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Development of A Training And Injury Log For Powerlifting: A Feasibility Study

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ABSTRACT

Research on risk factors and injuries in powerlifting has so far only been studied through cross-sectional/ observational studies. In other sports, training load has been prospectively investigated and shown to influence injury risk. However, no method to quantify training load in powerlifting exist. The purpose of this study was to assess the feasibility of a novel standardized method for prospective recording of training load and injuries. The study was conducted in two phases with eight powerlifters initially included in each phase respectively. In Phase 1, the powerlifters registered training load and injuries throughout four weeks and answered a feasibility questionnaire. Based on the results from the questionnaire, updates to the training and injury log were made and the powerlifters in Phase 2 used the updated version to log four weeks of training. Training load and injuries were reported consistently which made calculations on training load and injury incidence possible. The participants reported rate of perceived exertion as difficult to assess and report. However, 9/12 powerlifters stated that they could the training and injury log for a period of at least six months. In conclusion, this standardized training and injury log seems to be a feasible method to quantify training load and injuries in powerlifting. The method could be used in further prospective studies on training load and injuries in powerlifting and in clinical practice.

Keywords: resistance training, athletic injuries sports, athletes

INTRODUCTION

Powerlifting is a strength sport that consists of lifting maximal loads in three lifts: the squat, bench press and deadlift. According to two recently published systematic reviews the injury incidence in powerlifting is 1-4.4 injuries/1000 hours of training (1, 2). This is similar to weightlifting with an injury incidence of 2.3-3.3 injuries/1000 hours of training (1) and non-contact sports such as track and field where the incidence is 3.57 injuries/1000 hours of training (3).

However, previous epidemiological studies on injuries in powerlifting have one main methodological flaw, namely, the results are based on self-reported retrospective questionnaires. It is therefore possible that the previously calculated injury incidence is inaccurate. A cross-sectional study (4) regarding the prevalence of injuries in powerlifting reported that >70 % of powerlifters experienced pain and/ or injuries at the time of the study, which adds to the notion that previously reported injury incidence might be misleading. Further, unlike team sports at elite level (5, 6), in powerlifting, there are no routines or established instruments in place for prospective registration of injuries.

Furthermore, risk factors for injuries in powerlifting have been scarcely investigated. In other sports, changes in training load over time has been suggested as an important risk factor (7, 8). The workload-injury aetiology model (9) suggests that training load affects injury risk in three ways: First,

the training itself will increase the risk of injury simply by the exposure to training, compared to not training and having no exposure at all. Second, a high training load can result in accumulated fatigue that may increase injury risk through loss of motor control that comes with the fatigue. Third, training increases performance as the athlete gets stronger. This makes it possible for the athlete to tolerate a higher training load which in turn can decrease the risk of injury. Currently, there is no accepted instrument for registration of training load in powerlifting and therefore, before performing further studies on injuries in powerlifting, issues such as which variables should define training load in powerlifting and how they can most effectively be registered should be established.

Training load is usually quantified as external and/or internal load (10). The external load is defined as the athletes' exposure to training and competition. In team sports (11-14) the most commonly used measurements are total distance, top speed, time spent at a certain speed, and changes of direction while running measured with Global Positioning System and accelerometers. The internal load is defined as how an athlete is affected by the external load, or how the body reacts to training and competition. The most common measure of internal training load is perceived exertion per session (sRPE) and the most common method is to use a modified Borg CR-10 scale and then multiply the value with the duration of the training session in minutes (12, 15, 16). In order to follow trends in training load (internal or external), weekly changes can be assessed by calculating the acute:chronic workload ratio. The ratio between acute and chronic workload is calculated by dividing the acute training load (training load of one week) by the chronic workload (four-week average training load) and has been suggested as a modifier to injury risk (7, 8, 17).

In resistance training, measures of both internal and external training load are traditionally used in planning and monitoring load in order to maximize performance (18). Internal load is most commonly assessed with RPE with the CR-10 scale (18). It can be used to rate the training session in full (to calculate sRPE) or to rate each individual set of each exercise. If the latter is used, the level of exertion is rated as *repetitions in reserve* (RIR) where a "10" equals maximal effort, "9.5" equals that no more reps were possible, but a slightly heavier weight could have been used. A "9" indicates one repetition in reserve and "8" indicates two repetitions in reserve, and so on. Subjective estimation of RIR has been shown to correlate well to measures of barbell velocity during powerlifts (19). Internal training load have also been assessed by conducting questionnaires assessing general well-being and levels of stress since these factors can be affected in a negative way if the training load is too high (18).

For external load, volume, intensity and frequency of training are the most commonly used variables (18). Volume of training is defined as the total amount of training performed, intensity is the weight lifted, and the frequency is how often a certain lift is performed, or how often a certain muscle group is trained. The volume can be calculated in four ways; Repetition volume: Total number of repetitions performed over a certain period of time; Absolute volume: Total weight lifted over a certain period of time: set x repetitions x weight; Relative volume: Set x repetitions x % of 1RM (the maximal weight a person can lift one time) and Repetition maximum based volume: Set x repetitions x %RM.

