

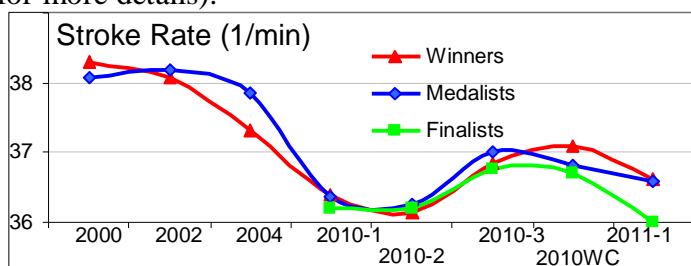
GPS boat speed and stroke rate

Last year GPS data on boat speed and stroke rate became available from FISA website www.worldrowing.com. The data for the World Cups and Championship regattas is presented in 50m splits. To check the accuracy of the data, we have derived an average speed over the whole race using GPS data and compared it with the speed obtained from official results. It was found that the accuracy significantly improved in this year World Cup in Munich: the percentage of correct rankings (GPS based ranking corresponds with official one) data increased up to 60.3% and average deviation of the GPS speed from the official results decreased down to 1.67%:

	2010 Cup1	2010 Cup2	2010 Cup3	2010 WCh	2011 Cup1
N GPS data in FA	82	83	84	84	78
Correct ranking	22	29	24	46	47
Correct ranking (%)	26.8%	34.9%	28.6%	54.8%	60.3%
Average speed deviation (%)	2.60%	3.74%	1.71%	1.99%	1.67%

The accuracy could be improved even more if GPS speed would be represented with two or more decimals. There are still some concerns about the accuracy of GPS stroke rate data, especially in small boats (see Attachments 1 and 2), where the data in side lanes looks quite untrustworthy. Therefore, we took for further analysis only the data of the medallists, which usually go on the middle lanes.

In RBN 2005/02 we already discussed average stroke rate in medallists of the main World regattas in 2000, 2002 and 2004, which was obtained for three medallists in every boat type from video footage. To check the possible effect of different methods of measurement, we took the stroke rate from a video of M8+ and W8+ during Worlds-2010 in Karapiro, compared it with GPS data and found that the average difference in stroke rate in three medallists was 0.2 str/min. This allows us to compare the data obtained using both methods. The chart below shows the average stroke rate in 14 Olympic boat types in the winners, medallists and finalists of World regattas (see Appendix 3 for more details):



The average stroke rate decreased by about one stroke per minute during the last decade: it was around 38 str/min in 2000-2002 and around 37 str/min in Worlds Championship-2010 and World Cup-2010 in

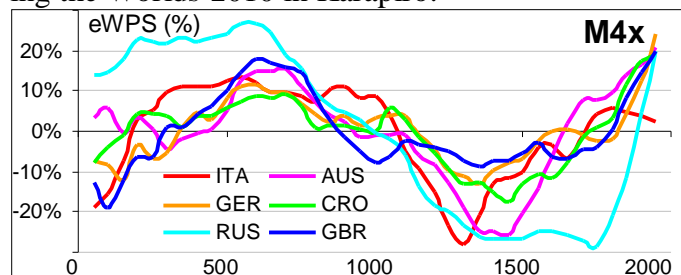
Lucerne. In other World Cups the stroke rate was 0.5-1 str/min lower. No significant difference in stroke rate between various place takers was found.

To analyse the stroke rate in various boat types and its variation during the race, we took the data of three medallists during the last five World regattas of 2010-11 and derived an average stroke rate over the whole race, its standard deviation (\pm SD) based on 20 50m splits, minimal and maximal values and their difference (range). In the following table the data is ranked based on average stroke rate:

Boat	Average	\pm SD	Min	Max	Range
W1x	34.6	2.4	31.4	40.9	9.5
W2x	34.8	2.4	32.3	41.4	9.1
LW2x	35.1	2.2	32.5	41.0	8.5
M1x	35.3	2.3	32.1	41.2	9.1
W4x	35.7	2.4	32.5	41.4	9.0
W2-	36.2	2.0	34.2	41.5	7.4
M4x	36.7	2.2	34.5	41.8	7.3
M2x	36.9	2.1	34.5	41.7	7.1
W8+	37.2	1.8	35.2	41.5	6.3
LM2x	37.4	2.1	35.0	42.3	7.3
M2-	38.0	2.0	35.8	42.8	7.0
LM4-	38.2	2.4	35.3	43.1	7.8
M4-	38.3	2.1	36.1	43.0	6.9
M8+	38.4	1.9	36.3	42.5	6.2

