ASSESSMENT OF ACCURACY OF INTRA-SET RATING OF PERCEIVED EXERTION IN THE SQUAT, BENCH PRESS, AND DEADLIFT

by

Colby A. Sousa

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This thesis was prepared under the direction of the candidate's thesis advisor, Dr. Michael C. Zourdos, Department of Exercise Science and Health Promotion, and has been approved by all members of the supervisory committee. It was submitted to the faculty of the College of Education and was accepted in partial fulfilment of the requirements for the degree of Master of Science.

SUPERVISORY COMMITTEE:

Michael C. Zourdos, Ph.D.
Thesis Advisor

Eric Helms, Ph.D.

Chun-Jung Huang, Ph.D.

Michael Whitehurst, Ed.D.

Michael Whitehurst, Ed.D.
Chair, Department of Exercise Science and Health Promotion

Valerie J. Bristor, Ph.D.
Dean, College of Education

Khaled Sobhan, Ph.D.
Interim Dean, Graduate College

July 20, 2018
Date

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I have been sitting at the computer for 4 hours now trying to find the right words to use. I have typed out up to 10 versions of some kind of thank you and then erase them because it does not give justice to how thankful I am. I have laughed and I have cried thinking about what to say. My heart is overjoyed. I will keep this short.

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ABSTRACT

Author: Colby A. Sousa

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The purpose of this research was to investigate how accurate trained lifters were at gauging intra-set rating of Perceived Exertion (RPE) in the squat, bench press, and deadlift. Ten resistance-trained males completed four sets to failure with 80% of their one-repetition maximum (1RM) and verbally indicated when they believed they were at a "6" and "9" RPE. Across all sets and all lifts, the called 9 RPE was more accurate than the called 6 RPE. Additionally, RPE calls were more accurate during set four vs. set one on the squat and deadlift at both the called 6 and 9 RPEs. Further bench press RPE calls were more accurate than squat and deadlift RPE at the called 6, while both bench and deadlift RPE calls were more accurate than squat RPEs at the called 9. Importantly across all sets all RPE calls assessed repetitions in reserve within one repetition of precision.

