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Trabajo Original

Otros

Efficacy of daily one-repetition maximum training in well-trained powerlifters and weightlifters: a case series

Eficacia del entrenamiento diario de una repetición de máximo peso en levantadores de pesas bien entrenados: una serie de casos

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Abstract

Introduction: The purpose of this study was to investigate the efficacy of daily one-repetition maximum (1RM) training of the back squat on maximal strength.

Material and methods: Three competitive lifters performed the squat for 37 consecutive days and are reported as individual cases. Participant 1 (P1) (body mass = 80.5 kg; age = 28 yrs.) and participant 3 (P3) (body mass = 108.8 kg; age = 34 yrs.) were powerlifters; participant 2 (P2) (body mass = 64.1 kg; age = 19 yrs.) was a weightlifter. Each participant had at least 5 years of training experience with the squat. During days 1-35, participants performed a 1RM squat followed by 5 volume sets of 3 repetitions at 85% or 2 repetitions at 90% of the daily 1RM. On day-36, participants performed only 1 set of 1 repetition at 85% of day-1 1RM; and a final 1RM was performed on day-37.

Results: Absolute and percent changes for P1 from day-1 to day-37 were +5 kg/2.3%, and from day-1 to peak (greatest 1RM of the period) were +12.5 kg/5.8%. P2 experienced a 13.5 kg/10.8% increase in 1RM from both day-1 to day-37 and day-1 to peak. P3 demonstrated a 21.0 kg/9.5% increase from both day-1 to day-37 and day-1 to peak. All 3 participants exhibited significant ($p < 0.05$) correlations between time (days) and 1RM (P1: $r = 0.65$, P2: $r = 0.78$, P3: $r = 0.48$).

Conclusions: Our findings suggest that daily 1RM training effectively produced robust changes in maximal strength in competitive strength athletes in a relatively short training period.

Key words:

Resistance training. One-repetition maximum. Strength sports. Skeletal muscle adaptation.

Resumen

Introducción: el propósito de este estudio fue investigar la eficacia del entrenamiento diario de una repetición máxima (1RM) de la sentadilla en fuerza máxima.

Material y método: tres levantadores de peso de competición realizaron la sentadilla durante 37 días consecutivos y se reportan como casos individuales. Participante 1 (P1) (masa corporal = 80,5 kg; edad = 28 años) y participante 3 (P3) (masa corporal = 108,8 kg; edad = 34 años) eran levantadores de fuerza; participante 2 (P2) (masa corporal = 64,1 kg; edad = 19 años) fue un levantador de pesas. Cada participante tenía por lo menos 5 años de experiencia con la posición en sentadilla de formación. Durante los días 1-35, los participantes realizaron una sentadilla de 1RM seguida por 5 conjuntos de volumen de 3 repeticiones al 85% o 2 repeticiones al 90% de la 1RM diario. En el día 36, los participantes realizan solo una serie de 1 repetición al 85% de 1RM del día 1; y el día 37 realizaron un 1RM.

Resultados: cambios absolutos y porcentaje para P1 del 1 día al 37: + 5 kg/2,3% y desde el primer día al máximo (1RM era el mayor) + 12,5 kg/5,8%. P2 experimentó un aumento de 13,5 kg/10,8% en 1RM del día 1 al 37 y del día 1 al máximo. P3 demostró un aumento de 21 kg/9,5% del día 1 al 37 y del día 1 al máximo. Los tres participantes exhibieron significativa ($p < 0,05$) las correlaciones entre el tiempo (días) y 1RM (P1: $r = 0,65$, P2: $r = 0,78$, P3: $r = 0,48$).

Conclusión: nuestros resultados sugieren que el entrenamiento diario de 1RM había producido efectivamente cambios significativos en la máxima fuerza en los atletas de fuerza competitiva en un periodo relativamente corto de entrenamiento.

Palabras clave:

Entrenamiento de resistencia. Repetición de máximo peso. Deportes de fuerza. Adaptación de músculo esquelético.

