Original Article

Analysis of speed strategies during World Orienteering Championships

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ABSTRACT

The aim of this study was to analyse if better orienteers run more constant yielding to suggest the better the place, the more constant the pace. In principle, this premise is supported from a biological point of view of the aerobe-anaerobic threshold concept, which is well elucidated in long distance running and implies that a constant pace slightly below the threshold leads to maximal performance through regularly use of cardiopulmonary and musculoskeletal system. To test this assumption race times of orienteers from the world championships at the Swedish Westcoast in Strömstad / Tanum were analysed concerning their steadiness of speed during the final course of middle and long-distance races. Interestingly statistical analyses mainly support the premise of relevance of steadiness in running. In woman, for long/middle distance a coefficient of determination between time and steadiness (calculated as standard deviation of all percentage deviations of individual split times and best time) of $R^2 = 0.254$ respectively of $R^2 = 0.825$ was detected. In men, for long/middle distance of $R^2 = 0.176$ respectively of $R^2 = 0.472$. Although, the method does not allow to strictly distinguish between cognitive and biological factors, it is implied that world class orienteers or more general orienteers get best results if running as constant as possible probably slightly below anaerobic threshold.

Key words: WORLD ORIENTEERING, CHAMPIONSHIPS, COURSE TIMES, CONSTANT SPEED.

Cite this article as:
Gasser, B.A. (2018). Analysis of speed strategies during World Orienteering Championships. *Journal of Human Sport and Exercise, 13*(2), 254-266. doi:https://doi.org/10.14198/jhse.2018.132.01

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Submitted for publication September 2017
Accepted for publication January 2018
Published March 2018
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

doi:10.14198/jhse.2018.132.01

INTRODUCTION

Orienteering is getting more and more popular and has gained increased popularity. In elite orienteering a professionalism has developed in the last decades resulting in a respectable number of world class elite runners and considerable number of juniors (Roos et al. 2015). These elite athletes devote a training and preparation time each day to achieve their competitive goals (Tønnessen et al. 2014). The introduction of new technology in the form of *'electronic punching'* and *'GPS monitoring'* in the sport has opened up new areas for investigation, particularly in the field of race strategies (Pribul and Price, 2005). For orienterring requirements can be arbitrarily divided into cognitive and biological ones. Cognitive aspects can be shortly summarized as on-foot navigation using map and compass through wild terrain interpreting objects, controll pace (running only as fast as an orienteer can read the map) and choosing the fastest routes between to controls (Chalopin 1994, Eccels 2014, Eccles 2006, Galory et al. 1986, Guzman et al. 2008, Seiler 1996). Interestingly due to physical differences respectively different somatotypus of orienteeres different routes e.g. straight up the hill versus around are faster as a result of biological differences (Lauenstein et al. 2013). Normally experts in the sport of orienteering have developed a cognitive advantage over years starting in the early childhood (Eccels 2014). Specifically, they have acquired knowledge of cognitive and behavioral strategies that allow them to circumvent natural limitations on attention (Eccels 2014). Besides the unquestionably very important cognitive aspects biological ones are to mention. Orienteering is an endurance running discipline differing from other running sports especially in the type of terrain encountered (Creagh and Reilly 1997). Hints exist that high aerobic power in orienteers are coupled with compared lower anaerobic performance (Creagh and Reilly 1997). The energy cost of running is greatly increased in rough terrain and studies revealed that Oxygen cost was about one fourth higher while running in a forest when compared with road running, whereby especially biomechanical differences in stride pattern contribute towards this increased demand (Eccles 2006, Eisenhut and Zintl 2009, Guzman et al. 2008, Pribul and Price, 2005). Despite the mentioned differences orienteering remains an endurance sport underlying the respective performance restrictions (Eisenhut and Zintl 2009, Held 1997,Hoppeler et al. 1985, Steffny 2008, Steffny 2010). This imply that performance is limited by the capacity of cardiopulmonary and musculoskeletal system (Eisenhut and Zintl 2009, Hoppeler et al. 1985). This premise is supported from a biological point of view of the aerobe-anaerobic threshold concept, which is well elucidated in long distance running and states that a constant pace slightly below the threshold allows minimizing total time (Eisenhut and Zintl 2009, Hoppeler et al. 1995, Steffny 2008, Steffny 2010). Cardiopulmonary system provides skeletal muscle with oxygen allowing the muscle to use its oxidative capacity for muscle contraction (Eisenhut and Zintl 2009, Hoppeler et al. 1985, Steffny 2008, Steffny 2010). Based on that oxidative capacity and cardio-pulmonic System especially VO_2 max has to be taxed as limiting factor of performance (Eisenhut and Zintl 2009, Hoppeler et al. 1985, Steffny 2008, Steffny 2010). Due to the fact, that scelet muscle (in orienteering especially of lower extremity) has to be adequatly provided with energy on a regular basis, from a theoretical point of view the best results are probably achieved when running as steady as possible (Eisenhut and Zintl 2009,Hoppeler et al. 1985,Steffny 2008, Steffny 2010). For the cardiovascular system results a regular heart rate some beats below the aerob-anaerobic threshold, means that the body does accumulate a lactate concentration between 2 to 4 mmol/l. Studies indicate that (elite) orienteers pace themselves such that their mean heart rate remains slightly below aerobe-anaerobic threshold (detected range was 167 to 172 beats/min)(Bird et al. 1993).Other studies identified wider ranges of mean heart rate (140 to 180 beats per min) with phases of strenuous anaerobic work, whereby the type of course significantly affected heart rate pattern (Bird et al. 1993, Karppinen and Laukkanen 1994). Karppinen and Laukkanen (1994) concluded that measured maximal and mean heart rate explains some but not all success in orienteering and proposes to use standard deviation of mean heart rate instead which reveals more information respectively explains more about success. Interestingly, in all races analyzed and taxed as successful standard deviation was less than 3 beats per minute implying the important fact of running with a constant pace (Karppinen and Laukkanen, 1994). These suggestions are strongly supported from a biological and is further supported from a cognitive respectivelly technical point of view. Besides running on a steady pace mistakes have to be avoided in order to minimize total time such as choosing fastest routes and avoiding search situations in controll area. This supports the argument that the more constant an orienteer runs the lower the total time is. This allows to focus to the aim of the study to analyse if better orienteers run more constant. It shall be presumed that the faster an orienteer competes the more constant perfrormance is delivered. In order for potential falsification, hypothesis is stated that there is no difference in variation of average speed between faster and slower athletes (Popper 1969).

