Time Changes in Resisted Sprinting With a Weighted Vest: 5 % of Body Weight or Back Squat?

The Use of The 1RM Back Squat and Body Weight as Load Strategy in Weighted Vest Sprinting

Simon Šiška, Tereza Králová, Zuzana Hlavoňová, Luděk Helis, Jan Cacek, Zdeněk Morávek

Faculty of Sport Studies, Masaryk University, Brno, Czech Republic

ABSTRACT

The purpose was to investigate whether runners who do not squat their body weight once will not be overloaded with a weight vest with a load of 5% of BW and will not maintain 95% intensity across ten repetitions of a 20-meter sprint. Eight adult female students (24,05±1,15 years old; body height 168±4,24 cm; body weight 60,39±5,53 kg) from the Faculty of Sports Studies at Masaryk University in the Czech Republic participated in this study. The categories were: 1 = NBW (1RM in the squat is relative body weight ± 5 kg), 2 = LBW (1RM in the squat is lower than BW-5 kg) and 3 = HBW (1RM in the squat is higher than BW +5 kg). The measurements were taken on three different days, each day running with another experimental condition: free sprinting, weighted vest sprinting with a 5% load of BW, and weighted vest sprinting with a 5% load of 1RM squat. With a weight vest with resistance at the level of 5% of body weight, during 49 sprints, the intensity decreased to a maximum of 4.82% (participant 4, NBW group, 1st run). Although, with weight vest resistance at the level of 5% of the 1RM back squats, during 68 sprints, the intensity decreased by a maximum of 6.59% (participant 1, NBW group, 8th run). It seems that the level of strength abilities of the lower limbs did not play a role in this, we can calculate 5% intensity from both BW and 1 RM squat. Since the HBW group could maintain the required intensity even at significantly higher weights than 5% BW, further research with a larger research sample is needed.

Keywords: sprint training, resistance sprinting, weighted vest

INTRODUCTION

Many team and individual sports, including track and field, require running sprinting ability, which consists of the acceleration phase and maximal velocity phase (Cronin & Hansen, 2006; Harrison & Bourke, 2009; Lockie et al., 2012; Young & Pryor, 2001). The effective use of the force produced by the athlete's body in short periods determines the athlete's ability to accelerate, reach and maintain maximum velocity (Cronin & Hansen, 2006). Step length, step frequency, and the direction of the propulsive force applied during the running step are limiting factors in both aspects (Morin et al., 2011). Specific training methods are needed to overload the neuromuscular and physiological systems with the aim of causing adaptations that transfer to reaching maximum sprinting potential (Hicks, 2017).

Resisted sprint training

The more appropriate use of resisted sprint training is to improve the acceleration phase rather than the maximal velocity phase. Due to the different kinematics of the both phases, it is necessary to overload them differently (Hicks, 2017). To improve sprint ability, six resisted sprinting methods are widely used: wearing a weighted vest, external load at the distal limb segment, pulling a parachute, uphill running, resisted treadmill sprinting and towing sledges (Rumpf et al., 2014). Limb loading is a method in which an external weight is typically added to the end of the limbs. This is likely to increase the moment of inertia that demands higher muscle activity (Hay, 1985). Studies by Ropret et al. (1998) and Martin (1985) show that an external load at the end of the lower limbs causes a reduction in sprint velocity. A reduction in the step frequency causes the speed reduction mechanism, with the step length remaining relatively identical. On the contrary, uphill running appears to be a suitable method for developing stride length. Increased gravitational action demands the production of higher propulsive forces provided by hip extensors. The expected manifestation should be an increase in step length when sprinting on a flat platform (Faccioni, 1993). Also the pulling parachute method is based on overcoming the added aerodynamic drag force applied in the horizontal direction. This may lead to an improvement in strength-specific sprinting ability through an increase in stride length (Alcaraz et al., 2008). Resisted treadmill sprints are differentiated according to whether the treadmills are motorized/non-motorized and curved/ non-curved. For land sprints over a shorter distance (10 yards), it correlates with a moderate incline setting at a higher resistance. Whereas for ground sprints over 30 yards, a lower resistance setting at a higher incline is more appropriate (Peacock et al., 2019).