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INTRODUCTION

The overarching training strategy for exercise performance optimization is based upon the Specific Adaptations to Imposed Demands (SAID) principle (1), which states the human body will adapt specifically to an external stressor. In strength sports, such as powerlifting, (i.e. squat, bench press, and deadlift) and weightlifting (clean and jerk and snatch) absolute specificity can be applied daily to the specific disciplines (i.e. individual lifts), in accordance with competition standards. However, despite the ability of a strength athlete to apply the SAID principle daily, it is recommended that resistance training of the same muscle group be performed 2-3x/wk. with a 48-hour recovery period (2). Nonetheless, previous literature has suggested that it is likely higher frequencies that are recommended for enhanced strength adaptation (3), and recent data has demonstrated a frequency of three days/wk. compared to one day/wk. to be superior for muscle hypertrophy (4). Therefore, investigating higher training frequencies is a logical extension of current methodologies to further explore strength and hypertrophy adaptations in accordance with SAID.

Moreover, powerlifting and weightlifting competitions only require one-repetition maximum (1RM) performance; therefore, for training to truly coincide with the principle of specificity, the competitive disciplines should be performed frequently and at a high percentage of 1RM. In fact, although not yet investigated in the scientific literature, reports exist that elite level weightlifters have trained the disciplines daily and maximally with success (5). Although daily and maximal training could conceivable lead to overtraining syndrome (6), it is also plausible that in accordance to Selye's (1956) general adaptation syndrome (GAS) model (7) positive adaptations and performance improvements may manifest. The GAS describes that an initial stressor will set off the "alarm reaction" stage, which is analogous to an initial stage of damage/fatigue in response to a new training stimulus. However, following a repeated stimulus, the body will ultimately recover and enter the 'stage of resistance', during which an individual exhibits an enhanced ability to cope with the demands of the stressor. In exercise specifically, this is similar to the repeated bout effect (RBE), which states when the same exercise (8) or muscle group (9) is repeated in training, there will be an attenuated myofiber damage effect. Theoretically, a discipline can be trained over time so that the RBE manifests to result in minimal damage even when a specific discipline is trained daily, which is in concert with the body's adaptability according to the GAS.

Therefore, the primary aim of this study was to examine the efficacy of daily 1RM and volume training on the back squat, followed by volume sets of the back squat, for producing 1RM strength enhancement in well-trained competitive powerlifters/weightlifters over 37 consecutive days. Further, we investigated the effects of this training strategy on muscle hypertrophy. We hypothesized that despite daily strength fluctuations, squat 1RM would experience robust increases and be positively related to time (days) of training over the 37-day period.

METHODS

PARTICIPANTS

Three male participants were recruited and are reported as individual case studies. Individual participant characteristics are displayed in table I. Participants 1 (P1, age = 28 yrs.) and 3 (P3, age = 34 yrs.) were competitive powerlifters in the raw division of the United States of America Powerlifting (USAPL) and participant (P2, age = 19 yrs.) was a competitive weightlifter of the United States of America Weightlifting (USAW). P1 and P3 had 10 years of training experience, while P2 had 5 years experience. Participants were informed of study procedures and provided written informed consent. The University's Institutional Review Board approved this study.

EXPERIMENTAL DESIGN AND OBJECTIVES

This study was designed to examine the effects of daily 1RM back squat training and subsequent volume sets on maximal

Table I. Anthropometric and muscle thickness measures at pre-, mid-, and post-testing

	Participant 1				Participant 2				Participant 3			
	Pre	*Mid*	*Post*	*Δ (%)*	*Pre*	*Mid*	*Post*	*Δ (%)*	*Pre*	*Mid*	*Post*	*Δ (%)*
TBM (kg)	80.5	81.6	80.9	0.47	64.1	64.4	64.7	0.94	108.8	110.4	109.8	0.92
FM (kg)	11.0	10.0	10.2	-7.27	3.9	4.9	4.4	12.80	19.3	20.6	17.6	-8.81
FFM (kg)	69.5	71.6	70.7	1.73	60.2	59.5	60.3	0.17	89.5	89.8	92.2	3.02
BF%	13.7	12.3	12.6	-8.03	6.1	7.6	6.8	11.48	17.7	18.7	16.0	-9.60
FFM%	86.3	87.7	87.4	1.27	93.9	92.4	93.2	-0.75	82.3	81.3	84.0	2.07
LQM Thickness (mm)	50.4	51.5	48.5	-3.77	42.5	48.1	45.4	6.82	49.1	48.1	48.0	-2.24
LQD Thickness (mm)	45.2	44.9	47.6	5.31	38.8	43.7	39.9	2.84	39.5	46.2	42.9	8.61
AQ Thickness (mm)	59.8	65.1	61.5	2.84	40.8	36.2	35.4	-13.20	44.4	44.0	46.8	5.41