METHODS

Participants

Participants from the world Orienteering Championships August 20-28, 2016 in Strömstad / Tanum at the Swedish West Coast were analyzed concerning their speed pattern during the final races in forest competitions. Analyzes contained final races in middle distance with 63 women and 72 men as well as classic distance with 59 women and 65 men.

Statistical analysis

Descriptive statistics for middle and long-distance course times were calculated for woman and men including analyses of normal distribution with Kolmogrov Smirnov test (Bortz 2005, Sachs and Hedderich 2006). Furthermore, for each control, best time was identified and taken as benchmark for other times. Deviation in percent from the best time were calculated for each time split between controls yielding to standard deviation of all percentage deviations of a race. Calculated deviations for each race were divided in the first and second part of the ranking list yielding to analyzes of significance of differences with Wilcoxon Tests. Analyzes were conducted with Graph Pad Prism 5.0 and Microsoft Excel.

RESULTS

Interestingly, race times between woman and men especially for classic race showed highly similar average total times in men and woman around 1h 52 min. This pattern is less clear in middle distance with total times around 45 min. Tab. 1a and Tab. 1b show details of course times.

Table 1a. Descriptive statistics for long distance

	long	men	long	women
Number of competitiors		52		59
Minimum	93 min 27 sec	0.073	86 min 24 sec	0.05
25% Percentile	105 min 8 sec	0.119	98 min 24 sec	0.153
Median	111 min 29 sec	0.175	108 min 24 sec	0.236
75% Percentile	121 min 18 sec	0.253	123 min 18 sec	0.372
Maximum	133 min 2 sec	0.646	161 min 2 sec	0.599
Mean	112 min 34 sec	0.206	112 min 34 sec	0.262
Std. Deviation	10 min 17 sec	0.119	18 min 17 sec	0.134
Std. Error	85 min 36 sec	0.017	2 min 26 sec	0.018
Lower 95% CI of mean	109 min 42 sec	0.173	107 min 43 sec	0.227
Upper 95% CI of mean	115 min 26 sec	0.239	117 min 10 sec	0.297

	long	men	long	women
Kolmogrov Smirnov distance	0.103	0.167	0.14	0.11
P value	> 0.10	0.0009	0.0058	0.0748
Passed normality test (alpha=0.05)?	Yes	No	No	Yes
P value summary	ns	***	**	ns

