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RESULTS FOR WORLD ROWING FEDERATION AND OLYMPIC EVENTS 1893-2019

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Abstract
Results in rowing have improved and here we estimate results for Olympic and World rowing championships based on the winning results from 1893 to 2019 obtained in the current seven Olympic events for men \((n = 556)\) and women \((n = 239)\). Data were collected from the official World Rowing Federation online records and from published results and the development analyzed by linear regression analysis to the year of competition. Results improved by about 0.7 s per year \((15 \pm 9.4\%)\) \((\text{mean} \pm \text{SD})\). Depending on the event the 2020 predicted mean time for the winning boat for men is 363 s \((\text{range 326 - 397})\) vs. 404 s \((362 – 439)\) for women \((10.3 \pm 1.1\% \text{ slower})\). The ten-year coefficient of variance for the original boats in Olympic and World Rowing Federation regatta remaining within the Olympic program, single scull and eight, decreased from 9 \(\pm 2\%\) \((1893-1903)\) to 2 \(\pm 0.4\%\) \((2009-2019)\). Reduced variability in winning times illustrates standardization of the rowing course and boats and the improvement in performance point to that body size becomes ever more important for success in competitive rowing.

**Keywords:** Fédération Internationale des Sociétés d’Aviron, results, rowing, Olympic games, World Rowing Federation

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**Introduction**
The development of rowing has been summarized until 1971 (Secher, 1973) based on results obtained during the international men’s rowing championships since their initiation in 1893 by The World Rowing Federation, previously known as FISA (Fédération Internationale des Sociétés d’Aviron) and by the International Olympic Committee (1896).

The relationship between the winning time and year of the event was calculated by linear regression for each of seven boat types for men: single scull, double sculls (since 1898), coxed pair (since 1894), coxed four, eight, coxless pair (since 1920) and four (since 1924) (Secher, 1973). The historical insight demonstrated an approximate 0.7 s per year average improvement.

Since the first analysis (Secher, 1973), the Olympic program for men’s coxed pair and four has been replaced by events for quadruple sculls and lightweight double sculls (maximal average body-weight 70 kg; 59 kg for women). Therefore, the update encompasses only five of the original seven events.

Women’s rowing was included in the FISA championships by 1951 for 1000 m, which was extended to the 2000 m by 1984. In this work, the previous analysis is updated with the addition of results for women events completed for the 2000 m distance. This evaluation of development of results in rowing provides an estimate for what could be accomplished during a 2020 World Rowing Federation regatta for the current 14 Olympic men’s and women’s rowing events.

Methods

Winning times for rowing conforming to the official rules of racing (The World Rowing Federation web site - FISA Rule Book 2017) were obtained from 556 men’s and 239 women’s races 1893 to 2019. Results previous to 1970 include races with the 2000 m distance measured from stern (on the starting line) to bow (on the finish line) and excluded data are described by (Secher, 1973). Data from 1893 to 1971 are obtained from (Secher, 1973) and those collected for 1972 to 2019 are from the official World Rowing Federation online records of Olympic and
World championship events (The World Rowing Federation web site 2020). Linear regression between World Rowing Federation’s regatta winning results and the year of competition was by GraphPad Prism (version 8.3.0, San Diego, CA). The year of the event is considered the independent variable (x) and the winning time of the race as the dependent variable (y) and the r-squared (goodness-of-fit) of each event is shown in Table 1. Results are presented as median and range or, for percentage changes as mean ± SD. A P-value of < 0.05 was considered statistically significant.

**Results**

Table 1 indicates that the current average race time for men is 363 s (326 - 397) and for women 404 s (362 - 439). For men, the average decrease in winning time has been by 0.79 (0.48 - 0.96) s·y⁻¹ and for women 0.60 (0.16 - 0.99) s·y⁻¹ with an average r-squared of the male results of 0.50 (0.12 - 0.69) and 0.10 (0.01 - 0.19) for the women results. The overall average decrease in winning time is about 0.7 s·y⁻¹ (Figs. 1 and 2). There has been no significant development of results for women’s single and quadruple scull and the four. Thus, men row about 41 (37 - 46) s (10.3 ± 1.1%) faster than women, scull boats are about 9 (7 - 12) s (1.9 ± 0.2%) faster than sweep boats with same number of rowers (two or four), and lightweights are about 10.5 (9 - 12) s (2.7 ± 0.6%) slower than the double scull in the open class.

