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Article Title: Comparison of Performance-Levels and Sex on Sprint Race Performance in the Biathlon World Cup

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Abstract

Biathlon is an Olympic sport combining cross-country skiing with the skating technique and rifle shooting. The sprint (7.5 km for women and 10 km for men) includes two shootings between the three laps of skiing. The aims of the current study are to compare biathletes of different performance-levels and sex on total race time and performance-determining factors of sprint races in the biathlon World Cup. The top 10-performers **(**G1-10) and results within rank 21–30 (G21-30) in 47 sprint races during the 2011/2012 to 2015/2016 World Cup seasons were compared regarding total race time, course time, shooting time, range time, shooting performance (rate of hits) and penalty time. G21-30 among men and women were on average 3–5% behind G1-10 in total race time, in which course time accounted for 59–65% of the overall performance difference, followed by 31–35% explained by penalty time. The remainder (i.e., 4–6%) was explained by differences in shooting time and range time. The women G1-10 exhibited on average 12% slower speeds than the men G1-10, and course time accounted for 93% of the total time difference of 13% between sexes. The average total hit rates were 92–93% among the G1-10 and 85% among the G21-30 in both sexes. In total, men shot on average 6 seconds faster than women. Course time is the most differentiating factor for overall biathlon performance between performance levels and sex in World Cup races. No sex difference in shooting performance was found.

Key words: cross-country skiing, Olympic sport, shooting, winter sport

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Introduction

Biathlon is an Olympic sport combining cross-country skiing with the skating technique and rifle shooting. Biathletes carry a 3.5-kg long rifle around the ski tracks and stop at the shooting range to perform five shots in the prone or standing position between each of the 2.5–5.0 km laps. In the Biathlon World Cup, the 7.5 (women) and 10 (men) km sprint is the most common event. The sprint includes two shootings between the three laps of skiing, where each missed target requires biathletes to ski an extra 150 m as a penalty.

While less research is available on competitive biathlon, a substantial amount of studies have focused on cross-country skiing in recent years.[1-4] These studies have shown that the world's best skiers of both sexes are approximately 6–7% faster than skiers on a high national level in Norway (~30 in World Cup) both in the field and in laboratory tests.[5,6] With regard to sex differences in cross-country skiing, Sandbakk et al.[7] documented a 17% sex difference in peak speed during a roller skiing test to exhaustion using the skating technique, whereas Bolger et al.[8] showed 9% faster average speeds among men in a case where the race distance was 50% longer for men (15 vs. 10 km). Differences in skiing performance between the sexes and performance levels have, to date, not yet been examined in biathlon.

In the most recent attempt to analyze the competitive demands of biathlon sprint races, Cholewa et al.[9] found an average course speed of 7 m/s, an 88% hit rate and a total shooting time (including both shootings) of 58 s among men top 30 during the 2001/2002 World Cup season. In that study, the authors found higher correlation between course time and total race time than corresponding associations between shooting performance (i.e., penalty time) and total race time. However, the study was done more than a decade ago, and the sport of biathlon has developed considerably, with more teams winning medals,[10] and changes to the race programme (i.e. inclusion of single-mix and mixed-relays) during the last decade. In addition,

performance analyses of women's biathlon races have not yet been investigated. Overall, this motivates a reappraisal of the demands of competitive biathlon, including an examination of factors responsible for differences between performance levels and sex.

Many previous studies have focused on the impacts of kinematical variables or psychological training programs on shooting performance in rifle shooting,[11,12] and biathlon.[13-17] Notably, sex differences in shooting performance in competitive rifle shooting seems to be nonexistent.[18] However, only two studies have focused on shooting performance and shooting times in Biathlon World Cup competitions,[19,20] and no previous studies based on World Cup competitions have compared men and women.

Therefore, the aims of the current study are to compare biathletes of different performance-levels and sex on total race time and performance-determining factors in the biathlon World Cup sprint races from 2011/2012 to 2015/2016. Specifically, we aim to compare total race time, course time, shooting time and range time, as well as shooting performance (rate of hits) and penalty time among top-10 performers (G1-10) to those finishing among 21–30 (G21-30) within both sexes, and hypothesize that skiing speed will exhibit the largest differences between sexes and performance levels, whereas shooting performance will not differ between women and men.