Table 1b. Descriptive statistics for middle distance

	middle	women	middle	men
Number of competitors		63		72
Minimum	33 min 57 sec	0.07	37 min 9 sec	0.049
25% Percentile	37 min 8 sec	0.115	40 min 22 sec	0.129
Median	40 min 14 sec	0.178	43 min 9 sec	0.238
75% Percentile	45 min 55 sec	0.292	48 min 50 sec	0.387
Maximum	102 min 40 sec	2.01	114 min 29 sec	2.356
Mean	44 min 17 sec	0.3	48 min 5 sec	0.348
Std. Deviation	12 min 12 sec	0.367	14 min 52 sec	0.408
Std. Error	1 min 11 sec	0.0462	1 min 45 sec	0.048
Lower 95% CI of mean	41 min 12 sec	0.208	44 min 35 sec	0.252
Upper 95% CI of mean	47 min 21 sec	0.392	51 min 34 sec	0.444
Kolmogrov Smirnov distance	0.221	0.301	0.252	0.256
P value	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Passed normality test (alpha=0.05)?	No	No	No	No
P value summary	***	***	***	***

When analyzing average individual deviations in long distance values between 0 and 0.65 in men and values between 0 and 0.65 in women can be identified. When analyzing deviations for middle distance values between 0 and 2 in men and somewhat smaller with values between 0 and 2.5 in women. These deviations are calculated for splits and not for the whole course. When embedding in other studies results seem to be large e.g. as comparative mean elite athlete's race-to-race performance yielded to a variation of 0.3 (Hébert-Losier et al. 2015). A comparison is possible if understanding times from control to control as one course (principally possible especially for long splits when keeping e.g. in mind the large distance between control one and two in men classic race yielding to the above-mentioned taxing of large differences). (Fig. 1).

Figure 1. Map of Classic distance men final races – the long distance between control 1 and 2 yielded to a best time of 22 min 13 seconds and the shortest split resulted from 26-27 with 47 seconds (Woc 2016). Time for splits between controls was 2 min 55 ± 46 sec (mean ± SEM). Left the typical terrain of a stony part is shown.

A tendency that time versus steadiness showed a higher coefficient of determination than time versus place (exception long distance men) is further detectable. When comparing long and middle distances higher values for coefficient of determination were identified in middle than in long distance with the highest values in middle distance woman (time versus steadiness $R^2 = 0.825$) yielding to a very high correlation coefficient of Pearson ($r = 0.92$).

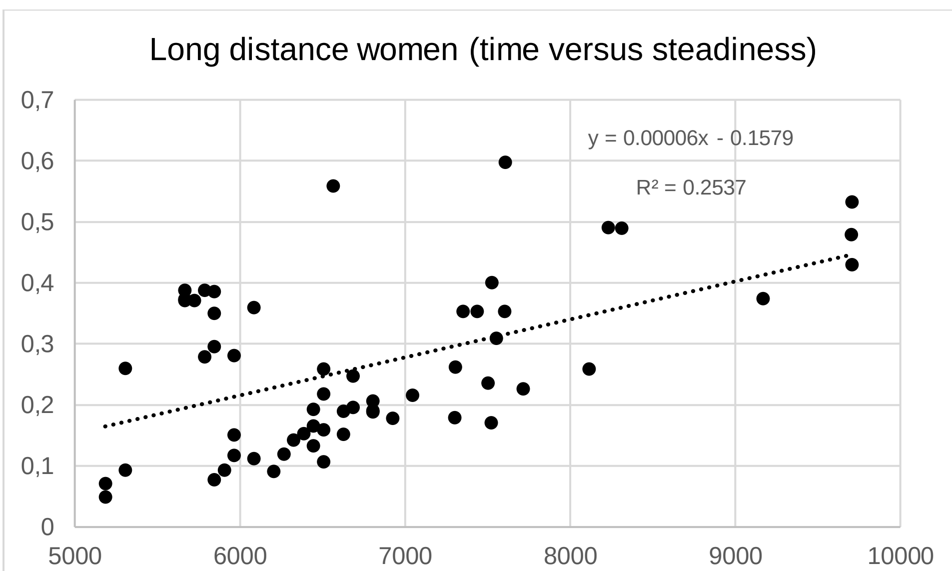

Figure 2a. Time versus steadiness woman long distance ($R^2 = 0.254$)(n = 63) / (11.2 km /480 Attitude / 18 controls) x – Axis time / y – Axis steadiness (calculated as standard deviation of all percentage deviations of individual split times and best time).