ASSESSMENT OF ACCURACY OF INTRA-SET RATING OF PERCEIVED EXERTION IN THE SQUAT, BENCH PRESS, AND DEADLIFT

LIST OF TABLES viii

LIST OF FIGURES ix

I. INTRODUCTION 1

II. REVIEW OF LITERATURE REVIEW 4

I. RESISTANCE TRAINING ADAPTATIONS 4

II. TOOLS TO MONITORING TRAINING LOAD 4

III. RIR-BASED RPE 6

IV. ACCURACY OF RIR-BASED RPE 7

V. CONCLUSION 8

III. METHODOLOGY 9

EXPERIMENTAL DESIGN 9

SUBJECTS 10

INTRA-SET RATING OF PERCEIVED EXERTION SESSIONS 11

Zourdos et al. 2016 12

LIGHT TRAINING SESSIONS 12

TESTING PROCEDURES 13

Anthropometric Assessments 13

Wilks Score 13

RPE Experience 13

Training Age 13

One-Repetition Maximum (1RM) Testing 13

Statistical Analyses 14

IV. RESULTS 16

OVERALL AND WITHIN LIFT REPETITIONS IN RESERVE DIFFERENCE (RIRDIFF) 16

SET-TO-SET REPETITIONS IN RESERVE DIFFERENCE (RIRDIFF) 18

BETWEEN LIFT REPETITIONS IN RESERVE DIFFERENCE (RIRDIFF) COMPARISONS 20

RELATIONSHIPS 22

V. DISCUSSION 24

APPENDICES 29

APPENDIX A: APPROVAL LETTER 30

APPENDIX B: INFORMED CONSENT 32

APPENDIX C: HEALTH HISTORY QUESTIONNAIRE 37

APPENDIX D: PHYSICAL ACTIVITY QUESTIONNAIRE 39

APPENDIX E: THE DAILY ANALYSIS OF LIFE DEMANDS FOR ATHLETES . 41

REFERENCES 42

LIST OF TABLES

Table 1: Timeline of Events.....10

Table 2: Subject Characteristics.....11

Table 3: RIRDIFF at Each Called RPE for Each Set: Lifts Combined 17

Table 4: RIRDIFF Within Each Lift Across All Sets at Each Called RPE 18

Table 5: Average RIRDIFF Across All Sets @6RPE.....19

Table 6: Average RIRDIFF Across All Sets @9RPE.....19

Table 7: Relationships Between Training Age and RIRDIFF 22

Table 8: Relationships Between RPE-RIR Experience and RIRDIFF 23

Table 9: Relationships Between Wilks Score and RIRDIFF.....23

Table 10: Relationships Between Total Reps and RIRDIFF 23

LIST OF FIGURES

Figure 1: Resistance-Exercise-Specific-Rating-Of-Percieved-Exertion-(RPE) ..... **Error! Bookmark not defined.**

Figure 2: Average RIRDIFF Between Lifts at 6 RPE 21

Figure 3: Average RIR DIFF Between Lifts at 9 RPE 21

I. INTRODUCTION

The amount of repetitions, which can be performed at a specific intensity of one repetition maximum (1RM), is highly individual. Specifically, a recent investigation observed that a range of 6-26 repetitions were performed in trained lifters at 70% of 1RM in the back squat (5). Consequently, prescribing a set number of repetitions at a percentage of 1RM could lead to highly varying degrees of difficulty between individuals. The repetitions in reserve (RIR)-based rating of perceived exertion (RPE) scale was developed to account for this issue by allowing individuals to rate the number of RIR at the completion of a set (44). Therefore, the RIR-based RPE scale can be used in lieu of percentage of 1RM to prescribe training load. Specifically, a training program could prescribe four sets of eight repetitions at an 8 RPE (2RIR) rather than prescribing sets of eight repetitions at 70% of 1RM, which would equate per set difficulty across individuals and rectify the limitations of percentage of 1RM load prescription. Furthermore, if RPE scores are too high or too low to meet the RPE goal, load can be adjusted based upon the scale, which is referred to as autoregulation (27).

Indeed, a recent investigation from Helms et al. (14) demonstrated that trained lifters received a small effect size benefit for squat(0.50) and bench press (0.20) strength when autoregulating load prescription with RPE versus percentage of 1RM over eight weeks of training. However, it is important to note that the utility of intra-session RPE is predicated upon the accuracy of the rating. Zourdos et al. (44) found that experienced

lifters gauged RPE more accurately at intensities ≥90% in the squat and Ormsbee et al. (27) replicated those findings at 100% of 1RM in the bench press. However, these investigations also reported a large variance in RPE reported when only one repetition was performed at 70% of 1RM, suggesting that it is difficult to assess RIR when far from failure. Indeed, Hackett et al. (11) found that individuals could report RIR with an accuracy of ±1 when 0-3 repetitions from failure in the chest press and leg press (11). Further, the accuracy of RIR has been shown to increase from set-to-set (13), likely due to fewer repetitions being performed in subsequent sets. However, the data regarding intra-set RIR accuracy has only been performed on the bench press, chest press, and leg press with only the bench press at 70% of 1RM being analyzed across multiple sets (13). Therefore, it is not known if intra-set or between set differences in RPE accuracy would be similar on the squat and deadlift or at higher intensities.

Importantly, the only study assessing RPE accuracy during multiple repetitions in the squat examined if powerlifters could effectively choose a load that would result in meeting a pre-determined RPE after eight repetitions (15). Thus, this data related to the squat was self-reported and it cannot be known if the RPE was truly accurate. The deadlift, similar to the squat and bench press, has had RPE validated with velocity, in that as deadlift load increased there was a concomitant decrease in velocity and increase in RPE (18), however, to our knowledge there is not data examining the accuracy of reporting RIR-based RPE in the deadlift.

