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Night Versus Day Orienteering – an Analysis of Differences in Speed

Nacht versus Tag Orientierungslauf – Eine Analyse hinsichtlich unterschiedlicher Laufgeschwindigkeiten

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Summary

- **Introduction:** It is to be expected that orienteering at night is more difficult due to light restriction for map-reading. This study aims to analyze the differences in speed at night versus daytime.
- **Methods:** The last three night Swiss Orienteering Championships were analyzed concerning average speed (performance per km as divisor of course time and the sum of horizontal distance in km and differences in altitude per 100m) and compared with day courses.
- **Results:** In night as well as in day competitions a U-shaped age/speed relation could be detected in men with a minimum at 24.9 years respectively 6.2min in day versus 26.9 years respectively 5.4min in night (Night R^2=0.3564 / day R^2=0.1437). The same pattern can be detected in women with 17.9 years respectively 8.3min in day versus 23.2 years respectively 7.3min in night competitions. (Night R^2=0.0533/day R^2=0.1909).
- **Discussion:** The results are probably a consequence of a positive selection bias that only well-trained competitors start in night orienteering, which is in principle in accordance with higher map reading skills in night versus day courses. Furthermore, this pattern can be detected when analyzing competitive categories but less when analyzing runners from recreational categories and might correlate with the aspect of specific preparation for national competitions.

Zusammenfassung

- **Einleitung:** Orientierungslaufen in der Nacht ist durch spezifische Charakteristika gekennzeichnet, wobei insbesondere an die kartentechnischen Fähigkeiten vermutlich höhere Anforderungen gestellt werden, was sodann zur adressierten Fragestellung dieser Untersuchung abweichender Laufgeschwindigkeiten an Tag versus Nacht führt.
- **Methodik:** Die letzten drei Nacht-OL Schweizer Meisterschaften wurden mit Hilfe des im Trailrunning und O-Bereich häufig verwendeten Leistungskilometerkonzeptes (durchschnittlicher Leistungskilometer als Teiler der Laufzeit und des zusammenfassenden Leistungsaequivalents von 100 Höhenmetern und 1km Horizontaldistanz) bezüglich unterschiedlicher Geschwindigkeitsmuster mit Orientierungsläufen am Tag verglichen.
- **Resultate:** Sowohl in der Nacht als auch am Tag zeigte sich bei den Herren eine U-förmige Alter/Laufgeschwindigkeitsbeziehung mit einem Minimum der durchschnittlichen Leistungskilometerzeit bei 24,9 Jahren respektive 6,2min am Tag versus 26,9 Jahren respektive 5,4min in der Nacht (Nacht R^2=0,3564/ Tag R^2=0,1437). Dasselbe Muster setzt sich bei den Damen fort mit 17,9 Jahren respektive 8,3min am Tag versus 23,2 Jahren respektive 7,3min in der Nacht (Nacht R^2=0,0533/Tag R^2=0,1909).
- **Diskussion:** Die Resultate sind vermutlich eine Konsequenz eines positiven Selektionsbias dahingehend, dass nur Athleten mit gutem Niveau und entsprechender Vorbereitung an Nacht-Orientierungsmeisterschaften teilnehmen, was bei dezidierter Betrachtung auch mit höheren kartentechnischen Anforderungen in der Nacht vereinbar ist. Das identifizierte Muster setzt sich bei isolierter Betrachtung in den eher wettkampforientierten Kategorien fort, nicht aber in den breitensportorientierten Kategorien und könnte entsprechend mit dem Aspekt der spezifischen Vorbereitung für Meisterschaftsläufe korrelieren.

SCHLÜSSELWÖRTER:
Orienteering, Night-Orienteering, Speed per Performance Km, Speed

KEY WORDS:
Orientierungslaufen, Nacht-OL, Leistungskilometer, Laufgeschwindigkeiten

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Introduction

Orienteering is getting more and more popular and has become from a little-known sport mainly practiced in Scandinavian countries to a well-known and wide-spread activity in Middle Europe, especially in Switzerland but also in Germany. The increasingly leisure sports character has contributed to an increase in different and new forms of competitions. Thus, in addition to the original long-distance (runs in the forest with course times longer than 1.5 h in elite categories), middle-distance (runs in the forest with course times around 40 minutes), sprint (runs in urban areas with course times about 20 minutes), night orienteering forms are becoming more and more popular. One essential component in orienteering sports is cognition with respect to map-technical capabilities, whereby it would appear that ›

Table 1

Subject data of the runners included from the years 2013, 2014 and 2015 (in each case Number=n/Age (Mean/Standard Deviation)). Categories: D18=junior women, H18=junior men, DAK=short-distance women, HAK= short-distance men, HE=male elite, DE=female elite, D45=senior women, H45=senior men.