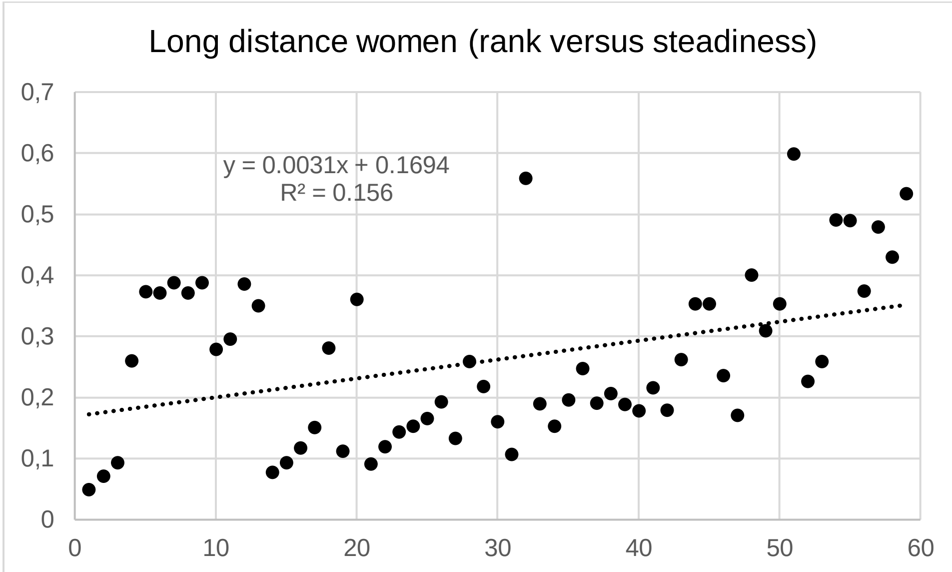

Figure 2b. Place versus steadiness woman long distance ($R^2 = 0.156$)(n = 63) / (11.2 km /480 Attitude / 18 controls) x – Axis rank / y – Axis steadiness (calculated as standard deviation of all percentage deviations of individual split times and best time).

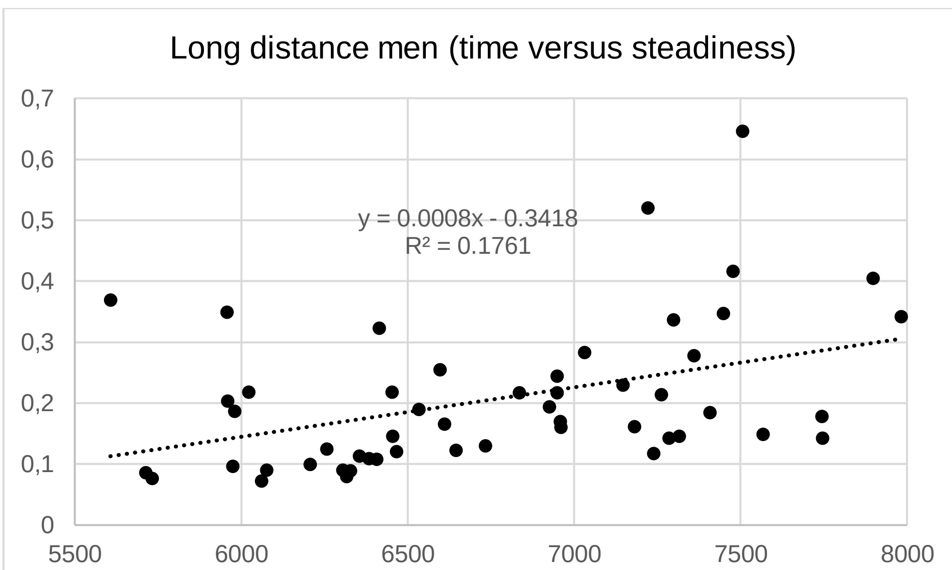

Figure 3a. Time versus steadiness men long distance ($R^2 = 0.176$)(n = 65) / (15.5 km / 640 Attitude / 30 controls) x – Axis time / y – Axis steadiness (calculated as standard deviation of all percentage deviations of individual split times and best time).