Methods

G1-10 and G21-30 in 47 biathlon sprint races during the 2011/2012 to 2015/2016 World Cup seasons were compared on total race time, course time, shooting time, and range time, as well as shooting performance and penalty time. The G21-30 were chosen since the first 30 skiers achieve World Cup points, which assures their motivation to give full effort throughout the entire race, but the group is still clearly separated from the G1-10. Total race time refers to the total finish time of the competition, including course time, shooting time, range time, and

penalty time. Course time is the time spent skiing, excluding time at the shooting range and penalty time. Range time refers to the time at the shooting range, excluding shooting time. Shooting time is the amount of time spent at the shooting mat in both shootings together. Penalty time is the time spent skiing in the penalty loop as a consequence of shooting performance. Course speed was calculated from the reported race distance in each race minus 200 m (due to the length of the shooting range) and divided by course time. Pacing analysis was done by comparing course time for each lap, excluding the first and last of the five split time segments on each lap to avoid influence from the start and final sprint on the pacing analysis. The excluded part of the course time corresponded to ~10% of the total course time. Course time was normalized for race distance to allow for comparisons of the relative contribution of course, penalty, range, and shooting times on total race time differences between the sexes. In addition, performance on individual shots (i.e., shots 1–10) were analyzed for both groups in both sexes. All analyses were based on race reports publicly available from the International Biathlon Union (IBU) datacenter (2016),[21] collected by the official time keeping company for biathlon world cup competitions (SIWIDATA GmbH, Merano, Italy), and permission to use the data for scientific purposes was given by the IBU.

The average race distances were (men; women, mean+SD) 10152±202 m; 7587±141 m. The height differences from the lowest to the highest point in the course were 45±9 m; 38±9 m. The longest climbs were 31±9 m; 26±10 m, and the total climbs were 336±41 m; 243±30 m. The average wind speeds were 1.3±1.2 m/s and 1.5±1.5 m/s. The average air temperatures were –0.9±5.3 ºC and –0.4±5.3 ºC, and the average snow temperatures were –1.1±1.7 ºC and –1.0±2.1 ºC, measured 30 min after the first start in each of the 47 competitions.

Statistical analyses

Variables were tested for homogeneity of variances in both groups using Levene's test, tested for normality and presented as mean and standard deviation (SD) or standard error (SE). Statistical analyses were performed using SPSS Statistics version 22 (IBM Corp., Armonk, NY, USA). Only races with complete result lists were included, and unusual cases were filtered out using the "detect unusual cases" function in SPSS on the main variables of course time, penalty time, shooting time, and range time with the race ID serving as case identifier. Cases with an Anomality Index above 2 were filtered out before applying the main analyses. Due to missing or extreme values, this procedure removed 10 and 17 results among men and 13 and 40 results among women in the G1-10 and G21-30, respectively, out of a total of 470 results in both sexes. A more conservative filter was applied for the shooting time analysis of individual shots, which removed 24 and 41 results among men and 30 and 63 out of 470 results in total among women in the G1-10 and G21-30, respectively. Results with shooting times of less than 6 s or above 30 s to first shots and results with shooting times less than 1 s or above 10 s to the four other shots in prone and standing position were removed for the shooting time analysis of individual shots. Independent-samples t-tests were used to test for significant differences between the G1-10 and G21-30 groups, as well as for sex differences regarding total race time, course time, penalty time, shooting time, and shooting performance. When data did not meet the criteria of normality (i.e., percent hits skewed towards 100%) a nonparametric test (Mann-Whitney U test) was performed.

Results

On average, G21-30 men were 3.4% behind G1-10 men in total race time (Table 1). The average difference in course time explained 59%, whereas penalty time accounted for 35%, shooting time 4% and range time 2% of the total race time difference between groups among

men. On average, G21-30 women were 4.6% behind G1-10 women in total race time (Table 1). The average difference in course time accounted for 65%, penalty time for 31%, and shooting time and range time both accounting for 2% of the total race time differences between groups among women (Figure 1). Additional sub-analyses of time behind the winner within the G1-10 groups of both sexes showed the same trend as the differences between the two performance groups (i.e. G1-10 vs G21-30), with 72-74% of the time behind winner explained by course time differences, 19-26% by penalty time and 2-7% by range and shooting time differences.

Relative to the G1-10, the G21-30 were on average 2–3% behind in course time, shooting time, and range time and missed on average 8–9% more shots, which resulted in 50–70% longer penalty times, within both sexes (Table 1).

G1-10 men and women skied the third lap 2–3% slower than the first lap, which was a significantly lower speed reduction than the corresponding 4% slower speeds on the third lap for the G21-30 ($p<0.01$). Both groups employed a "J-shaped" pacing, with the course time on the first lap being faster than the course times on the other laps but the last lap was faster than the second one. G1-10 skied closer to their average speed on lap 1 and 3 compared to G21-30 (Figure 2).

G1-10 women were 13% behind G1-10 men in total race time when course time was normalized for course distance ($p<0.01$). The average sex difference in course time (i.e., representing speed differences) accounted for 93% of the sex difference in total race time, whereas shooting time, range time, and penalty time accounted for 3%, 1%, and 3%, respectively (Table 1).

G1-10 women used 7–12% more time than G1-10 men for all individual shots during prone shooting and the first shot in standing shooting ($p<0.01$). In addition, G1-10 women spent 16–23% more time between the four last shots in standing compared to G1-10 men

($p<0.01$; Figure 3). The biggest absolute time differences between individual shots were 1.1 s and 1.3 s for the first shot during prone and standing shooting, respectively (both $p<0.01$).