Weighted vest method

The weighted vest method potentially increases the ability to produce ground reaction forces and power production during sprint-running by evenly distributed overloading near an individual's centre of mass (Macadam, Cronin, & Simperingham, 2017). Wearing a weight vest during sprints offers a greater vertical vector-training stimulus. In contrast, sledge pulling, especially at a higher percentage of body weight, is more suitable for horizontally oriented development (Cross et al., 2014). By wearing a weight vest with adequate weight, the vertical forces increase with each contact with the ground, thus increasing the demands on the eccentric strength of the extensor muscles (Faccioni, 1993). This effect could potentially increase the muscles' ability to store and utilise elastic energy. Furthermore, the weighted vest method simultaneously improves strength and technique elements of sprint training (Cronin & Hansen, 2006).

To effectively develop the running sprinting ability, a certain level of intensity is necessary. The acceleration phase should be produced at a minimum of 95% intensity of a 1RM (Cissik, 2005; Hansen, 2014; Rogers, 2000; Schiffer, 2011). That means a maximum time with or without additional weight should be at most 105% of baseline time (the maximum speed without additional resistance). Furthermore, Haugen et al. (2019) recommend intensity higher than 98% of a 1 RM to enhance acceleration. The amount of resistance in the resistance sprinting method varies. Resistance-induced reduction in power time is the determining factor for categorisation: light (< 10% velocity decrement), moderate (10–15%), heavy (15–30%), and very heavy (> 30%) loads (Petrakos et al., 2016). When using the resistance method, it is necessary to consider whether we aim for an acute or longitudinal effect and adjust the intensity of the selected resistance accordingly. It was found that with increasing vest load (5-40% BW), the time of sprint running on all distances (10 m to 50 m) increases significantly linearly (Macadam et al., 2019). Carlos-Vivas et al. (2019a) found that incremental loads of 10% BW resulted in maximal velocity decreased by 4–5% with each increment. This finding may indicate that the weighted vest method affects the maximum velocity phase more than the acceleration phase.

Considering the conditions of maintaining high intensity during sprint performances, the question is whether the recommended % of additional resistance should be calculated as a percentage of body weight. Therefore, the main idea is whether runners who do not have sufficiently developed lower limb strength abilities (testing by 1 RM squat test) and squat less than their body weight run with a vest with a resistance that represents a high load for them.. So weaker individuals who run with resistance not tied to actual muscle strength are likely overloaded. In contrast, stronger individuals whose squat 1RM is greater than their body weight can run with meagre resistance, which probably does not leave enough stimulus. Because they could run up to 105% of unresisted sprinting time with a more weighted vest.

METHODS

Participants

Eight adult female students (24,05±1,15 years old; body height 168±4,24 cm; body weight 60,39±5,53 kg) from the Faculty of Sports Studies at Masaryk University in the Czech Republic participated in this study. All of them were sport active, had previous experience with sprint running, and were familiar with the sprinting technique. They were also familiar with the technique and testing 1RM in squats to 90° in the knee joint. The results on 1RM squat were 67,86±11,61 kg. The participants were also divided into three categories based on the results of 1RM squats related to their body weight. Categories were: 1 = NBW (1RM in the squat is relative body weight ± 5 kg), 2 = LBW (1RM in the squat is lower than BW-5 kg) and 3 = HBW (1RM in the squat is higher than BW +5 kg). The distribution of participants in groups was in NBW (n = 4), LBW (n = 1) and HBW (n = 2). Participants number 2, 3, 4, 5 completed all 3 measurements. The other female runners (number 1, 6, 7, 8) did not take all the measurements due to other obligations. No proband was injured during the measurement.

The participants signed the Consent to participate in the research and processing of personal data, in which participants were informed about the study's aim and potential risks, and that data would be processed anonymously.