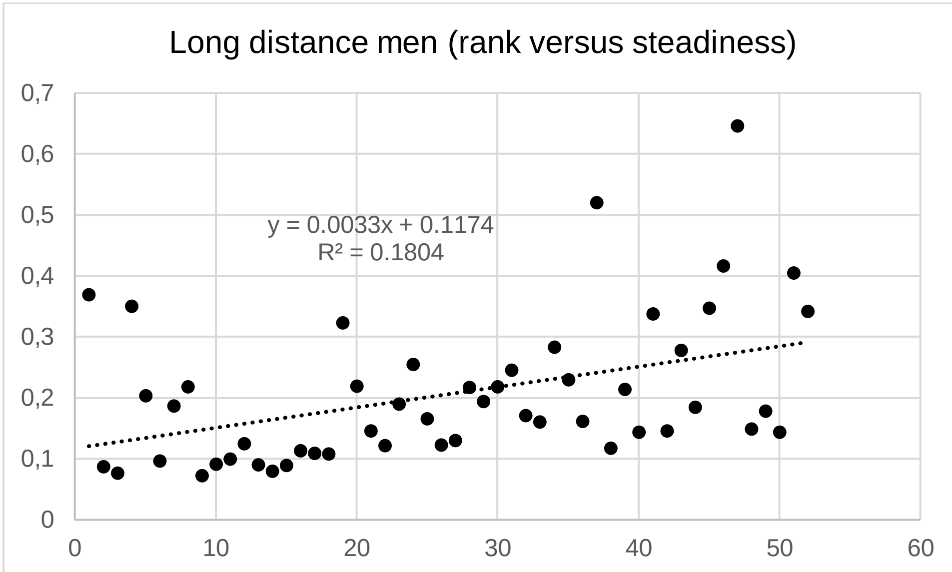

Figure 3b. Rank versus steadiness men long distance (R^2 = 0.184)(n = 65) / (15.5 km / 640 Attitude / 30 controls) x – Axis rank / y – Axis steadiness (calculated as standard deviation of all percentage deviations of individual split times and best time).

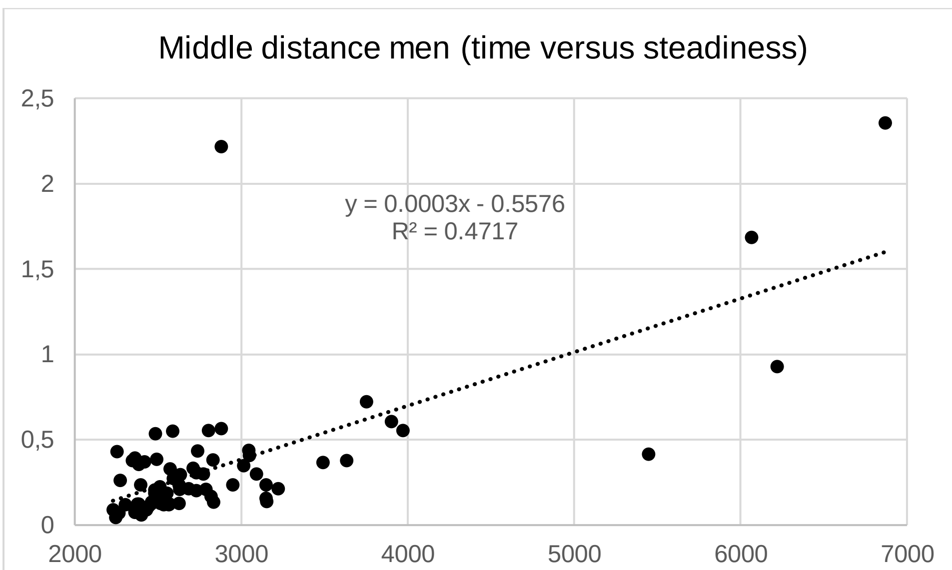

Figure 4a. Time versus steadiness men middle distance (R^2 = 0.472) (n = 63) / (5.1 km / 220 Attitude / 21 controls) x – Axis time / y – Axis steadiness (calculated as standard deviation of all percentage deviations of individual split times and best time).