Women's sculling boats use the lowest average stroke rate 34-35 str/min and men's sweep boats use the highest stroke rate 38-39 str/min. The larger the boat, the lower variation (\pm SD) and the range of the stroke rate during the race: in the singles, differences between minimal and maximal stroke rates were more than 9 str/min, but in the eights they were only about 6 str/min. Rowers in all boat types could produce quite a similar maximal stroke rate 41-42 str/min at the start and spurts, but the cruising stroke rate (minimal) was significantly lower in small boats: around 32 str/min, compared to 35-36 str/min in the big boats.

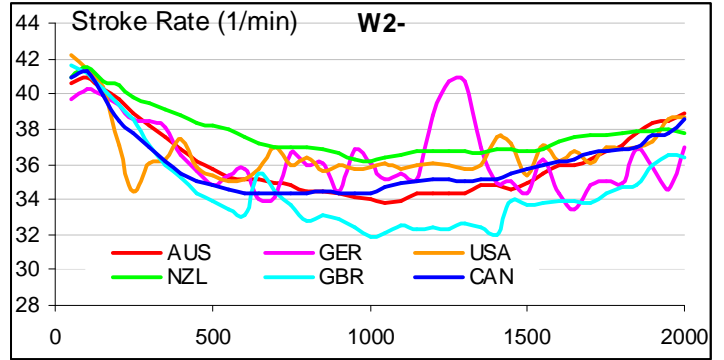
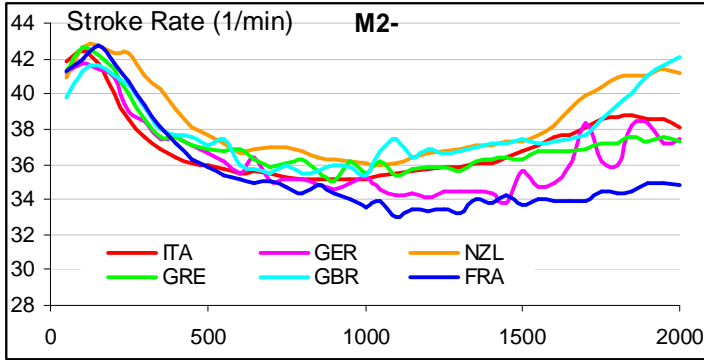
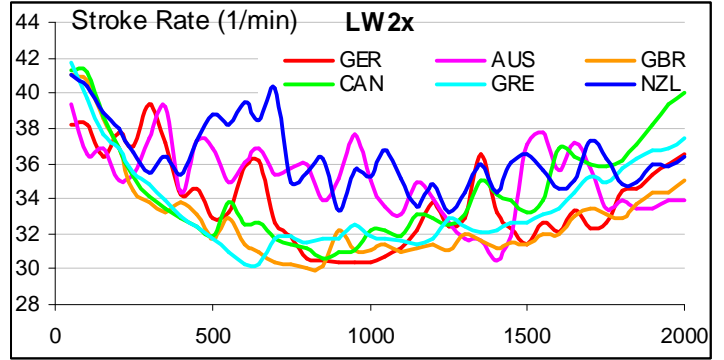
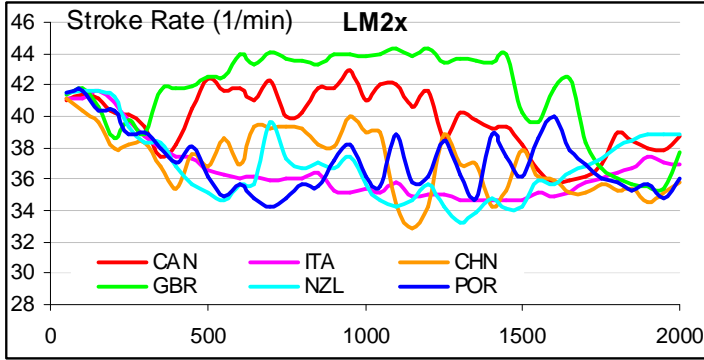
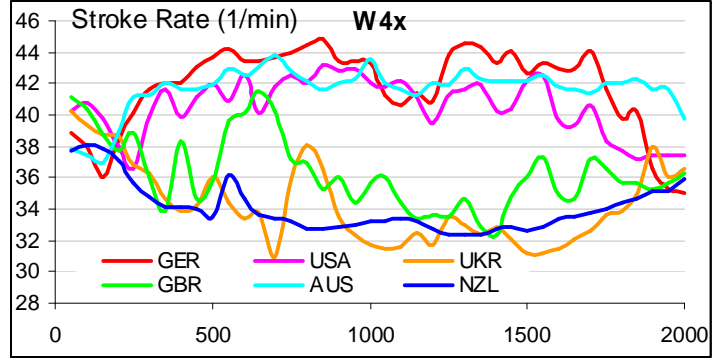
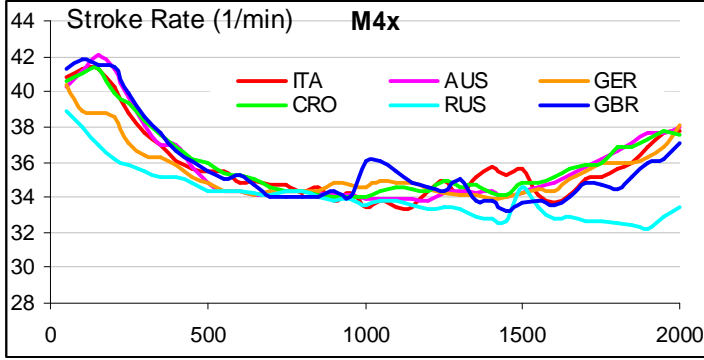
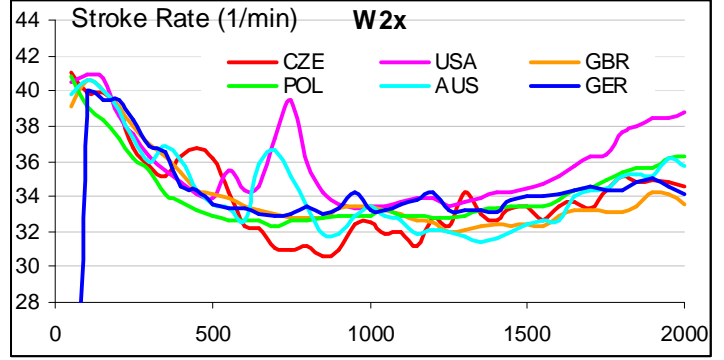
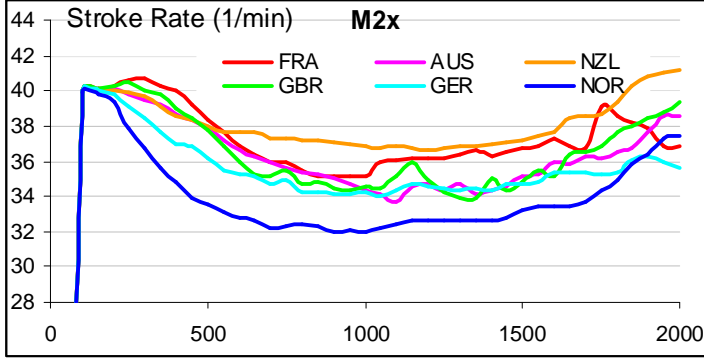
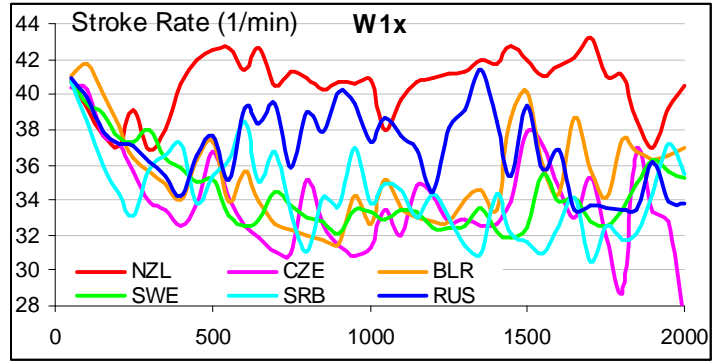
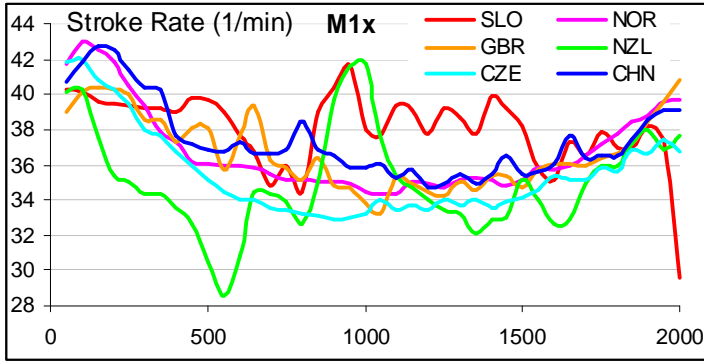
Available GPS data allows to derive information about relative effective work per stroke (eWPS), using our method proposed in RBN 2005/10. As an illustration, we show below a chart of eWPS in M4x race during the Worlds-2010 in Karapiro.