No previous study has aimed to prospectively register injuries and quantify training load in powerlifting, hence no established methods to do so exist. Since a training and injury log will have to be self-administered it is of great value that the method used not only provide appropriate data but is also user-friendly and does not burden the athletes.

Therefore, the aims of this study were to develop a standardized training and injury log and assess whether it is a feasible method for prospective registration of training load and injuries in powerlifting. The feasibility of the training and injury log was assessed from two perspectives. First, from the perspective whether reporting using the training and injury log will provide sufficient data to quantify of training load and injuries regarding measures of internal and external training load and injury incidence. Second, from the perspective of the powerlifters' experiences and compliance of using the training and injury log in relation to its merits and difficulties and compliance/adherence. More specifically, compliance in reporting training sessions, rating RPE, registering injuries and the probability that powerlifters would adhere to use of the log for a period of at least six months.

METHODS AND MATERIALS

Procedure

The training and injury log was developed and

assessed for feasibility in two phases, hereby defined as "*Phase 1*" and "*Phase 2*". In Phase 1, feasibility was evaluated from both perspectives described in the study aim. Participants logged their powerlifting training in a standardised training and injury log for a period of four weeks. Thereafter, calculations on external and internal load were made and a feasibility questionnaire was used to assess feasibility and the powerlifters' experiences on using the training and injury log.

In *Phase 2*, revisions based on the results of the feasibility questionnaire in *Phase 1* were made to the training and injury log. Thereafter, another group of powerlifters logged their training for four weeks using the updated version of the training and injury log and answered the same feasibility questionnaire used in *Phase 1*. The purpose of *Phase 2* was to assess whether these updates seemed to lead to any improvements in usability and therefore no calculations on their training data was made.

Participants

The present study was performed as part of a larger study assessing injuries among powerlifters (21). The participants in *Phase 1* of the present study were primarily recruited from the above-mentioned study. Participants in *Phase 2* were recruited independently. Recruitment was made via the Swedish powerlifting federation's website and social media. For *Phase 1* the inclusion criteria were at least 10 years' experience of powerlifting, currently training with the goal of competing in powerlifting and having current low back pain which caused them pain and/or limited their ability to perform the powerlifting exercises. For *Phase 2* the inclusion criteria were that the participants were currently competitive powerlifters.

In *Phase 1*, eight male powerlifters were included and for *Phase 2*, three female and five male powerlifters, were initially included but one dropped out before

Table 1. Background characteristics and training practices of the powerlifters.

Phase 1 – n=8 (male, n=8)	**Min**	**Max**	**Median**
Age (years)	31	48	35
Bodyweight (kg)	61	140	90
Height (cm)	163	190	175
Powerlifting experience (years)	8	25	16
Squat workouts per week (n)	1	4	2
Bench press workouts per week (n)	1	5	2
Deadlift workouts per week (n)	1	4	2
Training hours per week (n)	2	12	6,5
1RM squat (kg)	170.5	280	200
1RM bench press (kg)	92.5	203.5	172.5
1RM deadlift (kg)	215.5	305	280
Phase 2 – n=7 (male, n=4, female n=3)	**Min**	**Max**	**Median**
Age (years)	24	57	31
Bodyweight (kg)	50	107	77
Height (cm)	147	190	174
Powerlifting experience (years)	0.5	3	3
Squat workouts per week (n)	1	3	2
Bench press workouts per week (n)	2	5	3
Deadlift workouts per week (n)	1	3	2
Training hours per week (n)	6	15	7
1RM squat (kg)	90	215	170
1RM bench press (kg)	50	140	102.5
1RM deadlift (kg)	120	255	197.5

1RM= 1 repetition max

data collection were initiated. All participants answered a background questionnaire (Table 1).

Training and injury log

Data collection for *Phase 1* was performed during a period of four weeks in August/September 2017. The powerlifters had the training and injury log sent to them via e-mail and were instructed to contact the study administrator (LB) if they had any questions. Data collection for *Phase 2* was performed during four-week period in 2018 between March and April and was performed by the lead author (FA).

The training and injury log was constructed in Microsoft Excel and consisted of four sheets. In the first sheet the powerlifters were instructed to report the date of the training sessions, duration in minutes, rating of perceived exertion for the whole session using an RPE scale, exercises used, number of sets and repetitions, rating of perceived exertion for each individual set using RIR and if/when they experienced any pain or symptoms of injury.

If the powerlifters had experienced pain or symptoms of injury, they were instructed to explain these symptoms in the second sheet, which was the injury log. Here, the powerlifter reported location of pain/injury, when the pain/injury occurred, if it had sudden or insidious onset, if the powerlifter recognized the pain/injury from before, description of the pain/symptoms and which the consequences of the pain/injury were for that session. An injury was defined as a symptom that forced the athlete to modify or refrain from training. This is a definition that has been used in earlier studies on powerlifting (22-24). Sheet three and four were for instructions to guide the powerlifters in how to use the RPE and RIR scale and how to describe the locations of pain/symptoms.