**Discussion**

Men’s events show attenuated improvement of results. The yearly progress (slope of the regression lines) is now 0.3 s slower (0.8 ± 0.1 s·y⁻¹) than previously reported for the same five events (1.1 ± 0.4 s·y⁻¹, P < 0.02) (Secher, 1973). The reason why the improvement of results in rowing seems to have become smaller is not addressed but influences on results have been summarized (Secher, 1973; Steinacker, 1993). Among the mentioned factors, the boats and
oars are now made of carbon fiber rather than wood. To what extent the chosen material influences the results is not known but it is likely small. The racing course and shells have been standardized to provide for a fair race. The weight of the boats is minimally 14 kg for a single scull, 27 kg for a double scull and pair, 50/52 kg for a four/quadruple boats, and 96 kg for an eight (The World Rowing Federation web site 2020). Additionally, the “3-stay” rigger carrying the oar has been replaced by a carbon “wing” that makes the oar more stable within an aerodynamic profile and as it is placed high above the water, it is less likely to catch eventual troubled water. Furthermore, the oar blade has generally changed from ‘Macon’ to the ‘big blade’ shape.

Another factor influencing the improvement of results is that rowing has moved into what may be considered a professional discipline, allowing for increased training volume. Rowers from northern countries could not previously row throughout the year because of ice and short days in the winter. With widespread use of rowing ergometers and training camps, it has become possible for rowers from all countries to row all year round. Together these influences on results are reflected in the aerobic capacity of the rowers. Around 1970, the maximal oxygen uptake of male rowers was about 6 L·min⁻¹ while aerobic capacity now approaches 7 L·min⁻¹ (Secher et al. 1983; Godfrey et al. 2005; Mikulic, 2011; Nielsen and Christensen, 2020). Also, it is of likely importance for results that the number of participants in international championships has increased from about 100 (1900 and 1904 Olympics) to about 550 (2012 and 2016 Olympics) representing around 60 rather than about 8 countries (The World Rowing Federation web site 2020). Finally, it should be mentioned that the racing course has been standardized to a minimum 2 m depth of water in addition to defined starting conditions and buoys indicating 6 lanes 12.5 – 15 m in width (The World Rowing Federation web site - FISA Rule Book 2017).

It is a consideration that faster races influence the selection of rowers. A large body weight is an advantage in rowing as expressed when boat speed is scaled to body dimensions (Secher...
and Vaage, 1983; McMahon, 1971). In brief, water resistance increases with boat surface area and aerobic metabolism increases with about kg$^{0.75}$ in accordance with the model for allometric scaling of biological variables (Jensen et al. 2001; West et al. 1997). Additionally, because anaerobic metabolism increases with body weight and 2000 m rowing is accomplished by about 20% anaerobic metabolism (Secher and Vaage, 1983; Steinacker, 1993) a larger rower has an advantage. The rower must overcome the water resistance required to move the standardized weight of the boat that is relatively smaller for the larger oarsmen. Thus, part of the difference in results between men and women is due to their body weight (~90-100 vs. ~75-85 kg) as illustrated by the results obtained by lightweights compared to rowers in the open class. Influences such as larger rowers, more standardized racing conditions, and better training opportunities tend to improve racing time, suggesting that progression of results should increase rather than decrease. More uniform competition conditions could, however, also mean that it becomes more difficult to develop extraordinary results. When the FISA championships were introduced for single scull and the eight (1893-1903), the coefficient of variation for winning times was 9 ± 2%, while it is now only 2 ± 0.4% (2009-2019).

For the oldest boat types represented at the Olympic games (men single scull and eight), results have improved (5-year mean winning time; 1894-1898 vs. 2015-2019) by 68.3 ± 6.2 s (64 – 73) (15 ± 9.4 %) since their introduction. We suggest that the mentioned influences support improvement of performance but at the same time makes further progress increasingly difficult. In conclusion, a 2020 World Rowing Federation championship is predicted to on an average be covered in about 6 min for men and in 6.7 min for women.