Therefore, the primary aim of this study was to examine the accuracy of gauging intra-set RIR-based RPE when verbally called by the lifter at a perceived “6” and “9” RPE before continuing the set to volitional failure across multiple sets in the squat, bench

press, and deadlift at 80% of 1RM in trained males. We hypothesized that intra-set accuracy would be the same across all three lifts and accuracy in all three lifts would be more precise at the “9” vs. “6” RPE. Additionally, we predicted that the accuracy of both the called “6” and “9” RPEs would improve in subsequent sets due to fewer repetitions per set as a result of fatigue

II. REVIEW OF LITERATURE REVIEW

I. RESISTANCE TRAINING ADAPTATIONS

When an individual first starts to resistance train, strength gains are primarily due to neural adaptations (26). After a couple of months, hypertrophy is the dominant factor (26,38). Hypertrophy occurs when protein synthesis is greater than protein breakdown. Manipulation of acute training variables (i.e. exercise selection and order, intensity, volume and duration, frequency and rest intervals) causes mechanic and metabolic stress on the body (33,40). Frequency can be described as how often an exercise is performed. More frequent training generally produces greater strength gains than less frequent (20) but this does not take into account other variables. Volume is the total amount of work done (reps x sets x weight) (4). It has been determined that volume is the driving factor of skeletal muscle adaptations (24). Intensity in resistance training can be defined as how much (or the load) lifted. This can be determined off of a 1RM or by using RIR-RPE. RIR based RPE scale has shown to be effective for regulating daily training load (27,44). Due to the desirable outcomes of manipulation of these training variables, it is necessary to monitor training load.

II. TOOLS TO MONITORING TRAINING LOAD

In a periodized program, load is typically determined by a specific percentage of the athletes' predetermined 1RM (7). 1RM tests may not be accurate due to test administrator errors or poor performance which could potentially result in inadequate loads being prescribed in training (44). 1RM's conducted in novice individuals do not

provide accurate information (36) therefore subsequent loading based off this number would be incorrect. Certain tables are available that show repetitions allowed at different percentages of 1RM (1) but these do not account for the inter-individual variations in how many repetitions can actually be completed at these same percentages of 1RM. Other than percentage based programming, a RM training zone (i.e. 3-5, 6-8, or 9-11 repetitions) has been a common way to determine training load (7) but has similar limitations regarding the 1RM testing. The result of inaccurate training loads could negatively affect neuromuscular adaptations for optimal training.

Variation in human performance may be due to psychological variability and factors such as sleep (3) , nutrition (19), and life stress (2) which all could potentially affect strength during training. Autoregulation is the practice of adjusting training variables in response to athlete feedback (27). Use of autoregulation with intensity progression from week to week has been shown to have greater strength progress versus a fixed progression (25). Higher training volume and increased intensity are related to 1RM performance (30,31,34). Volume autoregulation is also beneficial as moderate volume produced greater strength gains compared to both low and high volumes (9). Though volume has been shown to be the main driver of muscular adaptations, too much volume may negatively affect recovery. Thus, autoregulation can be a useful tool to ensure the proper stimulus is being placed on the body.

It has been shown that movement velocity slows concurrently with diminished force production (37) thus, measurements of average concentric velocity can be taken to autoregulate session volume. Average concentric velocity can be measured using a linear position transducer attached to the barbell (8,32). Velocity stop is a method of

autoregulation that uses this device and once velocity falls below a pre-determined threshold compared to the fastest or first repetition of the set, the set may be terminated (10,23,28,37). This method has shown to be effective as it can autoregulate volume to achieve the desired adaptations mentioned previously (23,29).

III. RIR-BASED RPE

Velocity stop can be useful as it allows for autoregulation of volume but linear position transducers can cost more than $1,000 making it less viable for all lifters. Thus, using the RIR-RPE scale (17,44) may be a more practical option for volume autoregulation since it does not cost any money and there are strong inverse correlations between velocity and RPE in powerlifters (squat: $r = -0.87$, bench press: $r =- 0.79$, deadlift: $r = -0.82$) (14,27). The use of RPE stop produced greater combined lift volume (sum of squat, bench press and deadlift volume) during higher RPE stop percentages (15). This makes it a viable tool of autoregulation to implement in training to account for daily fatigue. Recovery and progress rates amongst individuals vary widely therefore the use of RPE can account for these individual differences (6,39) and be used as an accurate method of autoregulation.