Δ % = Percentage change from pre- to post-testing;; TBM = Total body mass; FM = Fat mass; FFM = Fat free mass; BF% = Body fat percentage; FFM% = Fat free mass percentage; LQM = Lateral quadriceps midpoint; LQD = Lateral quadriceps distal aspect; AQ = Anterior quadriceps.

strength levels and muscle hypertrophy. Each participant performed the back squat for 37 consecutive days with a 1RM performed on 36 days of the 37 days. Throughout days 1-30, participants performed a 1RM squat followed by five volume sets. The five volume sets consisted of either five sets of three repetitions at 85% of the daily 1RM or five sets of two repetitions at 90% of the daily 1RM, and this volume strategy was alternated between days. Day-31 began the taper period, during which volume was systematically decreased. On days 31 and 32 participants performed a 1RM followed by three volume sets, days 33/34 were a 1RM and two volume sets, and day-35 was a 1RM and one volume set. Day-36 consisted of a lighter session, during which participants performed only one set of one repetition at 85% of their pre-testing 1RM (i.e., day-36 was the only day where a max squat was not performed). To complete the study, participants performed a post-test 1RM with no volume sets on the 37th and final day. Before each session 360 mg of caffeine powder (Crystal Light® Energy) was mixed with a branched chain amino acids-BCAA (7 g BCAA/serving) (XTEND, Scivation™) and ingested, then training began 20-30 minutes later. Immediately following each session participants ingested 44 g of whey protein (Scivation Whey, Scivation™). Caffeine was fed to aid with mood state and recovery due to the intense, frequent, and fatiguing nature of the training protocol. BCAAs and whey protein were administered at doses to exceed 3 g of leucine, which has been recommended to be effective to maximize muscle protein synthesis (10), and to control for nutrient timing. Finally, each day participants recorded a perceived recovery status (PRS) score (11) upon entering the laboratory (i.e., before caffeine ingestion) and again 20-30 minutes following caffeine ingestion, immediately before the onset of training, for all 37 days.

All three participants refrained from any additional exercise for the duration of the study, aside from being permitted to perform the bench press and/or military press at a frequency of 2-3 times per week. Set and repetition prescriptions for additional exercise alternated each session between 3-5 sets of 8 repetitions, 6 repetitions or 4 repetitions with an intensity of an 8 rating of perceived exertion (RPE) on the repetitions in reserve (RIR) based resistance training-specific RPE scale (12). Participants were permitted to perform minimal upper body training to maintain strength for their respective sports in a muscle group unrelated to squat training. Participants refrained from exercise for 48 hours prior to day-1 of the study.

TESTING MEASUREMENTS

One-repetition maximum (1RM) and rating of perceived exertion (RPE)

For each 1RM attempt athlete's an RIR-based RPE, which was used to aid attempt selection and gauge difficulty (12). Regarding RIR-based RPE; an RPE of 10 corresponds to an absolute maximum effort, a RPE of 9.5 corresponds to zero RIR but the lifter perceived that the load could be increased and a successful attempt would still be possible, and an RPE of 9 corresponded to one RIR. Therefore, on pre- and post-testing days (i.e., days 1 and 37) a 1RM was recorded by one of 2 conditions: a) An RPE of 10 being recorded and the investigator determining any load increase would not result in a successful attempt or the participant failing on any subsequent attempt thereafter and b) a recorded RPE of 9 or 9.5 and then the participant failing on the subsequent attempt with a load increase of ≤ 2.5 kg. For all other 1RM days (i.e. days 2-35), a 1RM was determined when either of the above conditions for days 1 and 37 were met, or the additional condition of a lift being reported as a 9.5 RPE on or after the 3rd attempt of the day, and the investigator decided to cease attempts for that day. During days 2-35 a 9.5 RPE on or after the 3rd attempt was allowed as a 1RM to avoid frequent 1RM failures during the training period. RPE was also recorded during each day's final warm-up at 85% of pre-testing 1RM. All training sessions were supervised and 1RM was performed in accordance with USAPL rules (13) and validated 1RM procedures (12).