Test design a data collection

All measurements were conducted at the athletics stadium in Brno on the 10th, 17th and 24thMay 2022, with similar weather and time conditions on all three measuring days. On each measuring day (seven day rest between the measurements) participants performed one measured repetition of a free 20-meter-long sprint to determine the base time (0th time) with 3-minute rest. Then they run the ten experimental repetitions of a 20-meter-long sprint with different load on each day.The rest interval was 3 minutesbetween each sprint . Each day was testing another experimental condition. Three experimental conditions were designated: free sprinting, weighted vest sprinting with a 5% load of BW, and weighted vest sprinting with a 5% load of 1RM squat. Fifteen minutes warm-up (same for all testing conditions) consisting of a 3-minute continuous jogging and dynamic stretching with specific running drills and threesprints on 20-meters approx. at 60, 80 and 95% subjective effort was performed before the measured sprints. Time was measured by the TCi System (Brower Timing Systems, USA). All the measured sprints were conducted from a standing start position with the legs in stride 50 cm behind the first-timer gate at the belt height of athlete. The participants were allowed to start at leisure, and no starting signal was given.

The 1RM squat test was modified slightly from the established protocol in McBride, Triplett-McBride, Davie, & Newton (2002). This test was performed using a free weighted bar in the rack. A number of warm-up trials were given in the 1RM test protocol using bar weight 20 kg (4-6 repetitions), then 30% (8–10 repetitions), 50% (4–6 repetitions), 70% (2–4 repetitions), and 90% (1 repetition) of an estimated 1RM either from the subject's recommendation. From this point, the weights were increased to a point where the individual had 3–4 maximal efforts to determine the 1RM. Each subject was asked to lower the bar to the point where the knee angle was under 90°, marked by adjustable stoppers. Adequate rest was allowed between trials (3–5 minutes).

Due to the impossibility of measuring the wind conditions and because of the measurements on three different days, we analyse the data in terms of intensity loss using the 0th time (base time as free running) and the times in the subsequent ten runs in different conditions. The intensity limit for defining the intensity needed to develop the acceleration rate was set at 105% of the base time (time 0). For the reasons mentioned above, we did not conduct an inter-individual analysis between the individual experimental conditions.

RESULTS

Free running sprint times

The results in first Table 1 show times for baseline time (the first 20m-run), followed by times for the next ten 20-meter-long sprints. The participants were divided according to their strength test on the squat to the strength groups. Only one 20m-long sprint was observed as running up to 105% from the baseline time. It was participant number 7 from the HBW group in her 10th sprint.

Table 1. Time for 20-meters free runs (1.-10. attempt) without any additional weight in seconds

	PN	SG	Baseline (s)	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Mean	SD
FREE RUNNING (WITHOUT)	1	NBW	3.64	3.59	3.62	3.58	3.61	3.56	3.58	3.57	3.56	3.59	3.56	3.58	0.02
	2	NBW	3.60	3.62	3.57	3.64	3.61	3.67	3.62	3.62	3.62	3.65	3.64	3.63	0.02
	3	NBW	3.93	3.91	3.89	3.90	4.00	3.88	3.70	3.67	3.93	3.98	3.69	3.86	0.11
	5	LBW	3.63	3.71	3.76	3.71	3.79	3.73	3.81	3.74	3.75	3.74	3.77	3.75	0.03
	6	HBW	3.40	3.45	3.40	3.41	3.40	3.45	3.46	3.42	3.49	3.45	3.46	3.44	0.03
	7	HBW	3.30	3.36	3.32	3.30	3.32	3.26	3.33	3.35	3.39	3.43	**3.57***	3.36	0.08
	8	NBW	3.45	3.48	3.52	3.41	3.53	3.52	3.56	–	3.61	3.48	3.47	3.51	0.05

SD = standard deviation; PN = participant number; SG = strength group.

** Time higher than 105% of baseline time without any additional resistance*

– Time not measured because of TCi System error

Subsequently, we examined the consistency of the results of individual participants in free runs from the two indicators (Table 2). The first indicator was the percentage result of the slowest measured time, with the time as the baseline time. When running without external (additional) resistance, only one participant (no. 7 from the HBW group) estimated a higher value than the baseline time, specifically in run no. 10, whose intensity reached 108.18% of the baseline time.

The second indicator is the number of runs classified as the fastest run of 10 measured for each participant, which is also shorter than the baseline time. In the running, without resistance (free running), five participants achieved a better time during the ten measured times than in the first run (referred to as the baseline time).