	D18	H18	DAK	HAK	DE	HE	D45	H45
Night 2013	n=18	n=21	n=9	n=12	n=24	n=32	n=17	n=22
Age (Mean / SD)	20.5±0.5	17.4±0.5	29.6±7.3	43.1±7.8	24.9±4.6	26.1±4.7	46.5± 1.36	47.7±1.3
Day 2013	n=12	n=20	n=11	n=10	n=27	n=20	n=11	n=14
Age (Mean / SD)	20.4±0.5	20.5±0.5	31.5±9.1	45.1±12	32±8.3	29.3±4.3	50.4±1.6	50.5±1.4
Night 2014	n=20	n=21	n=12	n=14	n=20	n=34	n=15	n=21
Age (Mean / SD)	19.4±0.5	19.5±0.5	30.5±10.6	43.9±9.1	26.9±4.2	28.1±4.6	49.2±1.2	49.2±1.5
Day 2014	n=17	n=14	n=11	n=11	n=20	n=21	n=15	n=22
Age (Mean / SD)	19.5±0.5	19.5±0.5	31.3±9.6	40.5±10.1	27.6±5.4	30±7.8	48.9±1.3	49.1±1.5
Night 2015	n=19	n=24	n=11	n=13	n=24	n=33	n=17	n=24
Age (Mean / SD)	18.5±0.5	18.5±0.5	28±4.5	46.3±8.7	25.3±4.2	26.6±4.6	47±1.4	48±1.3
Day 2015	n=24	n=37	n=12	n=12	n=18	n=24	n=17	n=18
Age (Mean / SD)	18.4±0.5	18.4±0.5	34.8±12.2	41.6±9.9	29.4±17.8	26.1±4.3	48 ±1.5	48.2±1.3

the reduced light available at night is an impediment. Although new technically high-quality standard orienteering lamps are available for about the price of running shoes and have a high light performance (2000 Lumen with a beam up to 300 meters), the light conditions cannot be compared to daytime. This potentially brings more difficulty in orientation due to increased strain, especially on vision. Analyses have shown, for example, that visually-impaired orienteering runners (for example those with green/red blindness) have substantial difficulty reading maps in the presentation forms defined by the IOF (International Orienteering Federation). This is time-consuming and hinders speed (17). Comparable effects can be assumed for map-reading in limited light at night (20).

If the general physiological demands of this type of sport are analyzed thoroughly, the doubtlessly important running capacity must also be emphasized. In principle, the cardiopulmonary system is a central and performance-determining element for the runner (7, 12, 13, 20). This system is responsible for guaranteeing the blood supply to the skeletal muscles, especially in the lower extremities, during physical performance, for example in completing an orienteering course (13). The extent of blood supply, respectively oxygen, to the skeletal muscle decisively determines the oxidative capacity of the organ and thus forms the biological limit of performance capacity (13). These processes are, in principle, the same day and night, apart from certain environmental effects such as possibly lower temperature (4, 13).

In addition to the physical restrictions the cognitive components in a second approximation must be mention. Thought processes are the same, in principle, day and night. But still difficulties arise in orienteering at night. Holding, respectively reading, the map leads to an altered gait pattern with slower speed, which can be presumed to be more pronounced at night as a consequence of reduced recognition of the ground structures (18). Moreover, at night, prospective map-reading – looking around to identify objects – is less reliably possible due to limited light conditions (2, 5, 15, 11, 18).

The capability to modify behavior and to call up a technical-tactical repertoire, important per se, appears to take on additional meaning at night from the mentioned route selection, such as paths versus direct route in the forest crossing pathways. Circuitous routes on pathways appear to have (even) greater importance due to the potentially more certain approaches to the controls and avoidance of sources of error (6, 8, 9, 11, 16).

Some analyses of factors which determine running time have been made in orienteering (2, 10, 16). Analyses of the relationship of the competition form day versus night are, however, still missing. This permits formulation of the central question in this study as follows: is there a difference in mean running speeds at night compared to daytime? As hypothesis, in the sense of possible, potential falsification, it is postulated that the mean running times do not differ between runs in the daytime and at night (19).