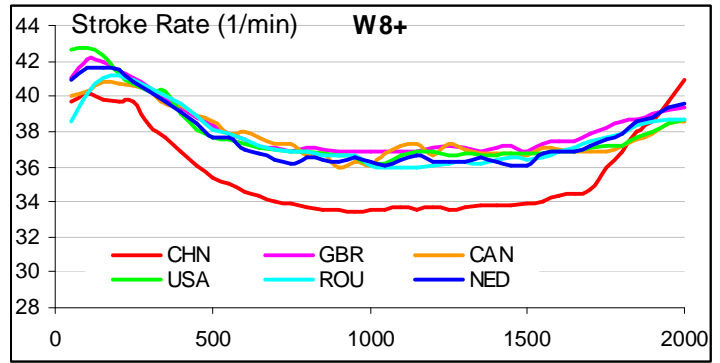
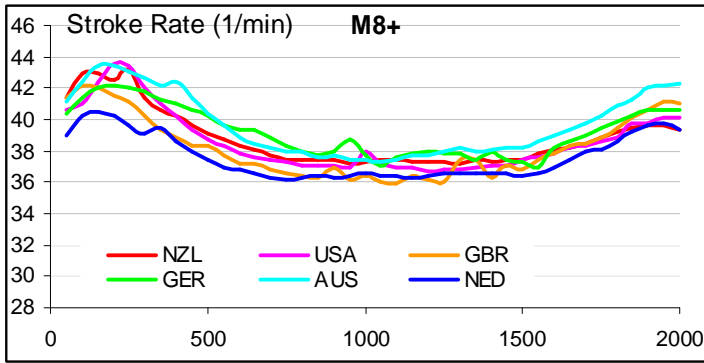
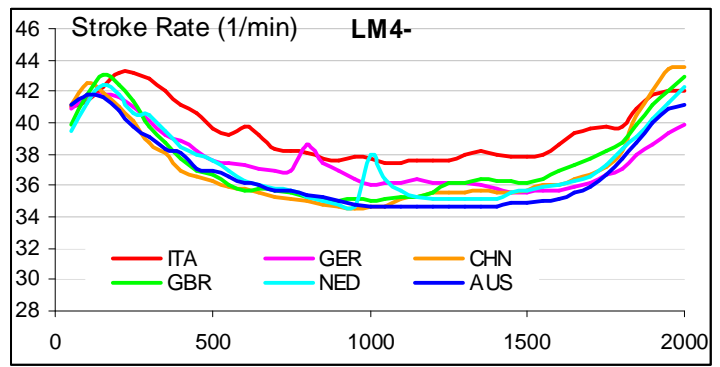
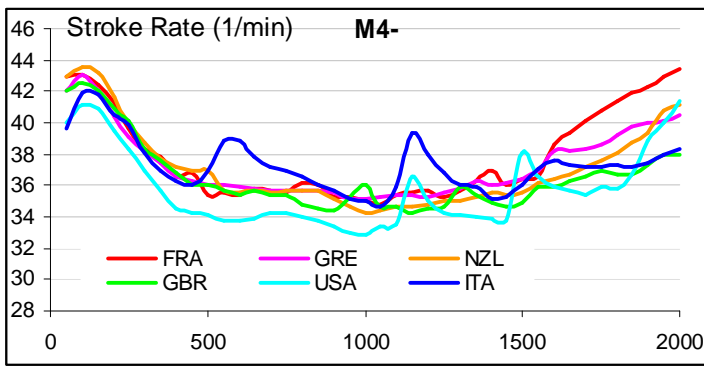


