	4.9	15.8
8	2.2	6.3	14.3	27.1	7.6	4.9	13.9
9	1.8	5.3	12.6	24.8	7.1	4.9	12.4
10	1.4	4.5	11.2	22.8	6.5	4.9	11.1

Note: G=gold, F=finalist, SF=semi-finalist, QF=quarterfinalist, B=bronze, M=medallist.

Appendix B: statistics for N=128

Table B1. Statistics for male standard draw tournaments with 128 athletes.

Rank	G (%)	F (%)	SF (%)	QF (%)	B (%)	5th (%)	M (%)
1	39.7	54.7	67.2	76.4	17.5	3.0	72.2
2	19.2	35.9	52.2	64.8	19.9	6.2	55.8
3	11.1	23.6	40.7	56.7	19.9	9.0	43.5
4	7.4	14.6	35.2	50.3	20.8	10.5	35.4
5	5.0	12.7	25.4	45.4	14.7	11.4	27.4
6	3.8	8.6	23.9	41.1	14.8	11.7	23.4
7	2.8	8.0	16.4	37.6	10.4	11.0	18.4
8	2.1	5.3	10.4	34.6	9.4	10.6	14.8
9	1.3	3.9	9.7	20.0	6.0	5.9	9.9
10	1.0	3.3	8.5	18.3	5.3	5.6	8.5

Note: G=gold, F=finalist, SF=semi-finalist, QF=quarterfinalist, B=bronze, M=medallist.

Table B2. Statistics for male random draw tournaments with 128 athletes.

Rank	G (%)	F (%)	SF (%)	QF (%)	B (%)	5th (%)	M (%)
1	36.5	47.1	57.9	68.3	8.3	1.2	55.3
2	17.7	28.8	41.3	54.3	9.7	2.3	38.5
3	10.6	20.0	31.9	45.4	9.6	3.0	29.6
4	7.2	14.9	25.8	39.0	9.1	3.4	24.0
5	5.1	11.5	21.4	34.2	8.5	3.7	20.0
6	3.8	9.3	18.2	30.5	7.9	3.8	17.1
7	2.9	7.6	15.7	27.4	7.4	3.9	15.0
8	2.3	6.3	13.7	24.9	6.8	3.9	13.2
9	1.9	5.3	12.1	22.7	6.3	3.9	11.7
10	1.5	4.6	10.7	20.9	5.9	3.9	10.5

Note: G=gold, F=finalist, SF=semi-finalist, QF=quarterfinalist, B=bronze, M=medallist.

Appendix C: statistics for random β

Table C1. Statistics for a standard draw tournament with random β with mean 0.509 and standard deviation 0.05 with 64 athletes.

Rank	G (%)	F (%)	SF (%)	QF (%)	B (%)	5th (%)	M (%)
1	39.5	54.4	67.0	76.8	17.8	3.2	72.2
2	19.0	35.7	52.3	65.7	20.3	6.5	56.0
3	11.0	23.5	40.9	57.9	20.3	9.5	43.8
4	7.3	14.5	35.5	51.7	21.1	11.1	35.6
5	4.9	12.6	25.5	46.8	14.8	12.0	27.4
6	3.8	8.6	24.2	42.8	15.0	12.4	23.6
7	2.7	7.9	16.6	39.3	10.4	11.5	18.4
8	2.1	5.3	10.5	36.3	9.4	11.0	14.7
9	1.3	3.9	9.9	21.2	6.0	6.3	10.0
10	1.1	3.3	8.7	19.5	5.3	6.0	8.6

Note: G=gold, F=finalist, SF=semi-finalist, QF=quarterfinalist, B=bronze, M=medallist.

Table C2. Statistics for a random draw tournament with random β with mean 0.509 and standard deviation 0.05 with 64 athletes.

Rank	G (%)	F (%)	SF (%)	QF (%)	B (%)	5th (%)	M (%)
1	36.3	46.8	57.9	69.0	8.9	1.5	55.8
2	17.6	28.7	41.6	55.5	10.3	2.7	39.1
3	10.6	20.0	32.4	47.0	10.3	3.5	30.3
4	7.2	14.9	26.2	40.7	9.8	4.1	24.7
5	5.1	11.6	21.9	36.0	9.2	4.4	20.8
6	3.8	9.4	18.6	32.2	8.5	4.6	17.8
7	2.9	7.7	16.1	29.1	8.0	4.7	15.6
8	2.3	6.4	14.3	26.7	7.4	4.8	13.8
9	1.9	5.4	12.5	24.4	6.9	4.8	12.3
10	1.5	4.7	11.2	22.6	6.4	4.8	11.1

Note: G=gold, F=finalist, SF=semi-finalist, QF=quarterfinalist, B=bronze, M=medallist.