Quantification of training load and injury incidence

For the quantification of both internal and external load using the training log, several variables were extracted. The internal load was measured using sRPE. The external load was measured using relative volume on squat, bench press and deadlift, respectively. Also, acute:chronic workload was calculated based on relative volume (external acute:chronic workload) and sRPE (internal acute:chronic workload). Since this study only included four weeks of training, acute:chronic workload was calculated by using each week's total relative volume and total sRPE as acute load and this was divided with the four week average load to get a ratio for each week.

Average percent of 1RM for each lift each week was used to describe relative external intensity and internal intensity was described using weekly average RIR which described how far from failure the powerlifters' trained each week. It was also assessed whether this training and injury log can be used to quantify injury incidence in injuries/1000 hours of training. The formula to calculate injury incidence was number of injuries divided by total number of training hours multiplied by 1000. Injury was defined according to a previous study on injuries in powerlifting (4) as a condition of pain or impairment of bodily function that affected powerlifters' training.

Feasibility questionnaire

The powerlifters' experiences in using the training log were assessed with 17 questions about their experiences of using the training and injury log including compliance to the training and injury log regarding number of reported sessions. The answers were collected through phone interview to give opportunity for qualitative answers and suggestions for improvements of the training and injury log.

The questionnaire was created in December 2017 based guidelines described by Ejlertsson (25). Intelligibility was then tested by having three powerlifters (two male, one female), who were not included in the study, log their training and perceived symptoms for one week using the training and injury log described above.

After logging their training, they answered the questionnaire while the author interviewed them using the think-aloud interviewing technique (25) where the questions are read out loud by the interviewer and the respondent explains how he or she is reasoning to reach to his or her answer to the question. Using this technique, it becomes obvious if the question is difficult to understand or if it is interpreted to ask for anything other than its intention (25).

Assessment of feasibility of the training and injury log

For the training and injury log to be considered feasible for further use, the following criteria was set; powerlifters had to report successfully logging 80 % of performed sessions, >50 % should report that they could consider using the training and injury log for a period of at least six and twelve months respectively.

Furthermore, variables of the training program and injuries needed to be reported correctly to enable calculations of external and internal training load (as described above) and injury incidence, for the training and injury log to be considered feasible.

Statistical analysis

The results were presented using descriptive statistics in figures, tables and in text. In accordance with current recommendations for feasibility studies (26, 27).

Results

Phase 1

The results are presented chronologically, i.e. results from Phase 1 followed by Phase 2. In Phase 1 there was one drop out, due to personal reasons not related to this study, leaving n=7 powerlifters available for Phase 1.

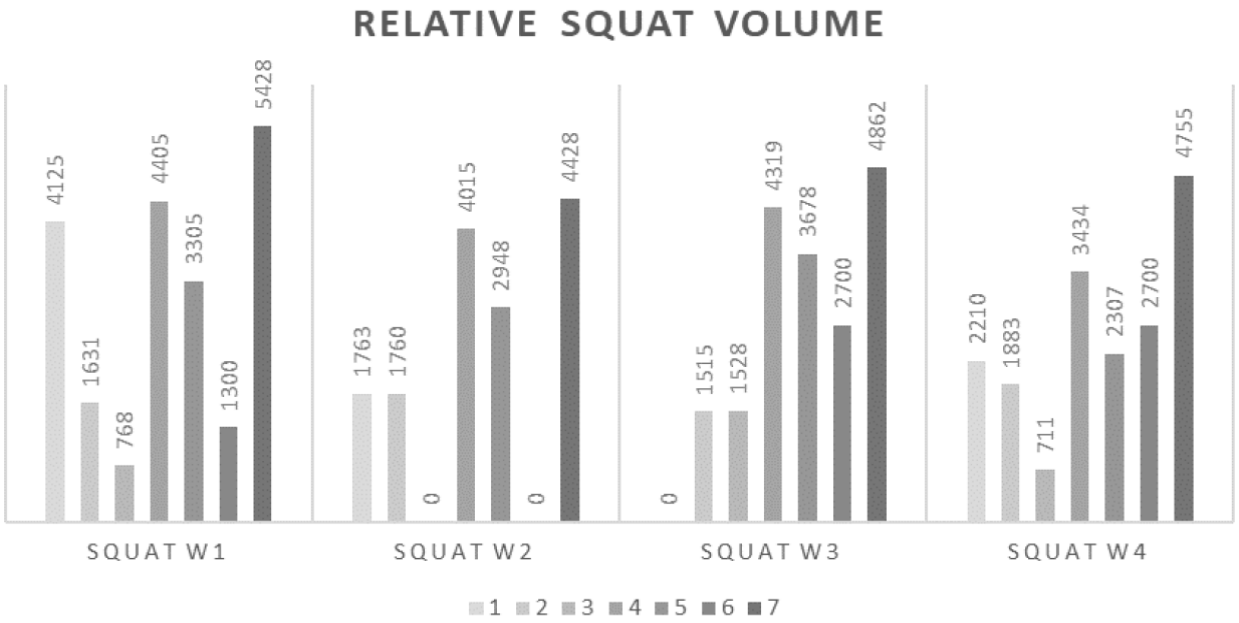

Figure 1. Relative squat volume in arbitrary units (i.e. set * repetition * % of 1RM) for powerlifter 1-7, week 1-4 (W1-4).