During prone shooting, both G1-10 men and women missed the first shot 1.9–2.1 times more often than the second shot (Table 2). During shooting in the standing position, the three first shots were missed on average 1.6 times more than all of the shots during prone and the other shots during standing among the G1-10 in both sexes (see Figure 4 for nuances between G1-10 and G21-30 within both sexes). Among men G1-10 during prone shooting, the first and last shot were missed 1.7 times more often than the three shots in the middle. Correspondingly, women missed the first shot during prone 1.5 times more often than the four other shots during prone, but did not miss the last shot during prone more than other shots. On average, the G21-30 and G1-10 in both sexes missed shots during standing 1.6 to 1.9 times more often than in prone position.

Discussion

In the current study, we examined the effects of performance level and sex on total race time, course time, shooting time, and range time, as well as shooting performance and penalty time for Biathlon World Cup sprint races during seasons 2011/2012 to 2015/2016. Both G21-30 men and women were on average 52-60 s behind G1-10 in total race time, in which course time accounted for 59–65% of the overall performance difference, followed by 31–35% explained by penalty time. The remainder (i.e., 4–6%) was explained by shooting time and range time differences. With course time normalized to course distance, we estimated that G1-10 women were on average 13% behind G1-10 men in overall performance, with the time lost in course time accounting for 93% of this difference between men and women. However, no sex differences in shooting performance were revealed (i.e., average hit rate 92–93% among

G1-10 and 85% among G21-30), although men shot on average 6 seconds faster than women in total.

The performance level differences in total race time appearing in both sexes were 3–5%, which are slightly less than those found for cross-country skiers.[6] The skiing performances between the G21-30 and G1-10 were even less distinct in the current study, with course time differences of 2–3%. Still, this is a 31–39 s time loss and thereby explains 59–65% of the overall time difference between the G21-30 and G1-10 in both sexes. The large influence of course time on overall performance corresponds to previous findings using correlational analyses in the Biathlon World Cup.[9] Interestingly, the average skiing speeds of 7.1 m/s found here are only slightly higher than those documented in the previous study among men top 30 in the 2001/2002 sprint World Cup.[9] However, differences in weather conditions, track preparations, course profiles and skis make direct comparisons challenging.

In addition, the 8–9% worse shooting performance among the G21-30 compared to the G1-10 led to ~18–19 s more penalty time and explained most of the further differences between performance levels in both sexes (i.e., 31–35%). Although a significant influence of shooting performance on total race time has been shown previously,[19] our analyses provide novel data on the actual influence of penalty time caused by more misses. Altogether, 94–96% of the performance differences between G1-10 and G21-30 biathletes are explained by course time and shooting performance (i.e., penalty time) in both sexes. The remaining differences were explained by shooting time (2–4%) and range time (2%). Thus, our data reveal that shooting time and range time differences between the G1-10 and G21-30 have a relatively low impact on the total performance in both sexes. Since shooting times are only reduced by 1-2 seconds among men since 2002,[9] this questions the importance of reducing shooting times, which has a relatively large focus among many coaches.

The largest difference in shooting performance between groups occurred during shooting in the standing position, where the G21-30 missed 10–11% more than the G1-10 in both sexes, whereas the G21-30 missed 5–7% more of the targets than the G1-10 during prone shooting. The reason for the larger differences between G1-10 and G21-30 when shooting in the standing compared to the prone position is likely caused by overall higher rates of mistakes in standing as well as greater technical difficulties in the standing position.

Both performance groups in both sexes skied the second and third lap slower than the first lap, which corresponds well with previous findings in cross-country skiing.[22] In both cases, the G1-10 had a more even pacing than the G21-30 by skiing the first and the third lap significantly closer to their average speed, which is also in line with recent investigations of lap times from 10–15 km for women and men in World Cup, World Championships, and Olympic cross-country skiing events.[4] To what extent the G21-30 would perform better by using a more even pacing strategy or if underlying differences lead to different strategies being optimal needs elucidation. In contrast to a few previous studies, where women used more even pacing than men,[4,23] we found no sex differences in our study.

The ~12% sex difference in speed is slightly higher than the 9–10% sex differences found in cross-country skiers on comparable performance levels.[1,8] This could be related to the greater metabolic cost of rifle carriage among women compared to men.[24] However, there are some limitations that should be noted when interpreting these data: e.g., in both cases men skied longer than women, which might have slightly reduced the actual sex difference in speed. In addition, men and women compete in slightly different tracks with different course profiles, and this might have a minor influence on the sex differences in speed found here.

As hypothesized, there were no sex differences in the shooting results, which corresponds to findings in competitive rifle shooting.[18] However, men shot on average 10–11% faster than women in both performance groups, with the largest sex difference in time occurring

at the first shot during both prone and standing shooting. This might be explained by men's disposition for higher risk assessment,[25, 26] and that shooting time has slightly more effect on the final ranking in the men's class compared to the women, or other mechanisms not previously investigated.