Average velocity

During all 1RM attempts, and each day's final warm-up set (85% of day-1 1RM), average velocity ($m \bullet s^{-1}$) was recorded via a Tendo Weightlifting Analyzer (TENDO Sports Machines, Trencin, Slovak Republic).

Wilks coefficient

Wilks coefficient is used during USAPL sanctioned competitions to determine relative strength and has been validated as a measure of relative strength (14). This coefficient is calculated by multiplying the weight lifted by a standardized bodyweight coefficient number.

Body composition

Body fat percentage (BF%) was measured during pre-, mid-, and post-testing on days 1, 15, and 37 respectively. BF% was estimated using the average sum of 2 skinfold thickness measurements obtained from three sites (abdomen, front thigh, and chest). If any site was > 2 mm different between measurements then a 3rd measurement was taken. The Jackson and Pollock formula was utilized to estimate body fat percentage (15). The same investigator administered all skin fold measurements and fat mass and fat free mass were extrapolated from BF% and total body mass.

Perceived recovery status (PRS)

Daily perceived recovery was measured via the PRS scale (11). Values on the scale range from 0-10, with 10 = Very well recovered/Highly energetic and 0 = Very poorly recovered/Extremely tired. Further, values of 0-2 were grouped as "Expect Declined Performance", values of 4-6 were bundled "Expect Similar Performance" and values 8-10 were bundled "Expect Improved Pe formance". The scale was administered every day immediately upon entering the laboratory prior to caffeine ingestion and 20-30 minutes later after caffeine ingestion immediately prior to training.

Muscle thickness (Ultrasonography)

Skeletal muscle hypertrophy of the quadriceps, as measured by muscle thickness (mm) via ultrasonography (BodyMetrix Pro, Intelametrix, Inc. Livermore, CA.), was assessed at pre-, mid-, and post-training on days 1, 15, and 37 respectively. Measurements of the lateral quadriceps mid (LQM) and distal (LQD) sites were taken at 50 and 70% respectively of the distance from the greater trochanter of the femur to the lateral epicondyle of the femur. In addition, the anterior quadriceps (AQ) was assessed at 70% of the distance from the greater trochanter of the femur to the medial epicondyle of the femur. The same investigator both palpated each participant for the landmarks and scanned the site with an ultrasound transducer containing acoustic gel to produce an image of muscle thickness (MT). All scans were performed on the right side of the body with the transducer held perpendicular to the skin and starting at the visible lateral muscular border and finishing at the visible medial muscular border. The average of two scans was used for analysis; however if the two values differed by greater than 2 mm a third scan was performed. In the event of a 3rd scan all three values were averaged.

Training History Questionnaire

Each individual completed a training history questionnaire during the initial visit to obtain information regarding training age and experience (16).

STATISTICAL ANALYSES

Absolute and percentage change was calculated for squat 1RM from pre-testing (day-1) to mid-testing (day-15), pre-testing to post-testing (day-37), and mid-testing to post-testing. Additionally, absolute and percentage change was calculated from pre-testing to peak 1RM (whenever the peak occurred). Further, the 36 1RMs were divided into quartiles (i.e., quartile-1: Q1, quartile-2: Q2, quartile-3: Q3, and quartile-4: Q4) and an average was calculated for each quartile to examine progressive trends in strength. Similarly, trends in average velocity at 1RM were examined in quartiles as well as changes in average velocity from pre- to mid- and post-testing and mid- to post-testing. Absolute and percentage changes in body mass, BF%, and MT were calculated from pre- to mid-testing, pre- to post-testing, and mid- to post-testing. Paired sample t-tests were utilized to analyze individual participant difference in PRS scores from pre to post caffeine consumption. A linear regression was used to examine relationships between the following variables: time (days) and 1RM, daily 85% velocity and 1RM, daily 85% RPE and 1RM, pre-caffeine PRS and 1RM, and post-caffeine PRS and 1RM. Correlation coefficient r scores and their associated p values were calculated for all regressions, and were interpreted as previously described (17). All analyses were performed using Statistica® 12.5 for Windows (StatSoft; Tulsa, OK, USA).