The winners CRO had the most consistent eWPS, i.e. efforts distribution, during the race (SD=8.6%) compared to the last place RUS (SD=20.4%), which applied too high efforts during the first half (high speed at low rate) and couldn't maintain it at finish.

Appendix 1 to Rowing Biomechanics Newsletter 122 (2011 May)

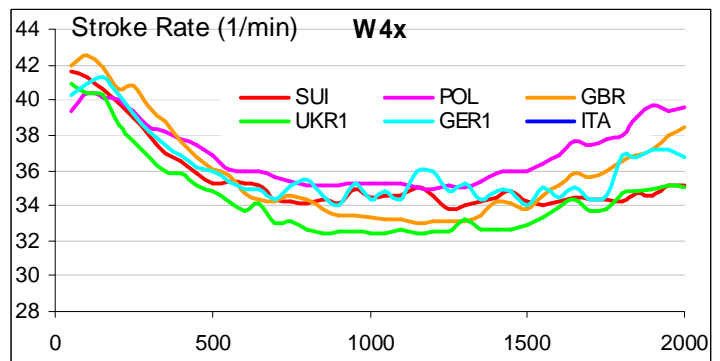
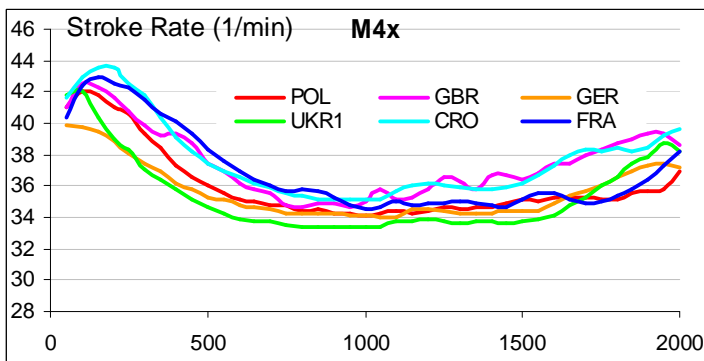
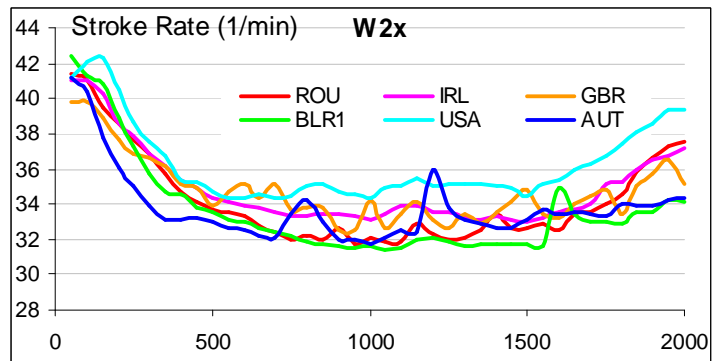
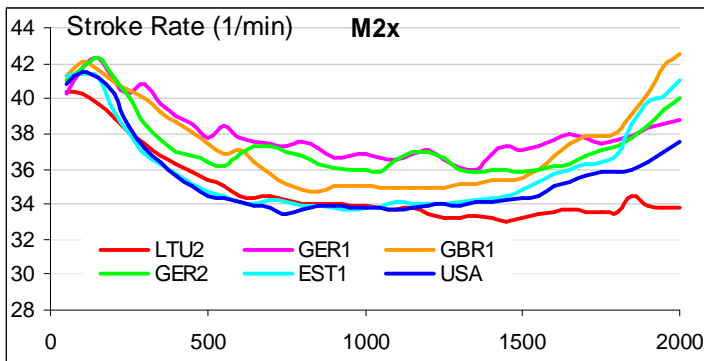
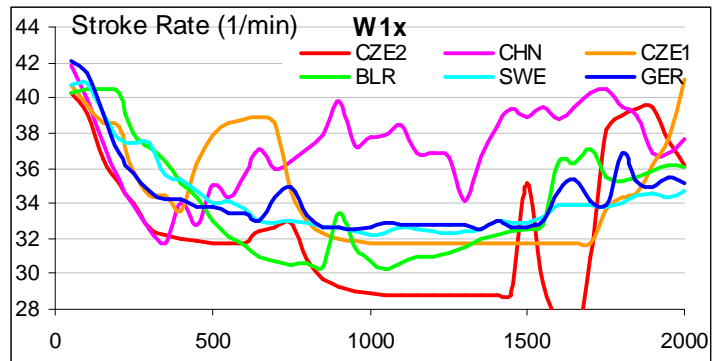
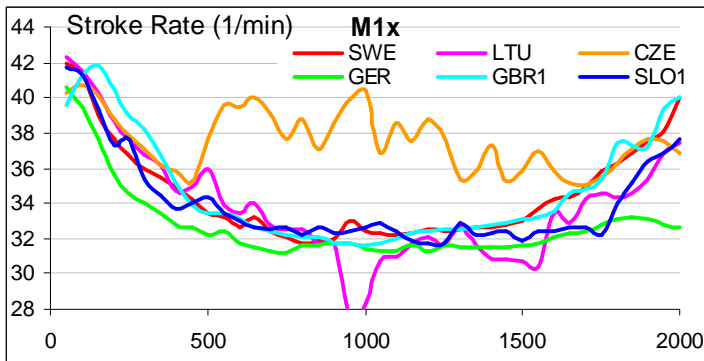
Graphical presentation of GPS stroke rate data during World Championship – 2010 in Karapiro