On average, the G21-30 and G1-10 in both sexes were 1.6 to 1.9 times more likely to miss a shot in the standing shooting position compared to shooting in the prone position. Earlier investigations of shot dispersion after exercise on different intensities found that prone shooting was minimally influenced by the intensity of exercise, but that shot dispersion was significantly increased during standing after high-intensity exercise.[27] This occurs even though the targets are 1.55 times bigger during standing than during prone, probably because of the increased degrees of freedom during standing. The difference is also affected by the supporting strap between the rifle and the arm that athletes use during prone shooting. In addition, increased postural stability and reduced movement of the rifle have been suggested as important factors of shooting performance during standing in biathlon.[15,28] Thus, external factors such as wind could also affect prone and standing shooting differently, with the largest influence on standing shooting.

G1-10 men missed the first and last shot during prone position more often than other shots in the same position, and G1-10 women missed the first shot during prone more often than other shots in the same position. When standing, the risk of a mistake appears to be sequentially lower for each shot in the series. It is unclear why these patterns occur, but it might be that the physiological recovery during standing affects the shooting performance sequentially for each shot as recovery proceeds during shooting[29,30] and that this effect is greater when shooting in the standing position compared to prone.[27] The reason for the effect being less pronounced in prone shooting, despite the 10–20 bpm greater heart rate drop in the prone position compared to standing,[30] could be that prone shooting performance is minimally

influenced by the intensity of exercise.[27] Here, we found that the last shot during prone shooting was missed more often than the three shots in the middle among men. Thus, psychological factors might also play an important role in these patterns of biathlon shooting performance.

Methodological considerations

Some athletes finished within G1-10 or G21-30 more often than others, which might have affected the results within G1-10 and G21-30 differently. However, since this study included 47 races, we regard the effect of individual tactics and capacities on the average performance of the groups to have minimal influence on our results. In addition, year-by-year analyses did not reveal any significant differences between the years investigated here (see supplementary table).

Conclusions

In conclusion, course time was the most important distinguishing factor for explaining the 3–5% differences between G21-30 and G1-10 biathletes, accounting for approximately 60% of the total race time differences between performance groups in both sexes. Altogether, course time and penalty time explained more than 94% of the total race time differences between G21-30 and G1-10 athletes. As hypothesized, there were no differences between the sexes in shooting performance, but female biathletes ski approximately 12% slower than male biathletes and shoot 11% slower during sprint competitions.

Practical Applications

Our results indicate that coaches and athletes should place the largest focus on improving skiing speed and shooting performance, rather than shooting time. Our data show that both groups of athletes skied the first lap significantly faster than the last lap, but that better performing athletes skied their first lap closer to their average speed than the slower athletes. Hence, it should be tested whether G21-30 athletes would perform better by using a more even

pacing strategy. In addition, most shots are missed during the first prone and standing shots, and standing position seems to differ most between G1-10 and G21-30 athletes. These aspects should therefore be given specific attention during training. However, to distinguish the very best athletes, the relatively small differences in range time and shooting time could play an additional role.

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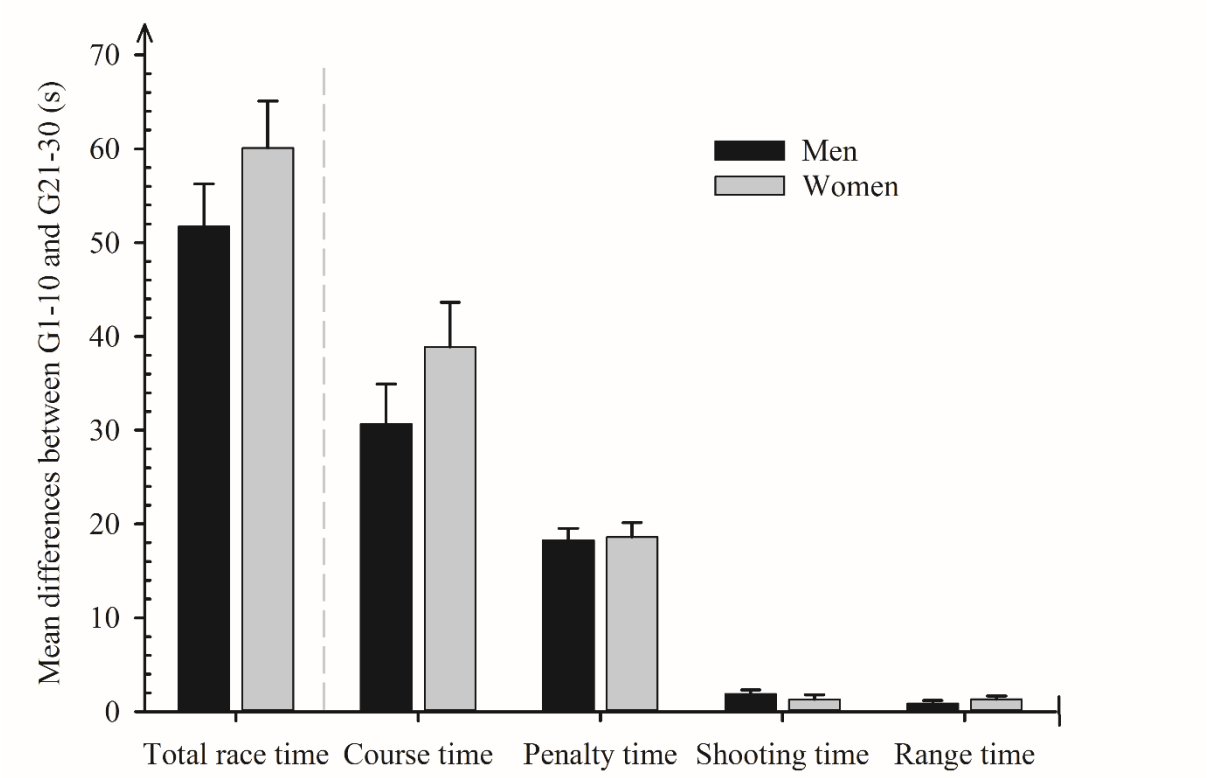