RESULTS

ANTHROPOMETRIC AND MUSCLE THICKNESS MEASUREMENTS

Anthropometric and MT measurements at pre-testing, mid-testing and post-testing and percentage change of those variables are displayed in table I.

ONE-REPETITION MAXIMUM (1RM) SQUAT

Table II displays the pre-, mid-, peak-, and post-squat 1RM for each participant and the significant ($p < 0.05$) along with r values for days and 1RM (r values: P1 = 0.65, P2 = 0.78, and P3 = 0.48) over the 36 max sessions. The following changes were seen from pre- to peak-1RM: P1 = +12.5 kg/+5.8% (215.0-227.5 kg), P2 = +13.5 kg/+10.8% (125.0-138.5 kg),

Table II. Squat 1RM and percentage change at pre-, mid-, and post-testing and pre-peak and correlations between time (days) and daily 1RM

	Squat 1RM (kg)			Δ (%)			r value	Peak 1RM (kg)
	Pre	*Mid*	*Post*	*Pre-Mid*	*Pre-Post*	*Pre-Peak*	*All 1RM Sessions*	*1RM kg/Day established*
Participant 1	215.0	222.5	222.0	3.5	2.3	5.8	0.65	227.5/35
Participant 2	125.0	130.0	138.5	4.0	10.8	10.8	0.78	138.5/37
Participant 3	220.0	232.5	241.0	5.7	9.5	9.5	0.48	241.0/37

Δ (%) = Percentage change; 1RM = One-repetition maximum.

and P3 = +21.0 kg/+9.5% (220.0-241.0 kg). Peak 1RM for P1 occurred on day-35, while peak 1RM for P2 and P3 occurred on day-37. Additionally, each participant experienced a decline in squat 1RM early during the 37-day period (Figure 1). The largest declines occurred for P1 at day-3 (-7.5 kg;-3.5%), for P2 at day-2 (-5 kg; 4.0%), and for P3 on day-2 (-5 kg; -2.3%). Figure 1 shows the daily percentage change in 1RM for each participant. The mean 1RMs during each quartile, for each participant can be seen in table III.

In terms of relative strength (Wilks Coefficient), P1 increased from 146.18 on day-1 to 154.20 at peak 1RM (+5.5%). The change in Wilks coefficient for P2 from day-1 to peak 1RM was +9.9% (100.53-110.51), while P3 increased Wilks from day-1 peak 1RM by +9.2% (129.89-141.90) (data not shown).

AVERAGE VELOCITY, RPE, AND PRS

All three participants had significant ($p < 0.05$) and inverse relationships between daily 85% RPE and daily 1RM (P1: $r = -0.70$; P2: $r = -0.50$; P: $r = -0.35$). However, only P2 had a significant relationship between daily 85% velocity and 1RM ($r = 0.75$, $p < 0.05$).

Regarding PRS, all three participants had significantly greater ($p < 0.01$) PRS scores immediately prior to commencement of training (i.e., post-caffeine consumption, P1 average: -6.7, P2 average, and P3 average: -5.7) compared to pre-caffeine consumption scores (P1 average: 4.8, P2 average: 6.3, and P3 average: 5.1). P1 exhibited significant ($p < 0.05$) and positive correlations between both pre- ($r = 0.43$) and post-caffeine ($r = 0.53$) consumption PRS scores and daily 1RM. Interestingly, P2 displayed a significant and inverse correlation between pre-caffeine PRS and daily 1RM ($r = -0.39$, $p < 0.05$), however there was no significant ($p > 0.05$) relationship between post-caffeine PRS and daily 1RM for P2; further there was no relationship between either PRS time point and daily 1RM for P3.