RPE-RIR was looked at during daily 1RM training and there were significant inverse relationships between daily RPE at 85% and daily 1RM (P1: $r = -0.70$; P2: $r = -0.50$, and P3: $r = -0.35$) (42). Therefore, RIR-RPE may be a good indicator of performance during training and adjustments may be made to determine daily training load. The RIR-based scale puts individuals on a “level playing field” and account for the day to day fluctuations due to the above mentioned variations in performance.

IV. ACCURACY OF RIR-BASED RPE

The RPE scale is an estimate and its success is dependent on its accuracy. Individuals were asked to complete five sets of 10 at 70% of 1RM and record RPE after each set in squat and bench. Participants reported RPE ratings that were short of maximal even when taken to volitional failure but were more accurate with each subsequent set (13). Looking into the individualization of lifters and the use of the RIR-RPE scale, experienced squatters provide more accurate scores at 1RM vs novice squatters and there the inverse association between scores and velocity was stronger in experienced versus novice squatters (44). As intensity increases, the speed of the movement decreases which therefore this inverse relationship shows that these lifters have higher neuromuscular efficiency in regards to maximal strength thus validating the RIR-based scale (44). It was also found that experienced lifters are more consistent at gauging RIR as they approach failure (44). Experienced lifters are more familiar with their training and how they adjust therefore novice lifters need to continue to practice using this scale over time which could lead to more accurate load selection.

When looking at in the accuracy of the RIR-RPE scale, RPE was closer to the target for bench press compared to squat during hypertrophy session (15). This may be due to that fact that squats require more technical skill and cause more systemic fatigue because of the amount of musculature involved. Therefore, a greater chance of error in technique is present, causing greater variability in RPE. Hackett et al. (11) looked at the accuracy ERF and showed that accuracy differed over the actual repetitions to failure (ARF) of 0-10 for both exercises, with accuracy in ERF decreasing as ARF increased. RIR was reported to be more accurately estimated when repetitions were within 0-3 of failure (11). This shows that accuracy depends on the state of fatigue of the individual.

Being able to assess how close one is to failure is important for proper prescription and monitoring (11). This will allow for proper stimulus and adequate recovery thus leading to optimal muscular strength and hypertrophy adaptations. While this study produced some novel information, it was conducted in the leg press and chest press only and not the main lifts. It also only used 70% of 1RM and the more repetitions completed, the less accurate RIR may be.

V. CONCLUSION

Autoregulation has been proven to be an effective tool in monitoring training load. A limitation of the scale is that if it is not accurate, then it is not useful. Therefore, this study aims to look at the accuracy of the RIR-RPE scale in the squat, bench press and deadlift at sets to failure with 80% of 1RM.

III. METHODOLOGY

EXPERIMENTAL DESIGN

The aim of this study was to examine the accuracy of reporting intra-set RPE and if the accuracy changes across multiple sets in the squat, bench press, and deadlift. Subjects reported to the laboratory for a total of eight sessions over a 3.5-week period. On day one of week one subjects reported to the laboratory to complete preliminary paperwork (health history and physical activity questionnaires) and have anthropometrics assessed. Next, subjects completed a five-minute standardized dynamic warm-up followed by validated (44) 1RM testing for the squat, bench press, and deadlift on the same day followed by a light training session, 48 hours later, for all three lifts (two sets of eight repetitions at 65% of 1RM). Next, 72 hours following light training subjects reported for day one of week two, in which they performed four sets of either the squat, bench press, or deadlift to volitional failure at 80% of 1RM. During each set subjects verbally indicated when they believed they were at a "6" or "9" RPE. There were 96 hours rest following this training session at which time subjects performed the same light training session as week one. Weeks three and four served exactly as week two except the two exercises not performed in the week one day one training session were performed. The weekly order in which exercises were performed was counterbalanced. A timeline of the protocol can be seen in Table 1.