Table 2. Differences between the fastest and slowest free-run attempts and baseline (also without any additional weight)

	PN	SG	Baseline (s)	Intensity limit 105% (s)	1–10. attempt		Diff. MAX-MIN (s)	Diff. MIN-BASE (s)	Diff. MIN-BASE (%)	Diff. MAX-BASE (s)	Diff. BASE x MAX (%)
					Min (s)	Max (s)					
FREE RUNNING (WITHOUT)	1	NBW	3.64	3.82	3.56	3.62	0.06	-0.08***	97.80	-0.02	99.45
	2	NBW	3.60	3.78	3.57	3.67	0.10	-0.03***	99.17	0.07	101.94
	3	NBW	3.93	4.13	3.67	4.00	0.33	-0.26***	93.38	0.07	101.78
	5	LBW	3.63	3.81	3.71	3.81	0.10	0.08	102.20	0.18	104.96
	6	HBW	3.40	3.57	3.40	3.49	0.09	0	100.00	0.09	102.65
	7	HBW	3.30	3.47	3.26	**3.57***	0.31	-0.04***	98.79	0.27	**108.18****
	8	NBW	3.45	3.62	3.41	3.61	0.20	-0.04***	98.84	0.16	104.64

PN = participant number; SG = strength group;

** time higher than 105% of Baseline time without any additional resistance*

*** % up to 105 %*

**** the fastest time from 1–10. running attempt faster than the baseline*

Sprint times with vest weight 5% of body weight

The results in Table 3 show times for baseline time (the first 20m-run), followed by times for the next ten 20-meter-long sprints, which were runs with weighted vest corresponding to the 5% of body weight. The participants were divided according to their strength test on the squat to the strength groups. We found no result with a time higher than the time corresponding to 105% of the baseline time for any participant or in any run.

Table 3. Times for 20-meters runs (1–10. attempt) with a weighted vest with 5% of body weight in seconds

	PN	SG	Baseline (s)	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Mean	SD
WITH 5% OF BODY WEIGHT	2	NBW	3.59	3.64	3.60	3.60	3.63	3.62	3.61	3.66	3.61	3.62	3.59	3.62	0.02
	3	NBW	4.14	4.07	3.85	3.93	3.89	3.91	3.84	3.84	3.84	3.80	3.93	3.89	0.07
	4	NBW	3.53	3.70	3.67	3.64	3.59	3.66	3.66	3.64	3.68	3.65	3.62	3.65	0.03
	5	LBW	3.88	4.01	3.82	3.80	3.80	3.88	3.88	3.85	3.91	3.82	–	3.86	0.06
	8	NBW	3.56	3.60	3.42	3.57	3.62	3.60	3.54	3.58	3.64	3.62	3.61	3.58	0.06

SD = standard deviation; PN = participant number; SG = strength group.

– Time not measured because of TCi System error

Table 4 shows the differences between the fastest and slowest runs. We identified 4 participants who could run in at least one of the ten measured runs with a vest weighing 5% of their body weight faster than during a basic free-run of the test marked as baseline time.

Table 4. Differences between the fastest and slowest run with the weighted vest with 5% of 1RM back squat attempt and baseline without additional weight

	PN	SG	Baseline (s)	Intensity limit 105% (s)	1–10. attempt Min (s)	1–10. attempt Max (s)	Diff. MAX-MIN (s)	Diff. MIN-BASE (s)	Diff. MIN-BASE (%)	Diff. MAX-BASE (s)	Diff. BASE x MAX (%)
WITH 5% OF BODY WEIGHT	2	NBW	3.59	3.77	3.59	3.66	0.07	0	100.00	0.07	101.95
	3	NBW	4.14	4.35	3.80	4.07	0.27	-0.34***	91.79	-0.07	98.31
	4	NBW	3.53	3.71	3.59	3.70	0.11	0.06	101.70	0.17	104.82
	5	LBW	3.88	4.07	3.80	4.01	0.21	-0.08***	97.94	0.13	103.35
	8	NBW	3.56	3.74	3.42	3.64	0.22	-0.14***	96.07	0.08	102.25

PN = participant number; SG = strength group;

***** the fastest time from 1–10. running attempt faster than the baseline*

Sprint times with vest weight 5% of 1RM back squat

The results in Table 5 show times for baseline time (the first 20m-run), followed by times for the next ten 20meterlong sprints with vest weighted 5% of 1RM back squat (to the 90° of knee flexion). The participants were divided according to their strength test on the squat to the strength groups. We observed that values higher than 105% of the baseline time (free running) were measured in two participants during the ten measured sprints. The first was participant number 1 (PN 1) from the NBW category, and she exceeded the 105% baseline time twice in runs no. 5 and 8. The second was participant no. 6 (PN 6), who was in the HBW category. PN6 exceeded the 105% baseline time in runs no. 5 and no. 6.