DISCUSSION

The primary aim of this study was to examine the effects of daily 1RM squat training followed by volume sets over the course of 37 consecutive days on maximal strength in three experienced and competitive lifters. The main finding of this study was that all three participants exhibited significant positive relationships between time (days) and 1RM (P1: $r = 0.65$, $p < 0.05$; P2: $r = 0.48$, $p < 0.05$; P3: $r = 0.78$, $p < 0.05$). Percentage increases in 1RM from day-1 to peak were: P1 = +5.8%, P2 = +10.8%, P3 = +9.5%. The main findings support our hypothesis as daily maximal and volume squat training substantially increased 1RM in well-trained powerlifters and weightlifters and is in support of the view that engaging in highly specific training can generate substantial strength gains in well-trained lifters (5).

Table III. Average 1RM during each quartile and percentage change in average 1RM from Q1 to Q4

	Q1	Q2	Q3	Q4	Δ (%) Q1-Q4
Participant 1	213.0	219.2	218.9	221.7	+4.1
Participant 2	124.2	129.8	131.9	134.6	+8.4
Participant 3	222.9	230.3	228.3	229.8	+3.1
Mean	186.7	193.1	193.0	195.4	+5.2

Q1 = Quartile 1, days 1-9; Q2 = Quartile 2, days 10-18; Q3 = Quartile 3, days 19-27; Q4 = Quartile 4, days 28-35, 37; Δ (%) = Percentage change; 1RM = One-repetition maximum; Mean = Average of all 3 participants.

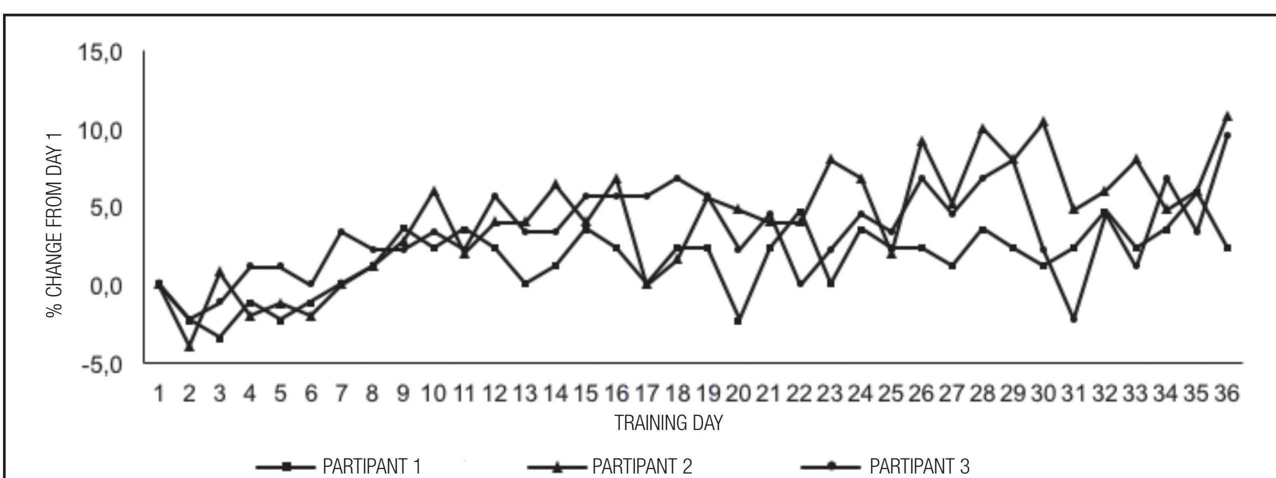

Figure 1.

Daily percentage change in squat 1RM for each of the 36 maximal training sessions in all 3 participants.