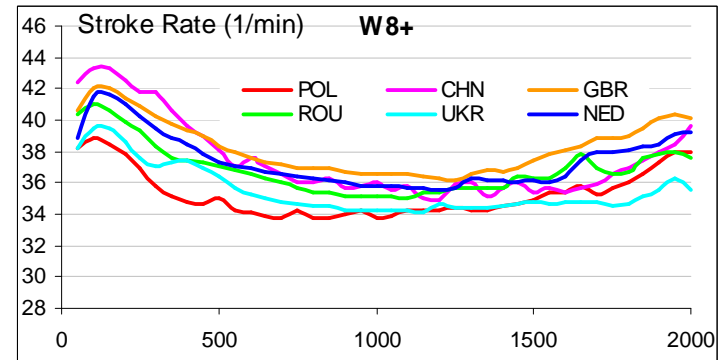
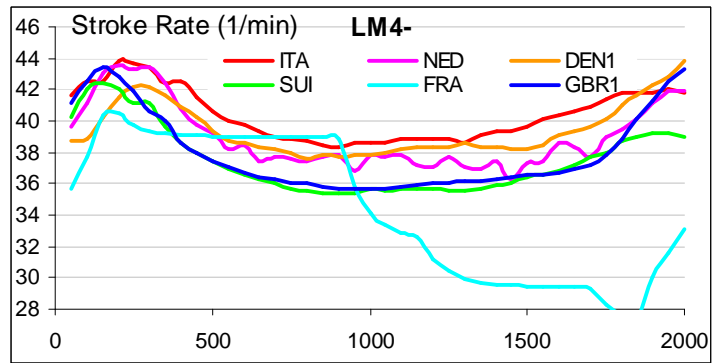
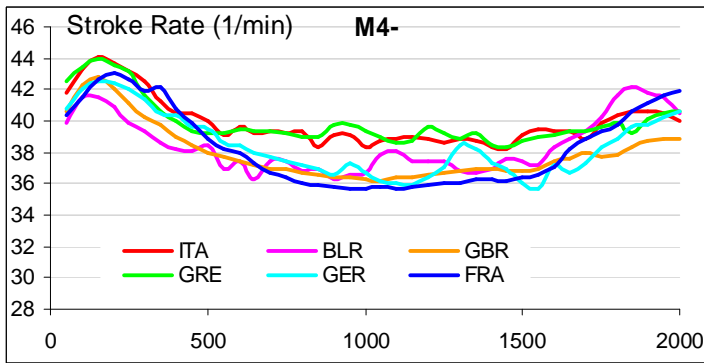
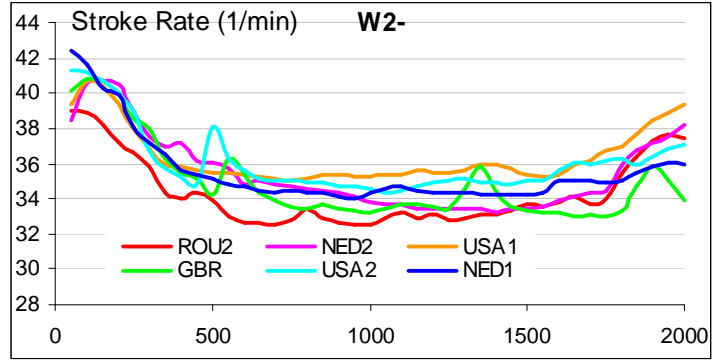