Table 5. Times for 20-meters runs (1.–10. attempts) with a weighted vest with 5% of 1RM back squat in seconds

WITH 5% OF BACK SQUAT	PN	SG	Baseline (s)	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Mean	SD
	1	NBW	3.49	3.60		3.63	3.52	**3.68***	3.58	3.35	**3.72***	3.63	3.64	3.59	0.10
	2	NBW	3.64	3.67	3.73	3.64	3.61	3.70	3.72	3.64	3.74	3.66	3.61	3.67	0.04
	3	NBW	3.65	3.77	3.73	3.64	3.68	3.72	3.71	3.70	3.74	3.68	3.60	3.70	0.04
	4	NBW	3.63	3.64	3.65	3.69	3.71	3.66	3.68	3.67	3.70	3.70	3.73	3.68	0.03
	5	LBW	3.63	3.70	3.78	3.74	3.79	3.77	3.73	3.74	3.78	3.79	–	3.76	0.03
	6	HBW	3.38	3.54	3.48	3.52	3.54	**3.57***	**3.59***	3.52	3.53	3.51	3.45	3.53	0.04
	7	HBW	3.42	3.43	3.43	3.35	3.44	3.44	3.47	3.46	3.4	3.57	3.54	3.45	0.06

SD = standard deviation; PN = participant number; SG = strength group.

** Time higher than 105% of baseline time without any additional resistance*

– Time not measured because of TCi System error

Table 6 shows the differences between the fastest and slowest test runs with a vest weighted 5% of 1RM back squat (90° knee flexion). The slowest runs identified that exceeded the threshold of 105% of the baseline time were compared with a baseline time at the level of 106.59% (for PN1) and 106.21% (for PN6).

We identified four participants who could run in at least one of the ten measured runs with a vest weighing 5% of 1 RM back squat faster than during a basic free-run of the test marked as baseline time.

Table 6. Differences between the fastest and slowest run with the weighted vest with 5% of 1RM back squat attempt and baseline without additional weight

WITH 5% OF BACK SQUAT	PN	SG	Baseline (s)	Intensity limit 105% (s)	1.–10. attempt		Diff. MAX-MIN (s)	Diff. MIN-BASE (s)	Diff. MIN-BASE (%)	Diff. MAX-BASE (s)	Diff. BASE x MAX (%)
					Min (s)	Max (s)					
	1	NBW	3.49	3.66	3.35	**3.72***	0.37	-0.14***	95.99	0.23	**106.59****
	2	NBW	3.64	3.82	3.61	3.74	0.13	-0.03***	99.18	0.10	102.75
	3	NBW	3.65	3.83	3.60	3.77	0.17	-0.05***	98.63	0.12	103.29
	4	NBW	3.63	3.81	3.64	3.73	0.09	0.01	100.28	0.10	102.75
	5	LBW	3.63	3.81	3.70	3.79	0.09	0.07	101.93	0.16	104.41
	6	HBW	3.38	3.55	3.45	**3.59***	0.14	0.07	102.07	0.21	**106.21****
	7	HBW	3.42	3.59	3.35	3.57	0.22	-0.07***	97.95	0.15	104.39

PN = participant number; SG = strength group;

** time higher than 105% of the baseline time without any additional resistance*

*** % up to 105 %*

**** the fastest time from 1.–10. running attempt faster than the baseline*

Comparison of the investigated methods

When comparing all investigated methods, we found that in free running testing, in one run out of a total of 69 measured (the time of the 7th run PN7 was not measured), there was an increase in time compared to the initial measurement (baseline time of free running) by over 105%, specifically 108.18% in 10th run of PN7. When running with a vest weighing 5% of body weight, all of the total 49 measured runs (run no. 10 at PN5 was not measured) were within the limit of 105% of the baseline time. When running with a vest weighted a 5% of 1RM back squat (90°knee flexion), we recorded an increase in time over 105% of the baseline time (free running) in two of the seven participants, where these two participants overcame the intensity of 105% twice. Participant No. 1 from the NBW category ran over 105% of the baseline time in the 5th and 8th runs when the slowest time was equal to 106.59% of the baseline time. Participant No. 6, from the HBW category, ran above 105% of the baseline time in runs. No. 5 and 6, when the slowest time corresponded to 106.21% of the baseline time. This means that out of 68 measured runs with a vest of weight as 5% of the 1RM back squat, only four runs exceeded the baseline time above 105%, of which the absolute highest overrun was at 106.59% of the baseline time (free running).