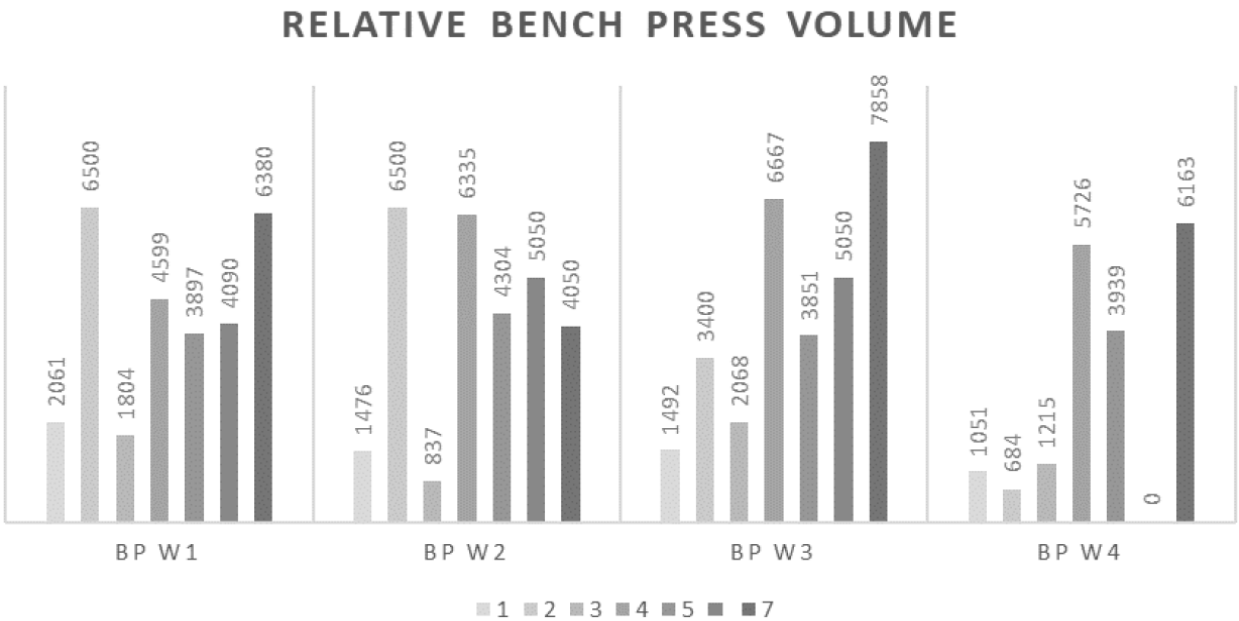

Figure 2. Relative bench press (BP) volume in arbitrary units (i.e. set * repetition * % of 1RM) for powerlifter 1-7, week 1-4 (W1-4)

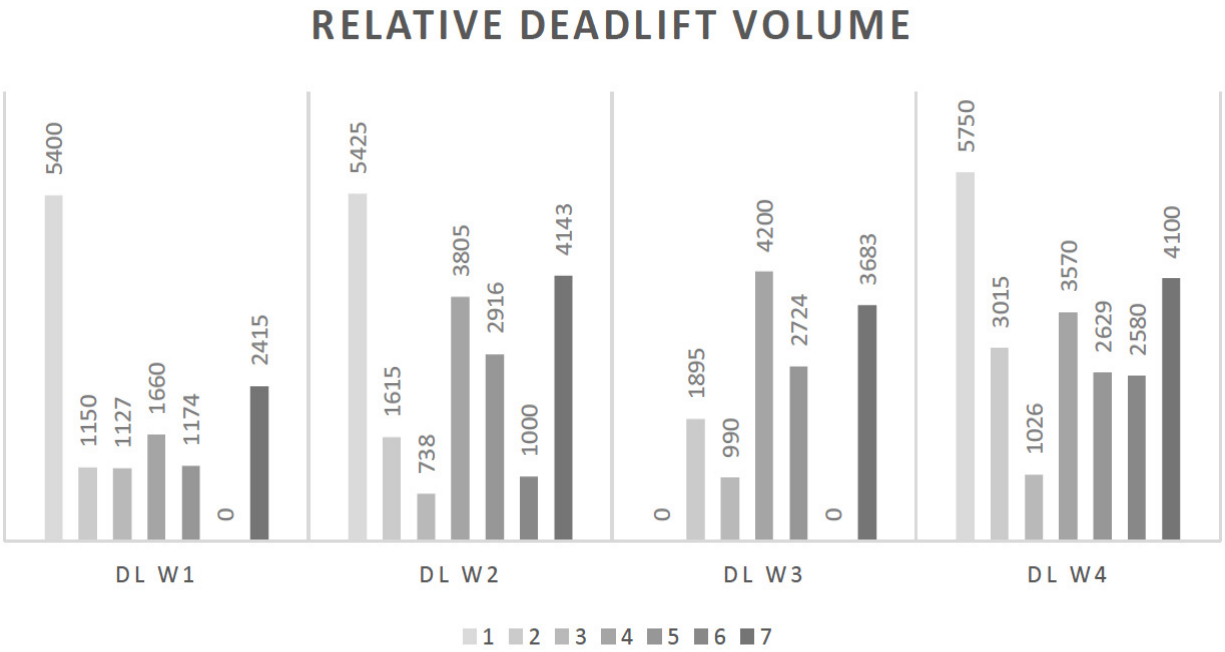

Figure 3. Relative deadlift (DL) volume in arbitrary units (i.e. set * repetition * % of 1RM) for powerlifter 1-7, week 1-4 (W1-4).