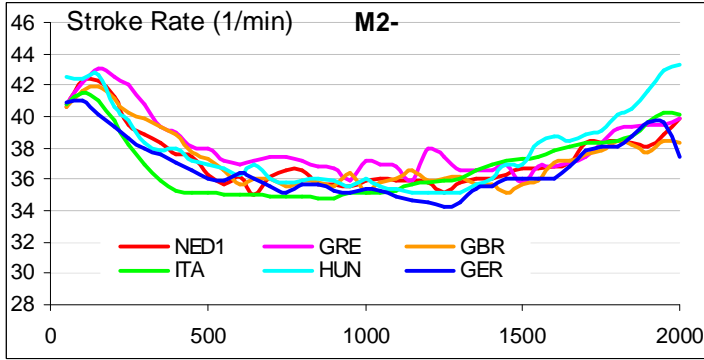
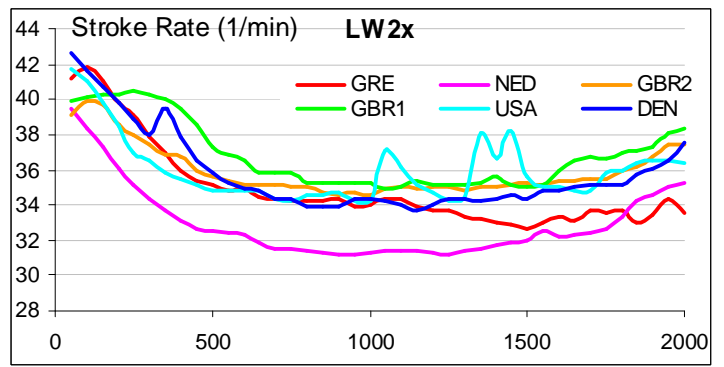
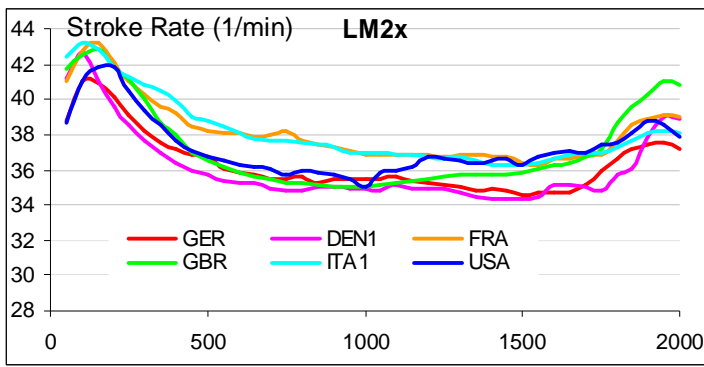