Table 1: Timeline of Events

	Day 1	Day 2	Day 3	Day 4	Day 5
Week 1		• HHQ • PAQ • AM • 1RM Testing			• LTS
Week 2	• TP				• LTS
Week 3	• TP				• LTS
Week 4	• TP				• LTS

Health History Questionnaire (HHQ), Physical Activity Questionnaire (PAQ), Anthropometric Measurements (AM), Light Training Session (LTS), Training Protocol (TP: 4 sets to failure at 80% of 1RM-one-repetition maximum).

SUBJECTS

Ten college aged (18-40 years old) males were recruited. For inclusion, all subjects must have performed the back squat, bench press, and deadlift exercises an average of at least once per week for at least two consecutive years as determined via the validated physical activity questionnaire (44). All subjects must have been able to squat and deadlift at least 1.5 times their body mass (BM) and bench press at least equal to their BM. Subjects who had any contraindications to exercise (i.e. heart disease, serious musculoskeletal disorders, injuries, etc.) as determined via the Health History Questionnaire, were excluded from participation. Additionally, all subjects were required to refrain from exercise for 48 hours prior to the 1RM testing session and refrain from additional exercise or supplementation outside of the study during the entirety of the 3.5 week protocol. Finally, the University's Institutional Review Board approved this investigation prior to data collection and all subjects provided written informed consent prior to participation.

Table 2: Subject Characteristics

	Age (yrs)	Height (cm)	Body Mass (kg)	Body Fat (%)	TA (yrs)	REX	Wilks Score
Mean	24.8	173.43	81.422	13.64	6.4	2.73	306.24
SD	3.79	8.57	16.43	7.01	3.87	1.49	66.13

TA=Training Age, REX = RPE Experience: 1=Use RPE all the time, 2= frequently use RPE, 3= sometimes use RPE, 4= have used it a few times, or 5=Never use RPE.

INTRA-SET RATING OF PERCEIVED EXERTION SESSIONS

On day one of weeks two, three, and four subjects performed four sets to volitional failure with 80% of 1RM on the squat, bench press, and deadlift. Only one of the exercises was performed each week and the order in which they were performed was counterbalanced across subjects.

Each session began with a brief five-minute dynamic warmup, followed by a specific warmup for that week's exercise wherein the subjects performed five repetitions with 20% of their 1RM followed by three repetitions at 50% of 1RM. Next, the four sets to volitional failure at 80% of 1RM was performed, with five-minutes of rest between sets. Repetitions were only valid if they met the standard set forth by the International Powerlifting Federation (38). For the deadlift, subjects were required to keep their hands gripped on the bar throughout each set, however repositioning of the feet between repetitions was permitted.

To assess intra-set RPE accuracy subjects were asked to verbally indicate when they believe they are at a "6" and "9" RPE, during each set and then continue to failure. Furthermore, the scale was shown and explained to each subject prior to each set. Both predicted repetitions to failure at each called RPE and actual repetitions performed were recorded then compared for analysis. Next, the difference between the actual and

predicted repetitions performed (actual repetition-predicted repetitions) was recorded as the RPE difference (RPEDIFF) for both intra-set RPEs.

Figure 1: Resistance-Exercise-Specific-Rating-Of-Percieved-Exertion-(RPE)

RESISTANCE EXERCISE-SPECIFIC RATING OF PERCIEVED EXERTION (RPE)

Rating	*Description of Perceived Exertion*
10	*Maximum effort*
9.5	*No further repetitions but could increase load*
9	*1 repetition remaining*
8.5	*1-2 repetitions remaining*
8	*2 repetitions remaining*
7.5	*2-3 repetitions remaining*
7	*3 repetitions remaining*
5-6	*4-6 repetitions remaining*
3-4	*Light effort*
1-2	*Little to no effort*

Zourdos et al. 2016

LIGHT TRAINING SESSIONS

A light training session was included for the squat, bench press, and deadlift 48 hours after 1RM testing, and 96 hours post-exhaustive training sessions each week to avoid detraining on those exercises (35). An exercise specific warmup was performed prior to each exercise in the light training session consisting of five repetitions with 20% 1RM, followed by three repetitions at 50% 1RM, then two repetitions at 60% 1RM with self-selected rest intervals. Subjects then performed the light training consisting of three sets of five repetitions at 70% of 1RM with five minutes of rest between sets and exercises.