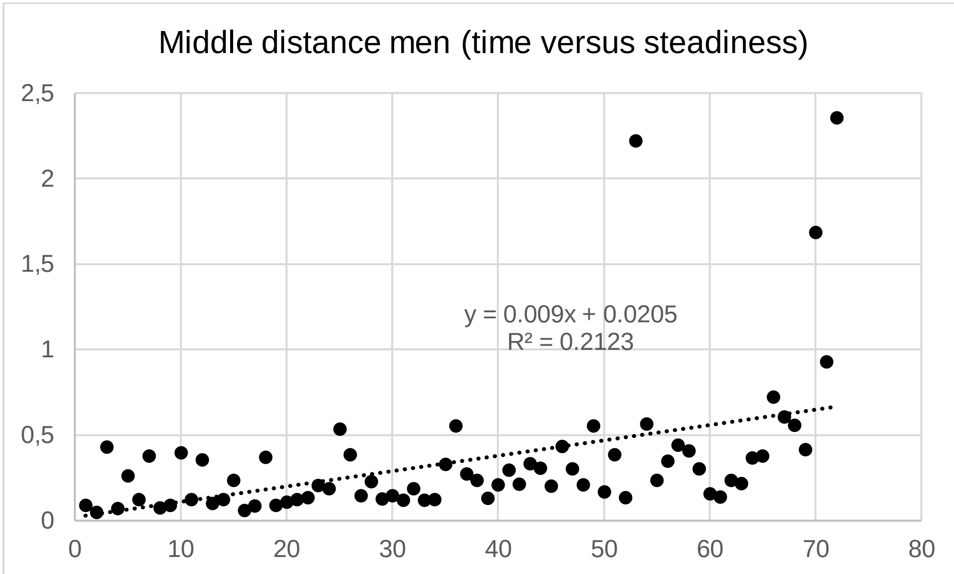

Figure 4b. Place versus steadiness men middle distance (R^2 = 0.212) (n = 63) (5.1 km / 220 Attitude / 21 controls) x – Axis rank / y – Axis steadiness (calculated as standard deviation of all percentage deviations of individual split times and best time).

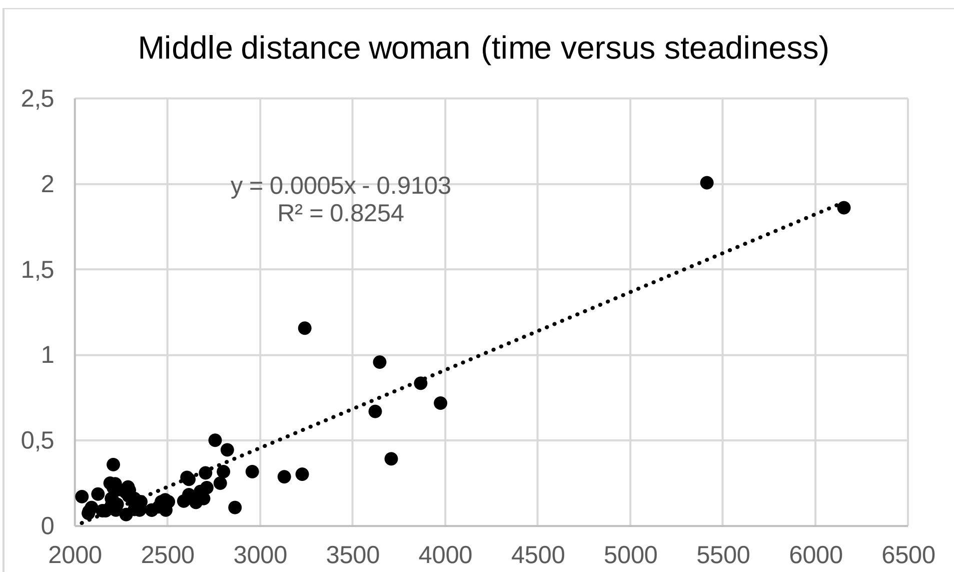

Figure 5a. Time versus steadiness woman middle distance (R^2 = 0.825) (n = 72) (6.3 km / 290 Attitude / 25 controls) x – Axis time / y – Axis steadiness (calculated as standard deviation of all percentage deviations of individual split times and best time).