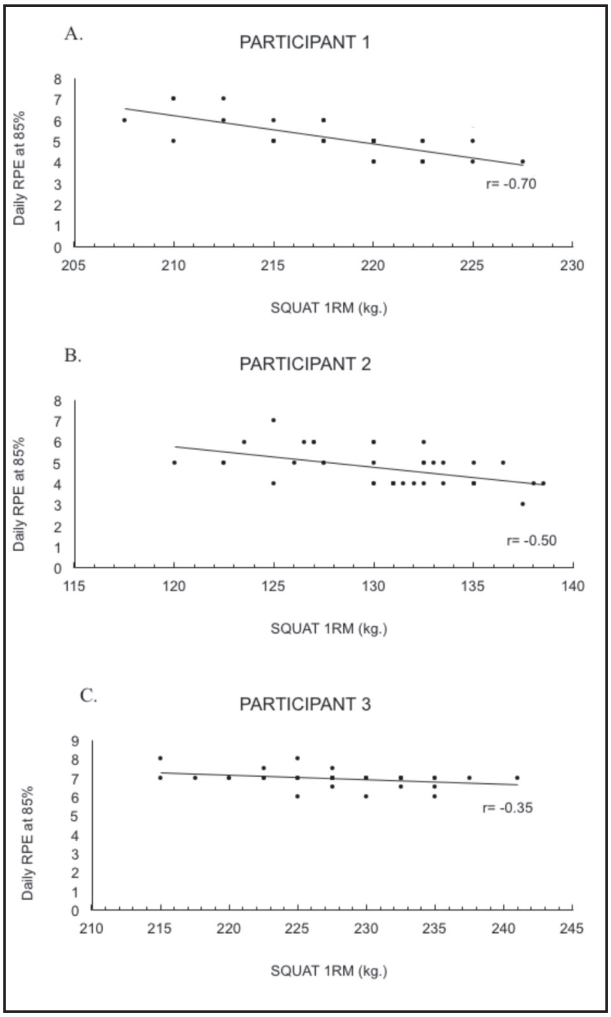

Figure 2.

Relationship between the daily RPE at 85% of pre-testing 1RM squat and the daily 1RM squat. Figure 2A depicts the relationship in participant-1, figure 2B depicts the relationship in participant-2 and figure 2C depicts the relationship in participant-3. RPE = Rating of perceived exertion; 1RM = One-repetition maximum. R-value stated within the figure; all relationships are significant ($p < 0.05$).

To our knowledge, the present study was the first to investigate the efficacy of daily 1RM and volume training on maximal strength. A plausible explanation for the considerable strength increases in well-trained lifters is the resultant neuromuscular adaptations of ultra-specific training. In support, is the analysis of daily average velocity, as data exists demonstrating average velocity at 1RM to have an inverse relationship with training status (12). Indeed, average velocities in the present study decreased from Q1: (P1: 0.20, P2: 0.34, and P3: 0.21 $m{\cdot}s^{-1}$) to Q4 (P1: 0.17/-15.0%, P2: 0.30/-11.8%, and P3: 0.20/-13.0%). Our results were consistent with previous literature (12) in that average velocity at 1RM was inversely associated with training status, as P1 (highest Wilks Coefficient) had the slowest mean average velocity over all 36 1RM sessions (0.19 $m \cdot s^{-1}$), followed by P3 who had the 2nd highest relative strength (0.22 $m \cdot s^{-1}$), and finally P2 who had the lowest Wilks coefficient and the highest average velocity (0.32 $m \cdot s^{-1}$) over the 36 maximal sessions. Therefore, in well-trained lifters neuromuscular adaptations still occur with high frequency/intensity training.