Methods

Subjects

Orienteering runners in the categories junior women (D18) and junior men (H18), short-distance women (DAK) and men (HAK), male elite (HE) and female elite (DE) and senior women (D45) and senior men (H45), who participated in the Night-orienteering Swiss Orienteering Championships in the years 2013, 2014 and 2015. Table 1 shows the number and age of the 477 competitors in the night competitions versus 418 competitors in day competitions, arranged by year and category.

Procedure

The average running speeds in the three night-orienteering Swiss Championships in the years 2013, 2014, 2015 were analyzed in the categories cited above. To quantify the average running speeds, the performance kilometer concept often used in trail running and orienteering was applied. Set in relation to the average performance kilometers separated by year and category, this was used as a correlate to running speed (1, 21). This was applied according to the distance information provided by the organizers, whereby 1km horizontal distance and 100 meters rise in altitude represent an equal performance correlate – a performance kilometer (1, 21). It must be noted here that the course data with respect to distance and altitude given by the course setter are those identified by the setter for the optimal route (not only the link between the individual controls), thus including potentially faster circuitous paths. This implies that the reported average performance kilometers are performance correlates under the assumption that no route error was made, but this is in itself one aspect of the sport.

The night-orienteering championships were held in the forests in Adlisberg 2013 (coordinates running area: 687/248/SOLV-No. 825), Grauholz-Wannental 2014 (coordinates running area: 605/206/SOLV-No. 1745), Buechwald 2015 (coordinates running area: 645/251/SOLV-Nr. 702).

These were compared to orienteering-competitions held in the daytime in an area as similar as possible with respect to path network, vegetation and topography. The comparison fo-

Table 2

Average kilometers for the categories junior women (D18) and junior men (H18)/senior women (D45) and senior men (H45) for the years 2013-2015.

	H18	P-VALUES MANN-WHITNEY U-TESTS WOMEN VERSUS MEN	D18	H45	P-VALUES MANN-WHITNEY U-TESTS WOMEN VERSUS MEN	D45
2013						
Average performance km±Standard deviation Night	5.9±0.9	z(3.449) p<.01	7.6±1.1	6.7±0.7	z(-4.024) p<.01	8.6±2.0
p-Values of Wilcoxon tests (Day versus Night)	z(-4.287) p<0.01		z(-3.729) p<0.01	z(-4.016) p<0.01		z(-3.182) p<.01
Average performance km±Standard deviation Day	6.4±1.6	z(-3.089) p<.01	7.6±1.5	6.9±1.4	z(4.348) p<.01	8.4±2.0
2014						
Average performance km±Standard deviation Night	5.8±1.1	z(-4.016) p<.01	7.4±1.0	6.9±1.0	z(-4.723) p<.01	9.8±1.7
p-Values of Wilcoxon tests (Day versus Night)	z(-3.729) p<.001		z(-4.287) p<.001	z(-4.016) p<0.01		z(-3.182) p<.01
Average performance km±Standard deviation Day	5.2±1.0	z(-4.485) p<.01	6.8±1.3	11.2±2.2	z(-6.839) p<.01	9±2.1
2015						
Average performance km±Standard deviation Night	7.3±1.2	z(-4.584) p<.01	8.8±1.4	9±2.1	z(-3.33074) p<.01	11.2±2.2
p-Values of Wilcoxon tests (Day versus Night)	z(-4.784) p<.001		z(-3.296) p<0.001	z(-3.563) p<.001		z(-2.828) p<0.01
Average performance km±Standard deviation Day	6±1.1	z(-3.200) p<.01	7.6±1.1	6.9±1.0	z(4.40281) p< .01	10.2±2.3

rest for the year 2013 was Baldegg (coordinates running area: 663/258 SOLV-No. 658). For the year 2014, both the night and day runs were held in the same running area Grauholz/Wannental. The daytime run (immediately after the night run) was over a shortened night-orienteering distance (ca. 45-85 percent) (12, 13). For the year 2015, the run on the map Bouleyres (coordinates running area: 573/163/SOLV-No. 921) was selected as comparison course.