Figure 1. Mean difference (± std. error) between top-10 performers (G1-10) and those finishing among rank 21-30 (G21-30) in total race time, as well as the time lost in course time (the time spent skiing, excluding time at the shooting range and penalty time), penalty time (the time spent skiing in the penalty loop as a consequence of shooting performance), shooting time (the total time spent shooting) and range time (the time at the shooting range, excluding shooting time) in both sexes in 47 Biathlon World Cup sprint races during the 2011/2012 – 2015/2016 seasons.

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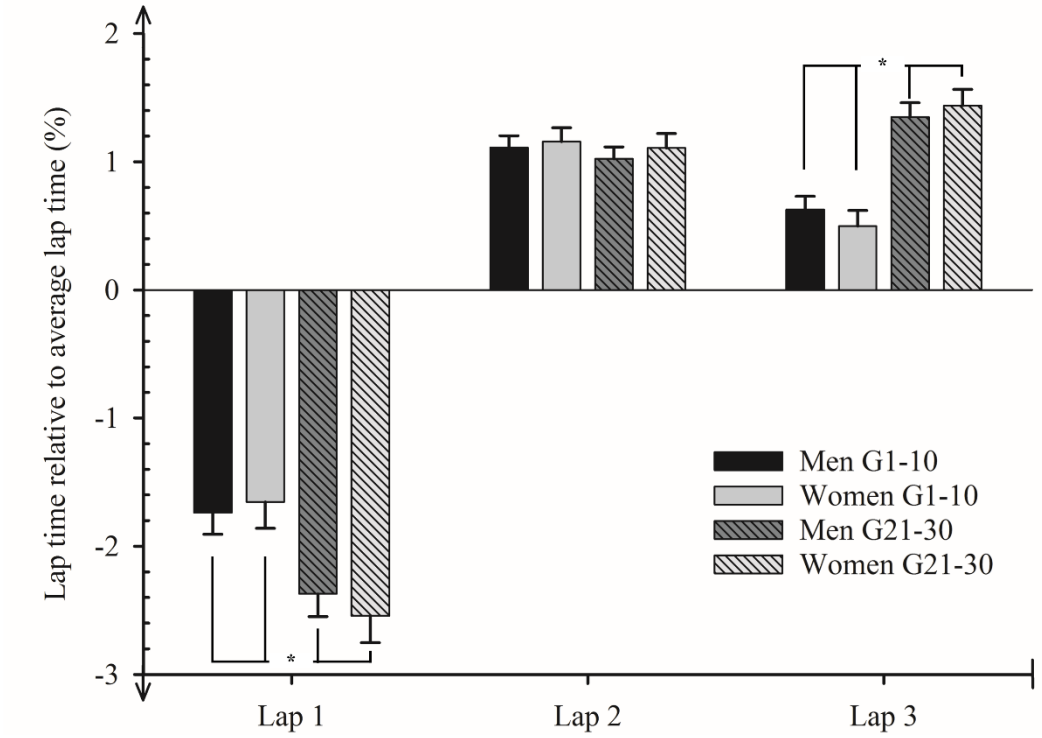

Figure 2. Lap time on each of the three laps (mean ± SD) as a percent of the mean lap time (based on three equal split times from each lap, excluding the final sprint) among men and women top-10 performers (Men G1-10 and Women G1-10) and those finishing among rank 21-30 (Men G21-30 and Women G21-30) in 47 Biathlon World Cup sprint races during the 2011/2012 – 2015/2016 seasons. * = performance group difference $p<0.01$