Both rapid and sizeable strength increases occur in novice populations (6), however, the rate of strength gain is considerably attenuated in well-trained individuals. Indeed, previous data have shown elite weightlifters to enhance lower body strength 3.5% over 1 year (18). Presently, we observed substantial changes, greater than the 3.5% previously found, in 1RM from pre-to-peak in lifters with ≥ 5 yrs. of training experience (P1: +12.5 kg/+5.8%; P2: +13.5 kg/+10.8%; P3: +21 kg/9.5%). It is probable that the daily volume sets were contributory in producing the considerable strength gains, as recent data has shown that strength may be volume-dependent in competitive lifters (16). It must be noted that the robust increases in strength were not without an initial decline. Consistent with the GAS (7) each participant achieved the described 'alarm reaction' stage following day-1. Specifically, on day-2, P2 (-5 kg/4.0%) and P3 (-5 kg/-2.3%) experienced their largest 1RM decline, while P1 experienced the largest decline on day-3 (-7.5 kg/-3.5%). Thus, even though each participant displayed a significant relationship between time and 1RM, this was not without an initial adaptation period (i.e. overreaching). Furthermore, there was a mean change of +5.2% in 1RM from Q1-Q4 among all three participants (Table II).

Regarding hypertrophy, findings were inconsistent, as all three participants experienced a positive percentage change in MT from day-1 to day-37 at two sites measured, but we also observed a decline in MT at one site for each participant (Table I). Interestingly, P1 and P2 displayed a greater increase in MT in terms of the sum of all 3 sites at mid-testing (P1: +10.38%, P2: +14.54%) compared to post-testing (P1: +4.38%, P2: -3.54%). A possible explanation greater MT increases at mid- versus post-testing in P1 and P2 is muscle edema due to myofiber damage (19), rather than true muscle hypertrophy. However, to counter the edema argument 1RM was increased at mid-testing in all 3 participants. Subsequently, as the training period continued participants made further adaptation to the repeated stimulus, resulting in continued strength enhancement. Ultimately, it is difficult to deduce if muscle edema existed at mid-point testing; however, it seems likely that neural factors and skill adaptation (i.e. technical efficiency) of the squat played the predominant role in enhancing 1RM strength in the present investigation due to specificity.

We anticipated substantial fatigue due to the demanding training protocol, thus participants' indicated training readiness via the PRS scale before training each day; while RIR-based RPE and average velocity at 85% of pre-testing 1RM were collected daily to analyze as possible predictors of daily 1RM. Interestingly, neither pre-training PRS scores nor 85% average velocity were consistently related to performance. However, all three participants had significant ($p < 0.05$) inverse relationships between daily RPE at 85% and daily 1RM (P1: $r = -0.70$; P2: $r = -0.50$, and P3: $r = -0.35$). Therefore, pre-training self-perceived recovery may not be as strong of a performance indicator compared to RPE/RIR after the onset of training. Thus, if determining daily training load based upon athlete-feedback (i.e. autoregulation) (12), it may be most appropriate to make decisions once the warm-up period has started rather than beforehand.

The following limitations of the current study do exist: a) only three individual cases were examined and b) the daily 1RM protocol employed was not compared to a control group performing traditional periodization/frequency. To counter, it is important to note that this investigation achieved significant novelty as the first to examine daily 1RM training in experienced lifters. Furthermore, this data collection is arduous and is impractical to carryout in a larger sample due to the uniquely fatiguing nature, thus the authors deemed it prudent to present a small case series as a basis for efficacy.

CONCLUSIONS

In conclusion, performing daily 1RM and volume back squat training volume produced robust changes in 1RM for three competitive strength athletes (P1: +12.5 kg/5.8%, P2: +13.5 kg/10.85%, and P3: +21.0 kg/9.5%) respectively from pre- to peak-1RM with significant positive relationships between time (days) and 1RM for each athlete. However, despite the promising results for daily 1RM training in the current study, it is imperative to state that caution must be used when implementing such an intensive training strategy. Moreover, in practice, many questions remain regarding the length of time this type of training is sustainable and how to incorporate this strategy within a macrocycle. It is unlikely this type of training can nor should be maintained year-round and rather may be more appropriate as a single intensity block (mesocycle) to peak for competition within a macrocycle of sound periodization principles. Furthermore, it is advisable that only lifters with multiple years of training experience and technical proficiency should engage in daily 1RM training; novice/intermediate trainees can make progress with much lower volume/frequency and should take advantage of the opportunity to progress with less demanding training. Importantly, daily 1RM training may enhance injury risk for novice individuals. Therefore, lifters/coaches must use appropriate discretion regarding training status and specificity of goals when considering this training strategy.

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