Appendix 2 to Rowing Biomechanics Newsletter 122 (2011 May)

Graphical presentation of GPS stroke rate data during World Cup-1 2011 in Munich





M8+ data was missing

Appendix 3 to Rowing Biomechanics Newsletter 122 (2011 May)

Stroke Rate in various boat classes during 2000-2011 period. Description of the regattas:

2000 – Olympic Games – 2000 in Sydney

2002 – World Championship – 2002 in Seville

2004 - Olympic Games – 2004 in Athens

2010-1 – World Cup 1 in 2010 in Bled, Slovenia

2010-2 – World Cup 2 in 2010 in Munich

2010-3 – World Cup 3 in 2010 in Lucerne

2010W – World Championship – 2010 in Karapiro, New Zealand

2011-1 – World Cup 1 in 2011 in Munich

Winners	2000	2002	2004	2010-1	2010-2	2010-3	2010W	2011-1	Average
LM2x	37.2	39.7	36.8	37.0	36.9	38.2	41.5	36.4	38.0
LM4-	42.0	40.9	41.0	39.3	37.9	37.8	37.6	39.4	38.4
LW2x	36.6	35.5	35.0	35.9	35.5	34.6	34.4	36.9	35.5
M1x	35.6	36.1	37.4	35.3	34.7	35.4	35.5	37.6	35.7
M2-	41.0	39.4	39.1	37.9	37.4	38.4	38.5	37.3	37.9
M2x	37.7	36.3	38.2	36.3	36.6	36.2	38.2	38.0	37.1
M4-	39.2	40.6	39.9	38.4	38.1	37.6	37.9	38.0	38.0
M4x	41.0	40.5	36.5	37.2	37.3	37.8	36.0	35.7	36.8
M8+	41.1	40.1	38.4	37.5	37.7	39.0	39.2	37.7	38.2
W1x	33.7	33.1	34.6	31.7	33.6	33.4	34.4	34.0	33.4
W2-	41.0	37.9	36.4	36.1	37.1	38.6	37.8	34.9	36.9
W2x	34.3	34.9	34.1	34.1	35.3	35.5	34.1	34.8	34.7
W4x	36.2	37.3	36.2	35.5	32.6	36.3	36.3	34.4	35.0
W8+	39.4	40.7	38.7	37.4	35.4	36.6	37.9	37.4	36.9
Average	38.3	38.1	37.3	36.4	36.1	36.8	37.1	36.6	36.6

The data marked in red was missing and inserted from the same boat type in similar regatta to maintain the average.

Medalists	2000	2002	2004	2010-1	2010-2	2010-3	2010W	2011-1	Average
LM2x	38.9	38.6	38.9	37.1	37.0	37.6	38.3	36.9	37.4
LM4-	40.5	40.8	40.4	38.7	38.5	39.0	37.2	37.3	38.2
LW2x	36.8	35.7	35.9	35.7	34.0	35.5	34.0	36.3	35.1
M1x	35.9	36.4	36.7	35.1	34.6	36.1	35.8	35.0	35.3
M2-	38.8	38.6	39.1	38.1	38.2	38.2	37.8	37.5	38.0
M2x	38.0	38.3	38.3	36.1	36.4	36.9	37.4	37.6	36.9
M4-	40.1	41.7	39.8	38.0	38.4	38.9	37.5	38.8	38.3
M4x	40.2	40.3	37.4	36.5	37.0	37.7	35.9	36.3	36.7
M8+	40.7	40.4	38.8	38.1	38.0	39.0	39.1	38.0	38.4
W1x	33.5	33.9	35.0	34.2	33.6	33.1	36.8	35.2	34.6
W2-	38.4	36.2	37.6	36.0	35.9	37.0	36.4	35.6	36.2
W2x	35.8	35.7	36.3	34.1	35.0	35.7	34.3	34.9	34.8
W4x	36.2	38.4	37.5	34.9	34.8	35.6	37.5	35.5	35.7
W8+	39.3	39.7	38.2	36.6	36.2	37.8	37.8	37.5	37.2
Average	38.1	38.2	37.9	36.4	36.3	37.0	36.8	36.6	36.6