REFERENCES


**FIGURE CAPTIONS**

**Figure 1.** Winning times for the European/World championships and Olympic games for men 1893 – 2019. Regression lines shown with their 95% confidence interval.

Footnote. Number of rowers X scull boats; - boat without cox; + boat with cox; M men; L lightweight.
Figure 2. Winning times for the World championships and Olympic games for women 1984 – 2019. Regression lines with their 95% confidence interval.

Footnote. Number of rowers; X scull boat; - boats without cox; + boat with cox; W women; L lightweight.
# Rowing championships development 1893-2019

## Table 1. The 14 Olympic events and their predicted time for 2020

<table>
<thead>
<tr>
<th>Event</th>
<th>Men</th>
<th>n</th>
<th>Year Initiated</th>
<th>Regression line</th>
<th>r²</th>
<th>95% CI</th>
<th>Women</th>
<th>n</th>
<th>Year Initiated</th>
<th>Regression line</th>
<th>r²</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1X</td>
<td>6:36*</td>
<td>100</td>
<td>1884</td>
<td>Y = -0.7899*X + 1992</td>
<td>0.64</td>
<td>390 to 405</td>
<td>07:19</td>
<td>34</td>
<td>1985</td>
<td>Y = -0.5986*X + 1648</td>
<td>0.10</td>
<td>427 to 452</td>
</tr>
<tr>
<td>2X</td>
<td>6.07*</td>
<td>98</td>
<td>1898</td>
<td>Y = -0.7342*X + 1850</td>
<td>0.68</td>
<td>361 to 374</td>
<td>6:46*</td>
<td>34</td>
<td>1986</td>
<td>Y = -0.7243*X + 1869</td>
<td>0.12</td>
<td>393 to 420</td>
</tr>
<tr>
<td>4X</td>
<td>5:42*</td>
<td>46</td>
<td>1974</td>
<td>Y = -0.4760*X + 1304</td>
<td>0.15</td>
<td>334 to 352</td>
<td>06:29</td>
<td>35</td>
<td>1985</td>
<td>Y = 0.1563*X + 73</td>
<td>0.01</td>
<td>378 to 400</td>
</tr>
<tr>
<td>2-</td>
<td>6:15*</td>
<td>82</td>
<td>1920</td>
<td>Y = -0.9611*X + 2316</td>
<td>0.69</td>
<td>368 to 382</td>
<td>6:58*</td>
<td>35</td>
<td>1985</td>
<td>Y = -0.9937*X + 2425</td>
<td>0.19</td>
<td>405 to 434</td>
</tr>
<tr>
<td>4-</td>
<td>5:49*</td>
<td>84</td>
<td>1924</td>
<td>Y = -0.6845*X + 1732</td>
<td>0.60</td>
<td>343 to 356</td>
<td>06:35</td>
<td>30</td>
<td>1989</td>
<td>Y = -0.3790*X + 1161</td>
<td>0.03</td>
<td>381 to 411</td>
</tr>
<tr>
<td>8+</td>
<td>5:25*</td>
<td>104</td>
<td>1920</td>
<td>Y = -0.6147*X + 1567</td>
<td>0.60</td>
<td>319 to 332</td>
<td>6:02*</td>
<td>35</td>
<td>1985</td>
<td>Y = -0.5278*X + 1428</td>
<td>0.13</td>
<td>353 to 372</td>
</tr>
<tr>
<td>L2X</td>
<td>6:19*</td>
<td>42</td>
<td>1978</td>
<td>Y = -0.7131*X + 1819</td>
<td>0.12</td>
<td>364 to 394</td>
<td>6:55*</td>
<td>36</td>
<td>1984</td>
<td>Y = -0.9128*X + 2259</td>
<td>0.13</td>
<td>400 to 433</td>
</tr>
</tbody>
</table>

Values are min:s; * progression (P < 0.05) since introduced as a World Rowing Federation championship event; n number of events; CI confidence interval for year 2020; number of rowers; X scull boats; - coxless boat; + coxed boat; L lightweight.