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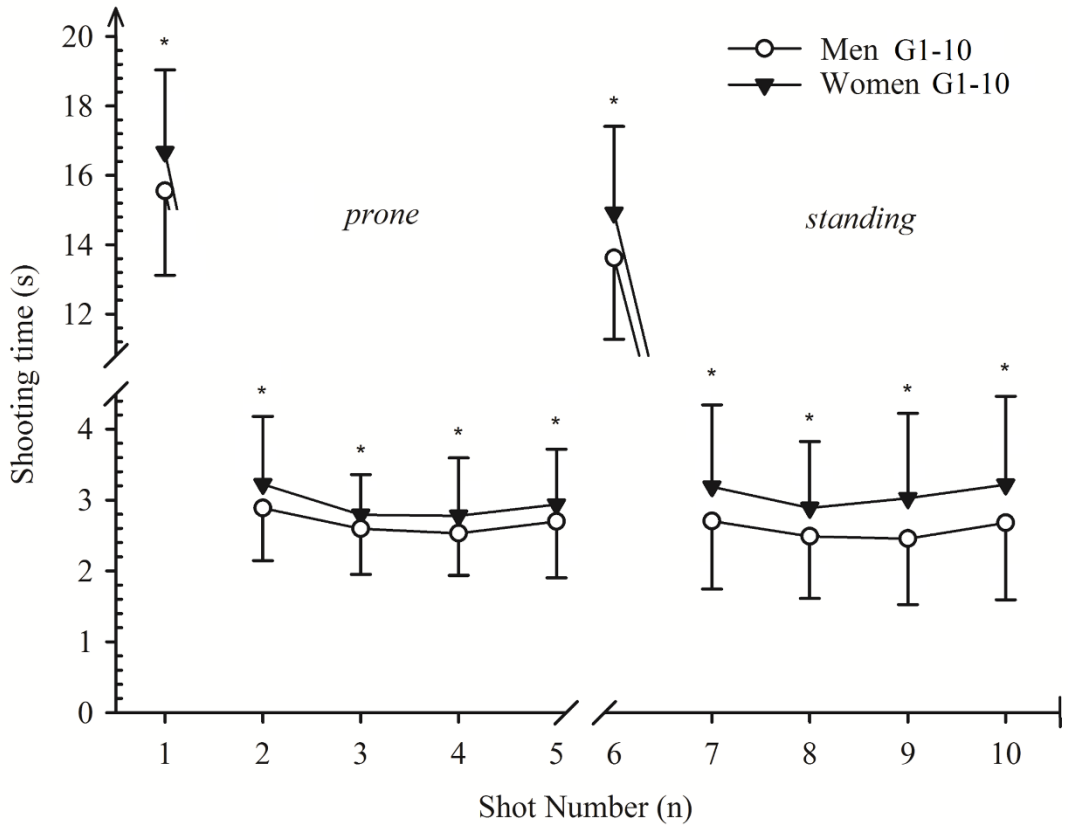

Figure 3. Mean shooting times for individual shots among top-10 performers (G1-10) in both sexes in 47 Biathlon World Cup sprint races during the 2011/2012 – 2015/2016 seasons. Shots 1-5 are prone shooting and 6-10 are standing. * = sex difference $p<0.01$

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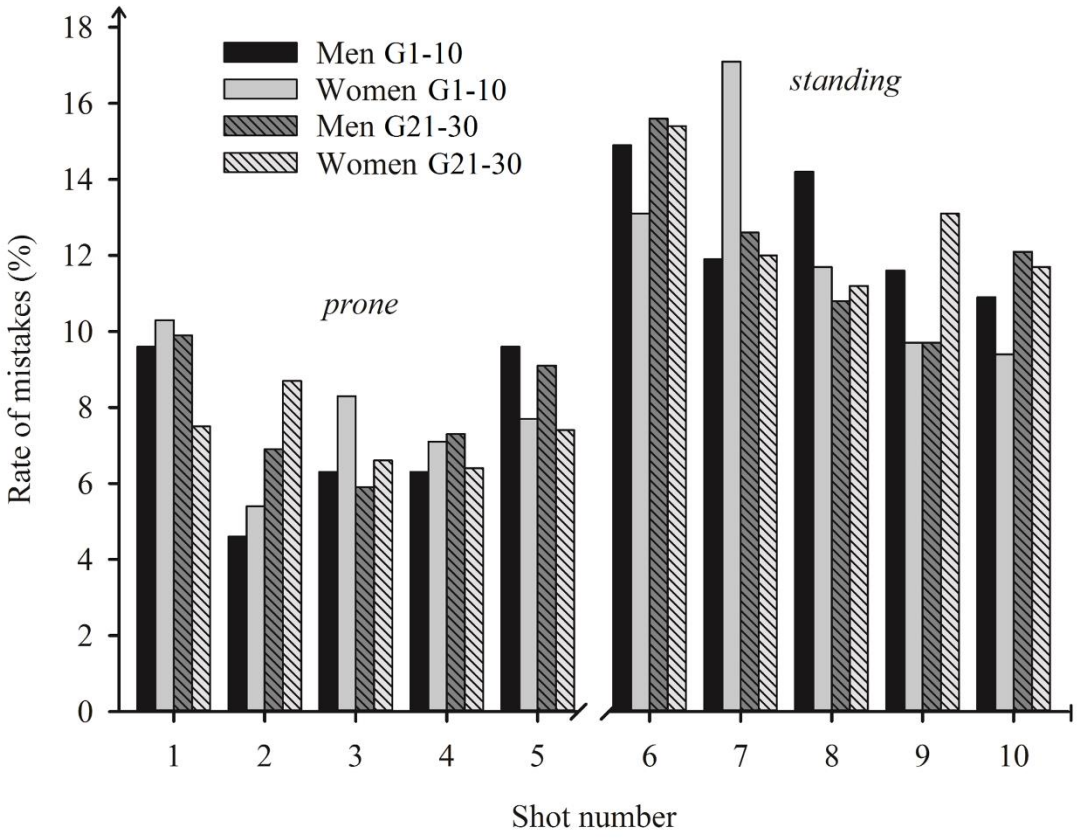