Statistical Assessment

The means and standard deviations of the average performance kilometers were calculated both for night-orienteerings and day-orienteerings by categories for junior women and men, short-distance women and men, elite women and men, senior women and men (Tab. 2, 3, 4, 5). Since the primary analyses using the Jarque-Bera test showed that the average performance kilometers were normally distributed in only a few partial random samples with respect to the categories in a given year, category-separate analyses of the average performance kilometers day versus night were performed using the Wilcoxon Test (3, 14). Mann-Whitney U-tests were performed to identify differences between women versus men categories (3). All test batteries of Wilcoxon and Mann-Whitney U-tests were examined in two-sided analysis with respect to significant differences. In addition, beyond year and category, 2nd degree polynomial interpolations were made by gender for the day and night competitions and the resulting minima calculated. Calculations were made using Microsoft Excel and SPSS 22.

Results

The calculated average performance kilometers±standard deviations as a correlate of running speed are given below for the years 2013-2015 for the categories junior women and junior men and senior women and senior men (Tab. 2, 3), as well as for men and women short-distance and men and women elite (Tab. 4, 5).

In addition, 2nd degree polynomial iinterpolations were calculated across categories and all three years because of the assumption of a U-shaped relationship between age and average running speed. For the male competitors, there was a local minimum at 24.9 years and 6.17min (n=223)(R^2=0.1473) at night. During the day, the local minimum was 26.91 years and 5.36min (n=271) (R^2=0.0533). For the women, the local minimum was at 17.9 years and 8.27min (n=195) (R^2=0.3464) during the day and a local minimum at 23.18 years and 7.32min (n = 206) (R^2=0.1909) at night.

Discussion

Speed was greater in the Elite categories than in the Junior and Senior field tests and in short-distance, whereby this can attributed especially to biological factors (age) (7, 20). A maximum performance capacity is relatively clear around the age of 25, independent of gender and the competition form day versus night. The women tended to run slower than the men, which is due to biological factors (Tab. 2, 3, 4, 5) (7, 20). If a comparison is made with the results of other studies, analyses showed a slowing starting at the age of 45 for both men and women (13±2% and 16±4%) per decade, which agrees with the results ›

Table 3

Course data junior women (D18) and junior men (H18)/senior women (D45) and senior men (H45) for the years 2013-2015, as Distance/Altitude/Controls.

	DISTANCE/ALT/ CONTROLS 2013	DISTANCE/ALT/ CONTROLS 2014	DISTANCE/ALT/ CONTROLS 2014
D18 Night	6.9/230/18	5.9/225/20	6.6/185/19
D18 Day	4.9/160/12	3.9/130/17	7/170/24
H18 Night	8.8/230/21	7.4/395/21	9.5/260/24
H18 Day	7.2/260/20	4.1/180/14	10.4/250/37
D45 Night	6.3/140/17	4.0/195/15	5.2/150/17
D45 Day	4.6/120/11	3.4/110/15	4/270/17
H45 Night	8.0/260/22	6.6/240/21	7.8/240/24
H45 Day	6.4/230/14	5.4/170/22	5.1/90.0/18

Table 4

Average performance kilometers separated for categories short-distance women (DAK) and men (HAK) and elite women (DE) and men elite (HE) for the years 2013-2015.

	HAK	P-VALUES DER MANN-WHITNEY U-TESTS WOMEN VERSUS MEN	DAK	HE	P-VALUES DER MANN-WHITNEY U-TESTS WOMEN VERSUS MEN	DE
2013						
Average performance km±Standard deviation Night	6.7±1.7	z(-3.748) p<.01	8.3±1.1	4.9±0.5	z(-4.416) p<.01	6.2±0.4
p-Values of Wilcoxontests (Day versus Night)	z(-5.233) p<0.01		z(-3.441) p<0.01	z(-4.198) p<0.01		z(-3.409) p<0.001
Average performance km±Standard deviation Day	9.5±2.1	z(2.050) p =.04	10.4±2.1	5.5±0.5	z(-3.734) p<.01	6.3±0.6
2014						
Average performance km±Standard deviation Night	10.7±2.5	z(-2.315) p=.02	12±1.7	5.3±0.6	z(-2.013) p=.04	6±0.9
p-Values of Wilcoxontests (Day versus Night)	z(-5.233) p<.01		z(-3.411) p=.001	z(-5.304) p<0.001		z(-3.409) p<.001
Average performance km±Standard deviation Day	7.7±1.4	z(4.042) p<.01	9.6±3.1	4.4±0.7	z(-5.767) p< .01	5.4±0.6
2015						
Average performance km±Standard deviation Night	7.6±1.4	z(-1.170) p<.24	16.8±4.6	7.5±1.1	z(-5.988) p<.01	7.5±1.1
p-Values of Wilcoxontests (Day versus Night)	z(-2.586) p<0.01		z(-.405) p=.686	z(-5.087) p<.001		z(-1.369) p=.171
Average performance km±Standard deviation Day	10.3±1.9	z(-4.294) p<.01	11.1±0.8	4.9±0.5	z(-4.898) p<.01	6.8±0.9