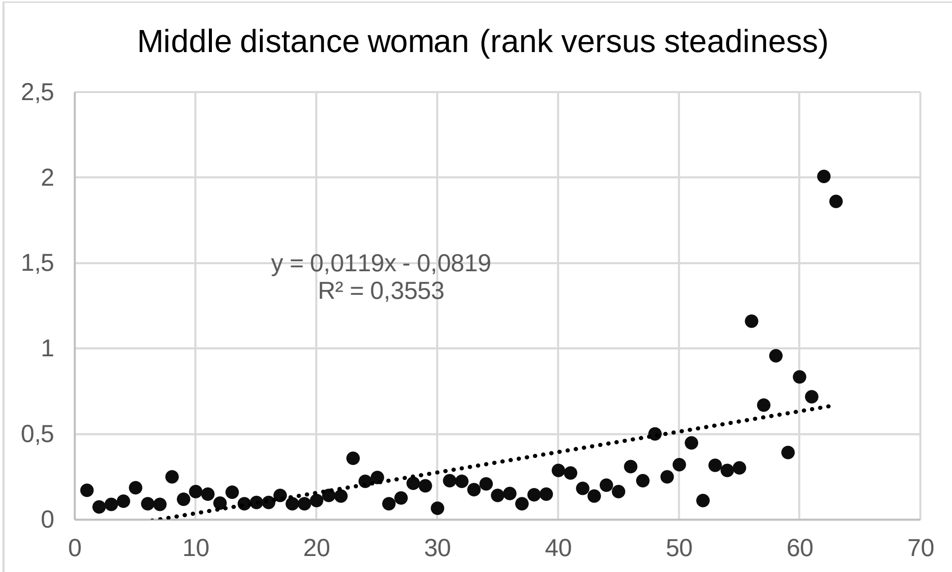

Figure 5b. Place versus steadiness woman middle distance ($R^2 = 0.355$) (n = 72) (6.3 km / 290 Attitude / 25 controls) x – Axis rank / y – Axis steadiness (calculated as standard deviation of all percentage deviations of individual split times and best time).

Tab. 2 clearly shows that except for women long distance with a p-value of 0.054 highly significant results can be detected when analyzing differences in standard deviations of speed for the first and the second part of the ranking list. Having Tab. 1a and Tab. 1b in mind it might be implied due to the fact of smaller calculated standard deviation in the first part of the ranking list versus the second part that orienteers from the first part compete more constant probably as one reason for lower total times.

Table 2. Analysis of significane of differences concerning calculated standard deviation of the first part of the ranking list versus the second part.

Wilcoxon signed rank test	long men	long women	middle woman	middle man
P value	0.0032	0.0543	< 0.0001	0.0001
Are medians signif. different? (P < 0.05)	Yes	No	Yes	Yes
Sum of positive / negative ranks	59 / -292	128 / -307	28 / -468	90 / -576
Sum of signed ranks (W)	-233	-179	-440	-486