TESTING PROCEDURES

Anthropometric Assessments

Total BM (kg) was measured by a calibrated digital scale (Mettler-Toledo, Columbus, Ohio, USA.) and body fat percentage (BF%) was estimated using the average sum of three skinfold thickness measurements acquired at three separate sites (abdomen, anterior thigh, and chest). The Jackson and Pollock equation was used to calculate BF% (22) and all anthropometric measurements were assessed by the same investigator.

Wilks Score

Relative strength was assessed using the Wilks Coefficient and has been validated as a measure of relative strength (41). It is used during USAPL sanctioned competitions and is calculated by multiplying the weight lifted by a standardized bodyweight coefficient number.

RPE Experience

To assess RPE experience, subjects completed a 1-5 Likert scale as follows: 1-"I use it all the time", 2- "I use it frequently", 3- "I use it sometimes", 4- "I have used it a few times", 5- "I have never used it".

Training Age

Training age was assessed as years consistently training each individual lift, thus a training age was established for the squat, bench press, and deadlift as individual lifts. Training age was obtained via the physical activity questionnaire.

One-Repetition Maximum (1RM) Testing

All 1RM testing were conducted in accordance with previously validated procedures (2). Squat, bench press, and deadlift testing were completed on the same day

in that order to the standard of the International Powerlifting Federation (21). Subjects were allocated a five-minute rest period between each exercise. Testing for each exercise began by the subjects performing five repetitions with 20% of their estimated 1RM (obtained from the physical activity questionnaire), followed by three repetitions at 50% 1RM, two repetitions at 70% 1RM, one repetition at 80% 1RM, and one repetition at 90% of 1RM. Following performance at 90% of 1RM, increases in subsequent 1RM attempts were determined at the investigator's discretion. To aid in attempt selection, ACV and rating of perceived exertion (RPE) via the repetitions in reserve (RIR)-based RPE scale (44) were collected on each 1RM attempt. Additionally, five minutes of rest was administered between each attempt. A 1RM attempt was considered valid if one of the following conditions were met: 1) Subject reported a '10' on the RIR/RPE scale and the investigator determined a subsequent attempt with increased weight cannot be successfully or safely completed, 2) subject reported a '9.5' on the RIR/RPE scale and missed the subsequent attempt with a load increase of 2.5 kg or less, 3) Subject reported a '9' or lower on the RIR/RPE scale and failed the subsequent attempt with a load increase of 5kg or less. All successive increases in load following the 90% 1RM performance were required to be less than or equal to the previous attempts increase in load. Finally, Eleiko barbells and lifting discs (Chicago, Illinois, USA) that have been calibrated to the nearest 0.25 kg were used to uphold the accuracy of load lifted.

Statistical Analyses

To quantify the directionality of error, the RPEDIFF was calculated. Thus, negative numbers represented "undershooting" the predicted number of total repetitions, whereas positive numbers represented an "overshoot" of the predicted number of

repetitions. To display "absolute accuracy", the mean absolute RPEDIFF (negative sign excluded for RIR undershoot) for each exhaustive set and for each session (i.e. all 4 sets within one session) was calculated. Thus, absolute RPEDIFF values were averaged for each individual squat, bench press, and deadlift set and for each total session. Both RPEDIFF over and undershoot values were averaged to generate mean so that differences in directionality of accuracy were assessed. Hedges *g* effect sizes were used to compare differences between the various RIRDIFF values between conditions. Additionally, Pearson's product moment correlations were used to examine relationships between training age, RPE experience, and Wilks score with RIRDIFF. All statistical analyses were performed using Microsoft Excel for windows and Statistica® for windows (StatSoft:Tulsa, OK, USA).