presented here (2) (Tab. 2, 3, 4, 5). With reference to the assumed hypothesis stated at the beginning, the methodical limitations with respect to the basic comparability of field tests must again be taken into account. In particular, it must be mentioned that the night-orienteering runs analyzed here were championships versus national runs in similar competitions during the day. It can be assumed that the specific preparation was correspondingly better for the night runs.

In the analysis of the results, it must be noted that no clear relationships could be detected in the Junior categories (H18/D18). It can be assumed, however, that the faster average speeds in the third year of competition is due to the competition form of loop-orienteerings. The fact that greater speed was attained in the night in one competition year could be due to a positive bias in favor of night-orienteerings, in the sense that only runners who very regularly participate in orienteering, took part at all in night-orienteerings, or that preparation was better due to the championship character. In men's short-distance, speed was greater during the day. This finding applied only in part to the women, whereby a selection bias is probably present here, too

Table 5

Course data by categories short-distance women (DAK) and men (HAK) and elite women (DE) and men elite (HE) for the years 2013-2015, as Distance/Altitude/Controls.

	DISTANCE/ALT/ CONTROLS 2013	DISTANCE/ALT/ CONTROLS 2014	DISTANCE/ALT/ CONTROLS 2015
DAK Night	3.6/60/9	3.10/100/12	3.6/80/11
DAK Day	3/70/11	2.8/80/11	2.5/60/12
HAK Night	5.1/250/12	3.9/160/14	4.6/130/13
HAK Day	3.5/120/10	2.8/80/11	3/75/12
DE Night	10.3/350/24	8.1/400/20	8.2/260/24
DE Day	11.8/380/27	5.2/180/20	5.1/130/18
HE Night	15/560/32	13.7/625/34	11.5/410/33
HE Day	8.1/240/20	6.1/270/21	6.3/150/24

(the numbers of participants is lower in night-orienteerings), in the sense that only runners well-acquainted with the orienteering technique take part in night-orienteerings. Among Senior women and Senior men, there was a relatively clear tendency to run faster during the day, the only exception being among women in the first competition year. If one tries to identify a pattern in the Elite categories, a first approximation presents a heterogeneous pattern, which can probably be attributed to various causes specific to the Elite categories (4,5,16).

On the one hand, the night-orienteerings analyzed were national championships coupled with the honor of title, which is correspondingly anticipated by the athletes, probably with the consequence that the start was not simply after training, but that more serious preparation was made than in the daytime competitions. These latter were only national runs and in particular, some of the best runners were also internationally active and did not participate in these competitions. In the men's Elite, there is apparently also a positive selection bias with respect to the participants, in the sense that in the comparison runs especially in 2014, reference was middle distance and thus not only actual elite runners were among the starters, which resulted in higher average times during the day.

In an attempt to reach a synthesis, it can be determined that among the Seniors, too, the speed tended to be slower at night than during the day. Taking into account that race three was conducted in loop form, results fitting this pattern are also found for Junior women and Junior men. Among the Elite, the afore mentioned aspects of positive selection bias and the preparation could be responsible for the sometime inverse relationships. Thus, there is a tendency for evidence that speed is lower at night than during the day. An attempt at explanation allows the deduction that cognitive tasks in the field are likely more difficult (interpretation of objects, route selection with potential detours).

From a biological point of view for the cardiovascular or musculoskeletal organ systems, there is, in principle, no limitation in running at night, apart from environmental conditions, such as temperature. In secondary interpretation of the results separated by year of performance, it can be identified that night speed was faster in numerous categories in 2013. This could be due to a positive selection bias with respect to orienteering capability in night-orienteerings. In 2014, speed was greater in almost all tested categories during the day, but the shorter comparison distance must be taken into account here. In 2015 speed at night was greater than during the day, but again, the competition form (loop orienteering with mass start) was likely responsible. The evidence makes clear that various factors determine running speed, whereby the starting field and form of competition may attain relevance in addition to the aspect day versus night.

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Conflict of Interest

The authors have no conflict of interest.

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