Table 2. External acute:chronic workload based on relative volume for each powerlifter, each week for the squat.

Powerlifter	Week 1	Week 2	Week 3	Week 4
1	2.04	0.87	0	1.09
2	0.96	1.04	0.89	1.11
3	1.02	0	2.03	0.95
4	1.09	0.99	1.07	0.85
5	1.08	0.96	1.2	0.75
6	0.78	0	1.61	1.61
7	1.11	0.91	1	0.98

Table 3. External acute:chronic workload based on relative volume for each powerlifter, each week for the bench press.

Powerlifter	Week 1	Week 2	Week 3	Week 4
1	1.34	0.97	0.98	0.69
2	1.52	1.52	0.8	0.16
3	1.22	0.57	1.4	0.82
4	0.79	1.09	1.14	0.98
5	0.97	1.08	0.96	0.99
6	1.15	1.42	1.42	0
7	1.04	0.66	1.29	1

Training load

Relative volume and external acute:chronic workload

For the main exercises (i.e. squat, bench press and deadlift) number of sets, repetitions and the load (kg) was reported accurately, which made it possible to calculate relative volume. To illustrate, relative volume is presented with arbitrary units for the squat, bench press and deadlift in figures 1-3. The value "0" means that the powerlifter did not train that lift during that week.

Based on the relative volume, the external acute:chronic workload could also be calculated, as presented in table 2-4 for the squat, bench press and deadlift respectively.

Table 4. External acute:chronic workload based on relative volume for each powerlifter, each week for the deadlift.

Powerlifter	Week 1	Week 2	Week 3	Week 4
1	1.3	1.31	0	1.39
2	0.6	0.84	0.99	1.6
3	1.16	0.76	1.02	1.06
4	0.5	1.15	1.27	1.08
5	0.5	1.24	1.15	1.11
6	0	1.12	0	2.89
7	0.67	1.16	1.03	1.14

Table 5. Internal acute:chronic workload based on sRPE for each powerlifter and each week.

Powerlifter	Average 4-week sRPE	Week 1	Week 2	Week 3	Week 4
1	2865	0.91	1.2	0.93	0.95
2	1640	1.02	0.91	0.64	1.43
3	1780	0.72	0.45	1.81	1.01
4	2367,5	0.67	0.85	1.25	1.24
5	1330	1.11	0.95	1.07	0.86
6	1245	1.08	0.84	0.92	1.16
7	3317.5	1.2	1.04	0.68	1.09

*sRPE= session rating of perceived exertion (Borg CR-10 * duration of training session in minutes)*

Table 6. Average RIR and average relative intensity for each powerlifter, each week for the squat.

Powerlifter	Week 1		Week 2		Week 3		Week 4	
	RIR	% of 1RM	RIR	% of 1RM	RIR	% of 1RM	RIR	% of 1RM
1	0	48%	0	71%	0	0%	0	50%
2	5	51%	6	55%	5	51%	6.3	67%
3	7	64%	0	0%	7.8	80%	8	79%
4	5.4	43%	5.3	49%	5.7	50%	4.7	44%
5	6.7	35%	5.5	42%	7	46%	4.3	43%
6	8	52%	0	0%	8.5	54%	8.5	54%
7	4.7	55%	3.9	61%	4.6	61%	5.6	65%

RIR= repetitions in reserve. 1RM= 1 repetition max.

sRPE and internal acute:chronic workload

sRPE was used to measure internal load and weekly sRPE. Both measures were reported consequently and varied between 800 and 3980 throughout the four weeks of training for all participants. sRPE could therefore be used to calculate internal acute:chronic workload through weeks 1-4, presented in table 5.

Intensity

Both absolute load (kg) and RIR for each set in the main exercises were reported accurately. Thus, external and internal intensity could be calculated/ registered through average relative intensity (% of 1RM) and average RIR respectively. To illustrate, both measures are presented for the squat, bench press and deadlift in table 6-8, respectively.

Injury incidence

Injuries, symptoms of injury and consequences of injuries, number of sessions and duration of sessions were reported consequently by all participants. When defining an injury as a symptom from a unique location, the injury incidence for the whole sample could be calculated to 109 injuries/1000 hours of training. When considering all reported symptoms of injuries as new injuries, i.e., symptoms from the same location on different days, the incidence was calculated to 241 injuries/1000 hours of training for the whole sample. Injuries per week, training hours per week and injury incidence per 1000 hours of training are presented for each powerlifter in table 9.