IV. RESULTS

OVERALL AND WITHIN LIFT REPETITIONS IN RESERVE DIFFERENCE (RIRDIFF)

Across all sets and all lifts the mean RIRDIFF was lower (i.e. RPEs were more accurate) at the called 9 (0.58 ± 0.2) vs. 6 (0.96 ± 0.38) RPEs with a large effect of 1.24. Additionally, when combing all lifts the RIRDIFF was meaningfully lower (ES range: 0.71-1.09) at the called 9 vs. the 6 RPE. The specific means and effect size for each set comparison can be seen in Table 3. Similarly, at each individual lift the RIRDIFF was meaningfully smaller with ESs of 0.74, 1.18, and 0.98 for squat, bench press, and deadlift respectively, in favor of the called 9RPE vs. the 6RPE for accuracy (Table 4).

Table 3: RIRDIFF at Each Called RPE for Each Set: Lifts Combined

Set	RIRDIFF @ 6 RPE	RIRDIFF @ 9 RPE	Effect Size (Condition Favored)
1			
Average	1.39	0.80*	1.09
SD	0.70	0.26	
90% CI	1.17-1.61	0.71-0.89	
2			
Average	0.85	0.49*	1.73
SD	0.26	0.13	
90% CI	0.77-0.93	0.45-0.53	
3			
Average	0.81	0.50*	2.13
SD	0.12	0.17	
90% CI	0.77-0.85	0.44-0.56	
4			
Average	0.77	0.53*	0.71
SD	0.42	0.22	
90% CI	0.63-0.91	0.46-0.60	
All Sets			
Average	0.96	0.58*	1.24
SD	0.38	0.20	
90% CI	0.90-1.02	0.55-0.61	

RIRDIFF=Repetitions in Reserve Difference, RPE= Rating of Perceived Exertion, CI= Confidence Interval. (Data for each set is the average RIRDIFF for the squat, bench, and deadlift together of that particular set.) *Meaningfully lower RIRDIFF at the called 9 vs. 6 RPE (more accurate RPE)

Table 4: RIRDIFF Within Each Lift Across All Sets at Each Called RPE

		RIR-Diff @ RPE 6	RIR-Diff @ RPE 9	Effect Size (Condition Favored)
Squat, All Sets	Average	1.06	0.71*	0.74
	SD	0.66	0.12	
	90% CI	0.88-1.24	0.68-0.74	
Bench, All Sets				
	Average	0.83	0.55*	1.18
	SD	0.31	0.11	
	90% CI	0.74-0.92	0.52-0.58	
Deadlift, All Sets				
	Average	0.98	0.59*	0.98
	SD	0.44	0.34	
	90% CI	0.86-1.10	0.48-0.70	

RIRDIFF=Repetitions in Reserve Difference, RPE= Rating of Perceived Exertion, CI= Confidence Interval. This table shows the average RIRDIFF at each called RPE across all sets for each individual lift. *Meaningfully lower RIRDIFF at the called 9 vs. 6 RPE (more accurate RPE).

SET-TO-SET REPETITIONS IN RESERVE DIFFERENCE (RIRDIFF)

The RIRDIFF diminished, thus intra-set RPEs were more accurate on both the squat and deadlift during set four vs. set one at both the called 6 and 9 RPEs. Surprisingly, the RIRDIFF was smaller, noting more accurate intra-set RPEs, during set one vs. set four for the bench press at both the called 6 and 9 RPEs. The associated means, standard deviations, and effect sizes can be seen in Tables 4 and 5 along with an RIRDIFF for each set during all exercises.

Table 5: Average RIRDIFF Across All Sets at 6RPE

Exercise		Set 1	Set 2	Set 3	Set 4	Set 1 Vs. Set 4 ES (Set Favored)
Squat	Average RIRDIFF	2.00	1.00	0.67	0.56*	1.08 (Set 4)
	SD	1.70	0.94	0.71	0.73	
Bench	Average RIRDIFF	0.63#	0.56	0.89	1.25	0.69 (Set 1)
	SD	0.52	0.53	0.78	1.16	
Deadlift	Average RIR DIFF	1.56	1.00	0.88	0.50*	0.97 (Set 4)
	SD	1.42	0.87	0.35	0.53	

RPE=Rating of Perceived Exertion, RIRDIFF=Repetitions in Reserve Difference, ES=Effect Size. *Meaningfully lower RIRDIFF on the 4th set vs. the 1st set. #Meaningfully lower RIRDIFF on the 1st set vs. the 4th set.