Figure 4. Rate of mistakes per shot among men and women top-10 performers (Men G1-10 and Women G1-10) and those finishing among rank 21-30 (Men G21-30 and Women G21-30) in 47 Biathlon World Cup sprint races during the 2011/2012 – 2015/2016 seasons. Shot 1-5 prone, shot 6-10 standing.

"Comparison of Performance-Levels and Sex on Sprint Race Performance in the Biathlon World Cup"
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Table 1. Total race time, course time, speed, shooting time, range time, penalty time and shooting performance in Biathlon World Cup sprint races during the 2011/2012 - 2015/2016 seasons for top-10 performers in each race (G1-10) and those finishing among rank 21-30 (G21-30) in both sexes.

	Men ($\overline{X}$ ± SD)		**Women ($\overline{X}$ ± SD)**	
	G1-10 N = 460	G21-30 N = 453	G1-10 N = 457	G21-30 N = 430
Total race time (s)	1508 ± 68	1560 ± 69*	1310 ± 72	1370 ± 77*
Course time (s)	1384 ± 63	1415 ± 65*	1171 ± 68	1210 ± 74*
Speed (m/s)	7.20 ± 0.30	7.05 ± 0.30*	6.33 ± 0.37	6.13 ± 0.37*
Shooting time (s)	56.3 ± 6.4	58.2 ± 7.0*	62.7 ± 7.3	64.0 ± 7.8
Range time[X] (s)	39.9 ± 4.9	40.8 ± 4.8	42.6 ± 5.2	43.9 ± 5.3*
Penalty time (s)	27.9 ± 16.6	46.3 ± 20.6*	33.5 ± 19.3	52.1 ± 26.2*
Hits (%)	93 ± 7	85 ± 9*	92 ± 8	85 ± 10*
	29.4 ± 3.9	30.0 ± 3.8	32.2 ± 4.0	32.8 ± 4.2
Time prone (s)	26.6 ± 4.3	27.7 ± 4.4*	30.3 ± 4.6	30.9 ± 4.7
Time standing (s)	95 ± 10	89 ± 13*	94 ± 10	90 ± 14*
Hits prone (%)	91 ± 12	82 ± 16*	90 ± 13	80 ± 16*
Hits standing (%)	21.9 ± 1.2	21.9 ± 1.4	24.0 ± 1.6	24.6 ± 2.0
PenaltyCost[Y](s)				

[X]Time at the shooting range excluding shooting time; [Y]The cost of one extra penalty within each group; * = $p < 0.01$ for difference between performance groups

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Table 2. The ratio of the probability of missing individual shots for top-10 performers (G1-10) and those finishing among rank 21-30 (G21-30) in both sexes. Shot numbers 1-10 (prone = 1-5 and standing = 6-10) are given in the leftmost column and bottom row of each table, respectively. The number in column Y and row X gives the probability ratio of missing shot X versus missing shot Y (i.e. in "Men G1-10" the probability of a mistake occurring on the first shot is 2.1 times higher than the probability of a mistake occurring on the second shot). The shading indicates distance from the equilibrium of ratio of rate of mistakes (1.0) and the rightmost columns give the average (avg.) probability of missing shot X compared to all other shots.

Men G1-10 (302 misses of 4550 shots)

X \ Y	1	2	3	4	5	6	7	8	9	10	Avg.
1		2.1	1.5	1.5	1.0	0.6	0.8	0.7	0.8	0.9	1.11
2	0.5		0.7	0.7	0.5	0.3	0.4	0.3	0.4	0.4	0.48
3	0.7	1.4		1.0	0.7	0.4	0.5	0.4	0.5	0.6	0.69
4	0.7	1.4	1.0		0.7	0.4	0.5	0.4	0.5	0.6	0.69
5	1.0	2.1	1.5	1.5		0.6	0.8	0.7	0.8	0.9	1.11
6	1.6	3.2	2.4	2.4	1.6		1.3	1.0	1.3	1.4	1.78
7	1.2	2.6	1.9	1.9	1.2	0.8		0.8	1.0	1.1	1.40
8	1.5	3.1	2.3	2.3	1.5	1.0	1.2		1.2	1.3	1.69
9	1.2	2.5	1.8	1.8	1.2	0.8	1.0	0.8		1.1	1.32
10	1.1	2.4	1.7	1.7	1.1	0.7	0.9	0.8	0.9		1.27