Table 7. Average RIR and average relative intensity for each powerlifter, each week for the bench press.

Powerlifter	Week 1		Week 2		Week 3		Week 4	
	RIR	% of 1RM	RIR	% of 1RM	RIR	% of 1RM	RIR	% of 1RM
1	9	81%	9	82%	9	83%	8	75%
2	6	65%	6	65%	0	68%	5	76%
3	5.9	82%	9	93%	8	90%	6.6	87%
4	7.3	55%	5.9	61%	6.2	58%	6	62%
5	5.9	56%	6.2	65%	6	59%	6.7	74%
6	7.9	71%	6.8	56%	6.8	56%	0	0%
7	6.8	62%	4.5	57%	5	57%	5.6	66%

RIR= repetitions in reserve. 1RM= 1 repetition max.

Table 8. Average RIR and average relative intensity for each powerlifter, each week for the deadlift.

Powerlifter	Week 1		Week 2		Week 3		Week 4	
	RIR	% of 1RM	RIR	% of 1RM	RIR	% of 1RM	RIR	% of 1RM
1	0	54%	4	54%	0	0%	6	55%
2	6.5	61%	5.5	54%	6	59%	5.4	59%
3	6.3	81%	8	82%	8	83%	8.4	85%
4	5.6	48%	7.2	57%	7.3	60%	6.6	56%
5	5	54%	5.7	44%	3.7	45%	3.7	42%
6	0	0%	7	40%	0	0%	6	43%
7	5.7	83%	5.2	70%	4.6	67%	5.3	72%

RIR= repetitions in reserve. 1RM= 1 repetition max.

Table 9. Frequency of injuries per week, training hours per week and injury incidence per 1000 hours of training.

	Powerlifter	1	2	3	4	5	6	7
Week 1	Training hours	6	7.5	3.5	5.2	7.7	3	8.8
	Injuries (unique localisations)	1	3	2	3	2	0	1
Week 2	Training hours	8.5	5.1	1.7	5.5	6.3	2.5	9.2
	Injuries (unique localisations)	0	1	0	0	1	0	1
Week 3	Training hours	9.5	3.2	6.2	6.5	6.7	2.5	8.7
	Injuries (unique localisations)	0	0	0	0	0	2	0
Week 4	Training hours	7	5.7	4	6.2	5.2	4	10
	Injuries (unique localisations)	1	0	0	0	0	0	0
Week 1-4	Injuries (unique localisations) per 1000 hours of training	65	186	130	128	116	167	55

Feasibility questionnaire

Of the seven powerlifters included in Phase 1, six answered the feasibility questionnaire. One person opted to not answer the feasibility questionnaire due to not remembering how he experienced the training and injury log.

Difficulties in using the training and injury log

Five powerlifters described the training log as either very easy or easy to understand and one powerlifter as neither easy nor difficult. No powerlifter thought that the training and injury log in general was difficult to understand. However, three powerlifters thought that rating RPE for the whole session was difficult, and one powerlifter mentioned that a powerlifting session can consist of both light and heavy exercises making it difficult to rate perceived exertion for the full session. Two powerlifters described that rating RPE for the whole session as neither difficult nor easy while one powerlifter thought it was easy. There were also some difficulties with rating RPE for each individual set where one powerlifter described it as difficult and a comment to this was that perceived pain could increase the RPE even though the used

weight was light. Four powerlifters described RPE for each individual set as neither difficult nor easy while one powerlifter described it as easy. Regarding the injury log, three powerlifters described it as very easy or easy, one as neither easy nor difficult and one as difficult.

Adherence to the training and injury log

Regarding adherence, two powerlifters answered that they had logged all their training sessions while four powerlifters had missed to log one or two sessions.

Two powerlifters had logged their training during the training sessions and four powerlifters one or more days after the sessions. RPE for the whole sessions was rated immediately after the training sessions had ended by two powerlifters and one or more days after training by four powerlifters. Two powerlifters rated RPE for each individual set directly after each set, one powerlifter later the same day as the training session, and three powerlifters one or more days after training. Injuries were logged immediately when they occurred by one powerlifter, later the same day by one powerlifter. Four powerlifters logged injuries more than one or more days after they occurred.

Probability of long-term adherence

Four powerlifters stated that they would be positive to use the training and injury log, for scientific reasons, for a period of six months. Two powerlifters answered that it would not be possible to use the training log for longer time periods with reasons being that one of them already had his own way of logging training and he did not want to adjust to anyone else's method. The other powerlifter said that he thought that logging training is boring.

Regarding the same question but for a period of 12 months, three powerlifters answered yes. Three answered no and stated the reasons being it would be too time consuming, that he/she had their own way of reporting or that it was boring.

Suggestions on updates to the training and injury log

Four of the powerlifters had suggestions on how the training and injury log could be made better and these are stated as quotes below.
"Poor overview, had to scroll a lot in the excel file. Too little space to write".

"Messy excel file, would look better if there were sheets for each week or month of training. Would also be favourable if there were standardised templates for the bench press, squat and deadlift".