Furthermore, we noted that many of the test runs in all conditions achieved faster times during these ten tests runs than during the essential measurement of the baseline time as free running. Specifically, in free running testing, a total of 5 participants out of 7 achieved a better time than the baseline time at least once during the ten measured runs. When running with a vest weighing 5% of body weight, they achieved a better time than the baseline time at least once during the ten measured runs, baseline time, and measurement of 3 female participants out of a total of 5. Four out of the seven female runners, when running with a vest weighing 5% of 1RM back squat, achieved a better time than the baseline time at least once during the ten measured runs.

DISCUSSION

This study aimed to evaluate whether determining the external load (expressed as a percentage) with the resisted weighted vest method is better from body weight or the 1 RM squat exercise.

The data suggest no drop in intensity below our chosen threshold of 95% in both resistant conditions (above 105% time of baseline free running time). With a weight vest with resistance at the level of 5% of body weight, during 49 sprints, the intensity decreased to a maximum of 4.82% (participant 4, NBW group, 1st run). Although, with weight vest resistance at the level of 5% of the 1RM back squats, during 68 sprints, the intensity decreased by a maximum of 6.59% (participant 1, NBW group, 8th run).

The maintenance of intensity above the level of the established 95% threshold during resistance sprints with a vest weighing 5% of body weight corresponds to the results of the studies of Alcaraz et al. (2008); Carlos-Vivas et al. (2019a); Carlos-Vivas et al. (2019b); Cross et al. (2014); Gleadhill et al. (2021) and Siperingham & Cronin (2014). In these studies, the authors evaluated the effect of a weighted vest with resistance at a level between 5% and10% of body weight as a decrease in intensity of 2.2% to 4.7% (the variable evaluated was time or velocity).

To the best of our knowledge, we have not found any studies analysing kinematic parameters during weighted vest resistance sprints with a 5% load calculated from maximal squat power.

Therefore, we cannot assess the conformity/inconsistency of our measured results with the previous ones.

One of the limitations of this study was the instability of the weather conditions on a different measurement day. Unfortunately, the wind speed and direction were not measured by any instrument. These factors could significantly affect the times measured in the runs. The generalisability of the results is limited by the size of the examined data-set as a whole. Because of this, even the individual strength categories (NBW, HBW, LBW) needed to be more significant. Furthermore, the variability of the examined group in terms of strength abilities of the lower limbs needed to be greater.

The avenues for future research include obtaining data in a running tunnel to ensure the stability of weather conditions to make the data as reliable as possible. Also, for a more significant impact, it would be necessary to include more subjects with a wide range of lower limb strength ability levels in the research. Assessing the effects of a weight vest with a higher percentage resistance would be interesting. Another avenue for future research could be an overview of the intensity curve during repeated sprints over a longer distance (e.g., 50m). In such a stretch, increasing fatigue could play a more significant role. In addition, an insight into the kinetic (or kinematic) indicators during the maximum velocity phase and not only during the acceleration phase would be obtained.

CONCLUSION

Sprinting with a weighted vest is a form of sprint training suitable to improve the kinetics and kinematics of sprint performance in developing athletes. Specifying information and strategies to set the load during sprint resistance training using a weight vest is essential. In our study, we dealt with a different approach than the one most often used when using a weight vest - adjusting the resistance according to the current power capabilities of the lower limbs. Our 5% load from a 1 RM squat did not cause a decrease in intensity below 95% during repeated sprint runs. Also, at 5% BW load, the intensity was maintained above 95% across repetitions. The level of strength abilities of the lower limbs did not play a role in this. However, further studies need to be conducted on a more extensive and variable research set to achieve a higher degree of generalisation.

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Contact Information

Simon Šiška
simon.siska@mail.muni.cz