DISCUSSION AND CONCLUSIONS

The aim of this study was to elucidate if performance is dependent on steadiness in orienteering respectively if better orienteers compete with a more constant pace. For this purpose, race times of world class orienteers from the world championships 2016 were analyzed concerning their steadiness of speed during the final course of middle and long distance races in the forest. In woman as well as in men a relatively clear pattern of higher variation of time for control points was detected for slower runners. The patterns are most clear for woman middle distance. Coming back to the initially stated hypotheses that no differences exist between faster and slower runners this hypothesis can be rejected. Based on the results it can be shown that faster orienteers run more constant. Statistical results are relatively straight forward e.g. the detected close correlative relationship of 0.92 in middle distance woman between course times and deviations of the best time can be mentioned. This imply, that the more constant an orienteer runs, the faster she/he is. If trying to compare these findings with otther studies e.g. Pribul and Price (2005) can be mentioned, however not finding significant differences for elite versus recreational orienteers when comparing relative speeds for the first, middle and penultimate legs of three orienteering races. It was therefore concluded that the differences in performance between elite and recreational orienteers are likely to be due to other factors such as a difference in overall fitness levels and absolute speeds sustained throughout the race (Pribul and Price, 2005). This is probably true when comparing sub samples with large differences in performance levels, but it does not hold when differences in performance levels are small or even very small like in the analyzed sub sample. The used method of calculating standard deviation of percentage deviation from the best time can also be questioned concerning its adequacy other approaches are definitly possible (Arnet 2009, Pribul and Price 2005). But principally the method includes already the aspect of an orienteer running constantly slower and therefore focuses soley on deviations of steadiness. However, some limitations hamper the analysis. Captured variance is not possible to clearly attribute to either cognitively or biologically factors. Undoubted orienteering actions entails both cognitive and biological restrictions whereby these components underlay several affecting mechanism (Cheshikhina 1993, Eccels 2014, Eccles 2006, Seiler 1990, Seiler 1996). In principle the results indicate that running more constant probably also due to biological restrictions yield to better results. As mentioned from a biological point of view this is clearly indicated from the aerobe-anaerobic threshold concept (Eisenhut and Zintl 2009,Hoppeler et al. 1985,Steffny 2010, Steffny 2008). Taking a more practical point of view e.g. the starting phase can be mentioned. An athlete sees the map at the start for the first time. The few seconds she/he wins when leaving the start point fast are not worth to win when not finding afterwards as soon as possible a steady and constant pace for the whole course. In principle the results clearly imply that the orienteering action in its complexity is probably best done when doing on a regular basis avoiding whenever possible peak level of performance. This is a consequence of constant use especially of cardiovascular and musculoskeletal system (Eisenhut and Zintl 2009, Hoppeler et al. 1985, Rolf et al. 1987). In order to increase performance probably training also for recreational orienteers specifically addressing threshold (e.g. High-intensity training) are well suited (Eisenhut and Zintl 2009, Hoppeler et al. 1985, Woc 2016). Despite of the training of all the important aspects like increasing VO_2max, improving general map reading skills, flexibility of running in rough terrain constant (orienteering) actions should be trained. Training methods such as following a line on the map from object to object are probably well suited to improve the orienteering action (running wihle map reading) and improve performance as a whole. Furthermore, based on newer findings that an optimal route clearly depends from the physic respectively somatotypus, planning a route accordingly to physical cababilites seem to further improve total performance (Lauenstein et al. 2013). To order in results in other studies former World-Class orienteer Timo Karppinen already concluded that measured maximum and mean heart rate explains some but not all success in orienteering and proposed deviations from mean heart rate as indicator (Lauenstein et al. 2013). Interestingly he already mentioned more than twenty years ago that Standard Deviation of mean heart rate reveals more about success (Lauenstein et al. 2013). Interestingly, in all successful races standard deviation was less than 3 beats per minute (Lauenstein et al. 2013). However, deeper analysis showed that mental demand, length of competition and mistakes all have an effect on Heart Rate standard deviation. 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. Particularly, it must be mentioned that top world class runners were analyzed at World Championships with small differences in performance levels in the analyzed sample. It can be assumed that the specific preparation was highly optimized for these races. Nevertheless, It can be assumed, that also in recreational orienteering the more steady it is competed, the faster respectively the lower the total amount of time. Coming to direct recommendations for orienteers different aspects can be mentioned. Interestingly in a study with top class orienteers Heart Rate and Heart Rate Variability (indicator of autonomous nervous system) were consistent with subjective feeling and training intensity (Laukkanen et al. 1998). This imply that no complex gear is necessary but training/competing based on feeling is adequate. As a mean, BORG-Scale (6-20) with its high validity might be an easy way for taxing intensity and consequently used e.g. in training diary could give valuable hints concerning extent and potential steadiness of exertion (Borg 1998, Scherr et al. 2013). Furthermore, some hints of the study indicate that wearing a heart rate gear might be sense full not only for elite but also for recreational orienteers with a potential of setting alarms when heart rate is increasing e.g. too fast (Karppinen and Laukkanen, 1994). In principle, this is an old wisdom, but former finish World class Runner Timo Karppinen was clearly able to point out an important orienteering specific aspect: *measurement helps an athlete especially to develop better self confidence* (Karppinen and Laukkanen, 1994).

To sum up analysis revealed that the better an orienteer performs the steadier she / he runs. This is probably due to different biological and cognitive mechanisms. From a biological point of view probably running slightly below anaerobic threshold best results are achieved (Eisenhut and Zintl 2009, Hoppeler et al. 1985, Rolf et al. 1987). This is a consequence of constant use especially of cardiovascular and musculoskeletal system (Eisenhut and Zintl 2009, Hoppeler et al. 1985, Rolf et al. 1987). In order to increase performance probably training also for recreational orienteers specifically addressing threshold (e.g. High-intensity training) are well suited (Eisenhut and Zintl 2009, Hoppeler et al. 1985, Woc 2016). Further the training of usage of specific orienteering skills as steady as possible is recommended: examples well suited might be line orienteering (following a line signed on the map) (Eccels 2014, Guzman et al. 2008). The first mentioned training example aiming to increase threshold in order to run with a higher constant pace, the second aims to train the other important skill in orienteering that map reading is constantly executed while competing helping an athlete to improve its performance in competitions.

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