Men G21-30 (627 misses of 4340 shots)

X \ Y	1	2	3	4	5	6	7	8	9	10	Avg.
1		0.9	1.1	1.2	1.0	0.5	0.6	0.7	0.6	0.6	0.80
2	0.7		1.2	0.9	0.8	0.4	0.5	0.6	0.7	0.6	0.71
3	0.6	0.9		0.8	0.6	0.4	0.5	0.5	0.6	0.5	0.60
4	0.7	1.1	1.2		0.8	0.5	0.6	0.7	0.8	0.6	0.77
5	0.9	1.3	1.5	1.2		0.6	0.7	0.8	0.9	0.8	0.98
6	1.6	2.3	2.6	2.1	1.7		1.2	1.4	1.6	1.3	1.77
7	1.3	1.8	2.1	1.7	1.4	0.8		1.2	1.3	1.0	1.41
8	1.1	1.6	1.8	1.5	1.2	0.7	0.9		1.1	0.9	1.19
9	1.0	1.4	1.6	1.3	1.1	0.6	0.8	0.9		0.8	1.05
10	1.2	1.8	2.1	1.7	1.3	0.8	1.0	1.1	1.2		1.35

Women G1-10 (350 misses of 4430 shots)

X \ Y	1	2	3	4	5	6	7	8	9	10	Avg.
1		1.9	1.2	1.4	1.3	0.8	0.6	0.9	1.1	1.1	1.15
2	0.5		0.7	0.8	0.7	0.4	0.3	0.5	0.6	0.6	0.55
3	0.8	1.5		1.2	1.1	0.6	0.5	0.7	0.9	0.9	0.90
4	0.7	1.3	0.9		0.9	0.5	0.4	0.6	0.7	0.8	0.76
5	0.8	1.4	0.9	1.1		0.6	0.5	0.7	0.8	0.8	0.83
6	1.3	2.4	1.6	1.8	1.7		0.8	1.1	1.4	1.4	1.50
7	1.7	3.2	2.1	2.4	2.2	1.3		1.5	1.8	1.8	1.99
8	1.1	2.2	1.4	1.6	1.5	0.9	0.7		1.2	1.2	1.32
9	0.9	1.8	1.2	1.4	1.3	0.7	0.6	0.8		1.0	1.07
10	0.9	1.7	1.1	1.3	1.2	0.7	0.6	0.8	1.0		1.04

Women G21-30 (624 misses of 4210 shots)

X \ Y	1	2	3	4	5	6	7	8	9	10	Avg.
1		0.9	1.1	1.2	1.0	0.5	0.6	0.7	0.6	0.6	0.80
2	1.1		1.3	1.4	1.2	0.6	0.7	0.8	0.7	0.7	0.94
3	0.9	0.8		1.0	0.9	0.4	0.5	0.6	0.5	0.6	0.69
4	0.9	0.7	1.0		0.9	0.4	0.5	0.6	0.5	0.5	0.67
5	1.0	0.9	1.1	1.2		0.5	0.6	0.7	0.6	0.6	0.78
6	2.0	1.8	2.3	2.4	2.1		1.3	1.4	1.2	1.3	1.75
7	1.6	1.4	1.8	1.9	1.6	0.8		1.1	0.9	1.0	1.35
8	1.5	1.3	1.7	1.8	1.5	0.7	0.9		0.9	1.0	1.25
9	1.7	1.5	2.0	2.1	1.8	0.9	1.1	1.2		1.1	1.43
10	1.6	1.4	1.8	1.8	1.6	0.8	1.0	1.0	0.9		1.31

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Supplementary table. The differences in average total race time, course time, penalty time, shooting time and range time between those finishing among rank 21-30 (G21-30) and the top-10 performers (G1-10) in each race within both sexes in Biathlon World Cup sprint races during the 2011/2012 - 2015/2016 seasons.

Women G21-30 vs. G1-10	**2011**	**2012**	**2013**	**2014**	**2015**
Total time (s)	70.9	59.6	57.8	54.9	55.6
Course time (s)	45.7	37.3	35.7	37.2	36.8
Penalty time (s)	21.3	20.6	18.3	16.1	16.5
Shooting time (s)	2.8	0.2	2.3	0.4	0.9
Range time (s)	1.0	1.5	1.5	1.1	1.4
Men G21-30 vs. G1-10	**2011**	**2012**	**2013**	**2014**	**2015**
Total time (s)	56.3	49.6	50.8	47.7	56.3
Course time (s)	34.7	27.5	29.6	27.7	36.1
Penalty time (s)	19.0	18.5	18.2	18.0	17.8
Shooting time (s)	1.9	3.1	1.9	1.1	1.2
Range time (s)	0.8	0.5	1.1	1.0	1.3