"Digitalise it with a phone application connected to some sort of computer program".

"Make it clearer whether which sets of training to log, maybe from 60-70% of 1RM and heavier or so".

Feasibility of the training and injury log – Phase 1

The training and injury log fulfilled the criteria of feasibility of >80 % of reported sessions since only four participants missed one or two sessions. Regarding long-term use of the training and injury log, 67% (4/6 participants) were positive to use it for six months, and 50% (3/6 participants) were positive to use it for 12 months. Therefore, the criteria of >50 % of participants reporting a positive response to possible long-term adherence was also fulfilled.

Phase 2

In *Phase 2*, one of the included participants (male) dropped out due to unknown reasons, i.e. the participant would not give a specific reason when asked, leaving six powerlifters for *Phase 2*.

Based on the information from the feasibility questionnaire in *Phase 1*, the training and injury log was updated to a new version. Instead of using a Microsoft Excel file, the log was converted to a Google Sheets document, making it possible to log training using a smart phone during the training sessions. Also, the training and injury log was updated with a new sheet for each training week, to prevent the training sheet from being too long. Lastly, an instruction video on how to use the training and injury log was made and sent to all participants. The background questionnaire was also updated whereas the participants were asked to enter their 1RM for variations of the powerlifting exercises that they include in their training, such as narrow grip bench press, stiff legged deadlift and front squat.

Feasibility questionnaire

Difficulties in using the training and injury log

All six powerlifters answered that the training log in general was either easy or very easy to understand and two of them stated that nothing was difficult to understand. Four powerlifters considered sRPE to be the most difficult part and two of them explained it

by describing powerlifting sessions to often be both heavy and light. Three powerlifters described sRPE as difficult and three as neither difficult nor easy. Regarding RPE for each individual set, four powerlifters classified it as either easy or very easy while two powerlifters thought it was neither difficult nor easy.

Adherence to the training and injury log

In *Phase 2*, all six powerlifters had logged all training sessions. Two powerlifters logged their training during the training sessions and four powerlifters later the same day as the training sessions occurred.

sRPE was rated directly after the training sessions by four powerlifters and two powerlifters rated sRPE later the same day as the training sessions occurred. All six powerlifters rated RPE for each individual set immediately after the sets. Regarding injuries, one powerlifter logged them immediately when they occurred and four powerlifters later the same day they as they occurred. One powerlifter did not sustain any injuries during the study.

Probability of long-term adherence

Five powerlifters stated that they would be positive to use the training and injury log, for scientific reasons, for a period of six months. One powerlifter stated he could not, due to sRPE being too difficult to assess. For a period of 12 months, four answered yes and two no. The ones who said no stated that sRPE was too difficult to assess or felt insecure of her own adherence for such a long period of time.

Suggestions on updates to the training and injury log
Three powerlifters had suggestions on how to update the training and injury log to make it better. The suggestions are stated below.

“For long term purposes it would be nice to have a new training and injury log for each month, to prevent it from becoming too extensive.”

“The sheets could be a bit polished with different colors, bold headlines etc.”

“Would be more user friendly with a phone application than Google Sheets.”

Feasibility of the training and injury log – Phase 2

The training and injury log fulfilled the criteria of feasibility of >80 % of reported sessions, since all six stated that they logged all sessions. Regarding long-term use of the training and injury log, 83% (5/6 participants) were positive to use it for six months, and 67% (4/6 participants) were positive to use it for 12 months. Therefore, the criteria of >50 % of participants reporting a positive response to possible long-term adherence was also fulfilled.

DISCUSSION

This is the first study to develop and assess the feasibility of a training and injury log to quantify training load and injury incidence in powerlifting. The purpose of this study was to assess feasibility from two aspects: feasibility of quantifying training load and injuries and usability. The results are promising, and this method seems to be feasible for use in a large-scale study.

All variables used to quantify training load have been used in earlier studies (15, 16, 18), however, not all have been used in powerlifting. The measures of internal load, sRPE and RIR, was registered in the training log, but the participants also reported that these variables were the most difficult to register. sRPE was considered hard to grasp because of the character of a powerlifting session being both hard and easy within the same session and therefore difficult to make an average rating representing the whole session. This is understandable since a powerlifting session can stretch from 30 minutes to several hours long, where the most time is spent resting between sets. Before further use in powerlifting sRPE might need to be re-validated.

Regarding RIR, none of the participants in *Phase 1* reported RIR to be easy to assess, while in *Phase 2* no participant thought it was difficult to assess. This could be explained by the fact that in *Phase 1*, only 2 of 6 powerlifters did their rating immediately after sets, which likely interfered with the actual rating. In *Phase 2*, all six participants rated RIR directly after their sets. The reason for this difference between *Phase 1* and *2*, could probably be attributed to the fact that participants in *Phase 2* had an instruction video to guide them, and this probably led to more accurate ratings of perceived exertion. Therefore, since RIR previously has been shown to correlate well to objective measures of performance such as bar speed (28) this indicates that RIR is a usable tool to measure internal intensity in powerlifting provided that explicit instruction of when and how to perform the rating are given.

For quantification of external load, the relative inten-

sity (average percent of 1RM) and the relative volume were used. The average percent of 1RM provided an objective measure of intensity which also could be compared to measures of internal load, i.e. RIR. Relative volume was used since powerlifters of different strength can be compared to each other, which cannot be done with absolute volume. Other measures of volume (such as RM volume) were considered too extensive since it requires that many more variables, e.g. 1RM, 2RM, 3RM etc. to be collected which could decrease compliance in reporting.

In *Phase 1*, however,1RM was only known for the competition style lifts while all variations of the main lifts (e.g. narrow grip bench press) were included in the relative volume, based on the same 1RM. This problem was, however, corrected in *Phase 2* where the powerlifters, were asked to report their 1RM for all variations of the competition lifts which they included in their training. The purpose of this changes was to, more accurately, be able to calculate external training load, since the 1RM for variations of the competition style lifts most often differ from the actual competition style 1RM. Thus, the volume could be calculated with more accuracy. Finally, the acute:chronic workload could also be accurately calculated based of the measures of internal and external load which allows for further investigations on the relation between training load and injuries in powerlifting.

Reporting of injuries were made consistently and only one participant expressed difficulties in registration of injuries. However, some methodological improvements are needed regarding the quantification of injuries derived from the injury log. First, there is no consensus on the definition of a sports injury in powerlifting although the definition used in the present study has been in a previous study in powerlifting (4), it similar to some and different from some other sports. For example, in football (29) the definition is “Any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time loss from football activities”, which is similar to the definition used in the present study. While in rugby (30), injury is defined as “Any physical complaint, which was caused by a transfer of energy that exceeded the body’s ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match or rugby training, irrespective of the need for medical attention or time-loss from rugby activities”, which is quite different and also excluded most overuse injuries where structural integrity oftentimes is not compromised. Second, the need to define how to distinguish new injuries from prolonged injuries became evident when quantifying the injuries from the training and injury log. The participants often reported the same symptom/location for several sessions during the four-week period although some session could also be free of symptoms. Timpka et al (31) has recommended, for self-reported injury data, to distinguish acute injuries, referred to as sports trauma, from chronic injuries, referred to as sports illness. This, however, do not contribute to distinction of new and prolonged injuries which is an issue which will need to be addressed in future prospective studies.

Regarding adherence to the study and reporting, there were a total of 16 participants in this study whereas three of them dropped out during different parts of the study. There was one dropout in Phase 1 due to personal reasons not related to this study. There were two dropouts in *Phase 2*, both for reasons unknown and they subsequently did not log their training or answer the feasibility questionnaire. Based on the answers from the participants that completed the study, the training and injury log seems to be user-friendly regarding adherence. However, in purposes of user-friendliness, it seems to be of importance that the training log is as minimalistic as possible. To prevent the training log from feeling too extensive with many sheets and to increase chances of long-term adherence, it is recommended that the powerlifters report their training on a monthly basis.

Methodological considerations

There are some methodological considerations that needs to be discussed. First, this study was divided into two phases with the purpose to assess feasibility of the training and injury log. In *Phase 1*, feasibility was assessed from both perspectives whereas in *Phase 2* only from the powerlifters’ perspective regarding usability. The reason for this was that the research questions regarding training load were considered fully answered in *Phase 1* and answering them again in *Phase 2* would not contribute any more to the purpose, since the data on training load was not to be statistically analyzed.

Second, data from the feasibility questionnaire was collected through a phone interview. It was a time efficient way of collecting answers and the powerlifters were given the opportunity to nuance their answers and it gave the opportunity to discuss the questions and answers if needed. This resulted in more qualitative and valid answers. However, when

answering questions in person, there is always a risk of bias whereas the participant might answer what he or she thinks that the interviewer wants to hear, and it cannot be excluded that the answers would have differed if the questionnaire was conducted via e-mail or as an online survey.

Lastly, the feasibility study design needs to be addressed. Feasibility studies aim to answer specific questions regarding the methodology of a planned study (32). Orsmond and Cohn (27) exemplifies this in their paper about guiding questions for feasibility studies. For example, they phrase questions like: "can this work?", "does it (the intervention or method) show promise?", "is the data relatively complete?" and "is the procedure suitable and acceptable to participants?". A design with research questions like this does not invite to any statistical comparisons and cannot be answered with firm "yes" or "no". Also, hypothesis testing is not recommended because of the risk of type 1 and type 2 errors (26, 27). Because of these reasons, it is also not possible to answer the question "is this training and injury log feasible?" with a simple "yes" or "no"; that is an answer that needs nuance and a large amount of subjective judging, which must be seen as a limitation.

CONCLUSIONS

Based on the findings of this study, it can be concluded that the presented standardized training and injury log is usable in terms of quantifying training load registering injuries. The method developed in this study can be applied in further research to assess the validity of different measures of training load in powerlifting. Lastly, the method can be applied in both clinical practice and sports injury research to prospectively record training load and injuries in a cheap and practical way.

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DECLARATION OF INTEREST STATEMENT

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