Table 6: Average RIRDIFF Across All Sets at 9RPE

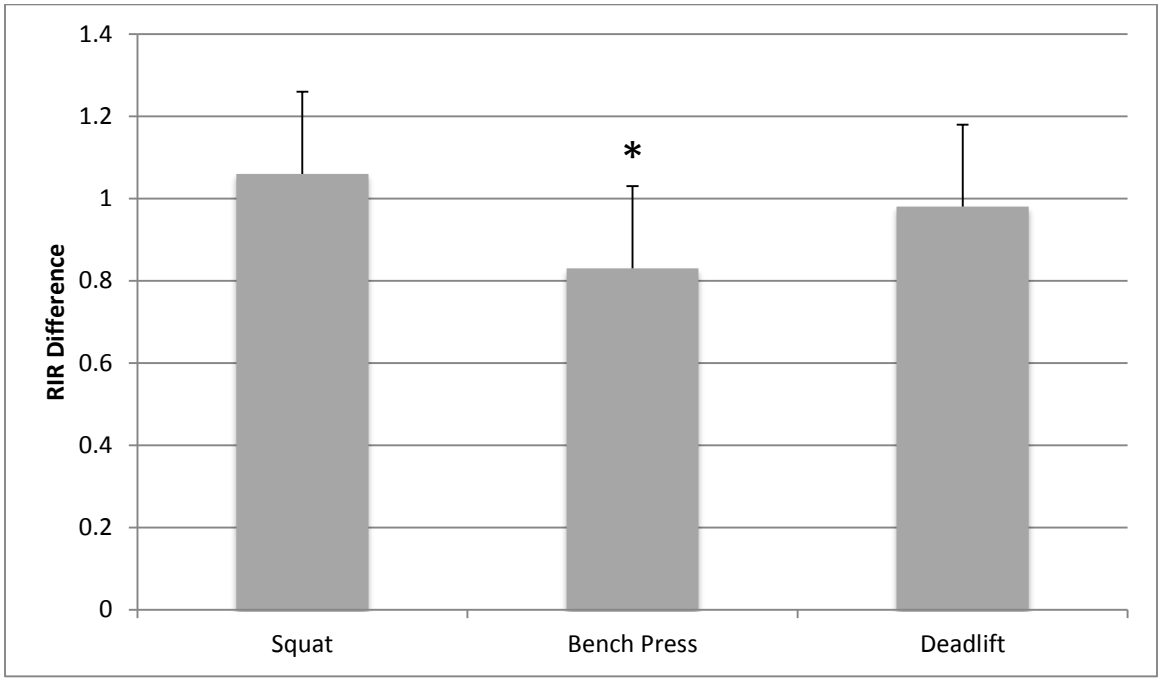
Exercise		Set 1	Set 2	Set 3	Set 4	Set 1 Vs. Set 4 ES (Set Favored)
Squat	Average RIRDIFF	0.89	0.70	0.67	0.60*	0.44 (Set 4)
	SD	0.60	0.67	0.87	0.70	
Bench	Average RIRDIFF	0.50#	0.50	0.50	0.71	0.32 (Set 1)
	SD	0.53	0.76	0.53	0.76	
Deadlift	Average RIRDIFF	1.00	0.75	0.33	0.29*	0.90 (Set 4)
	SD	1.00	0.71	0.52	0.49	

RPE=Rating of Perceived Exertion, RIRDIFF=Repetitions in Reserve Difference, ES=Effect Size. *Meaningfully lower RIRDIFF on the 4th set vs. the 1st set. #Meaningfully lower RIRDIFF on the 1st set vs. the 4th set.

BETWEEN LIFT REPETITIONS IN RESERVE DIFFERENCE (RIRDIFF) COMPARISONS

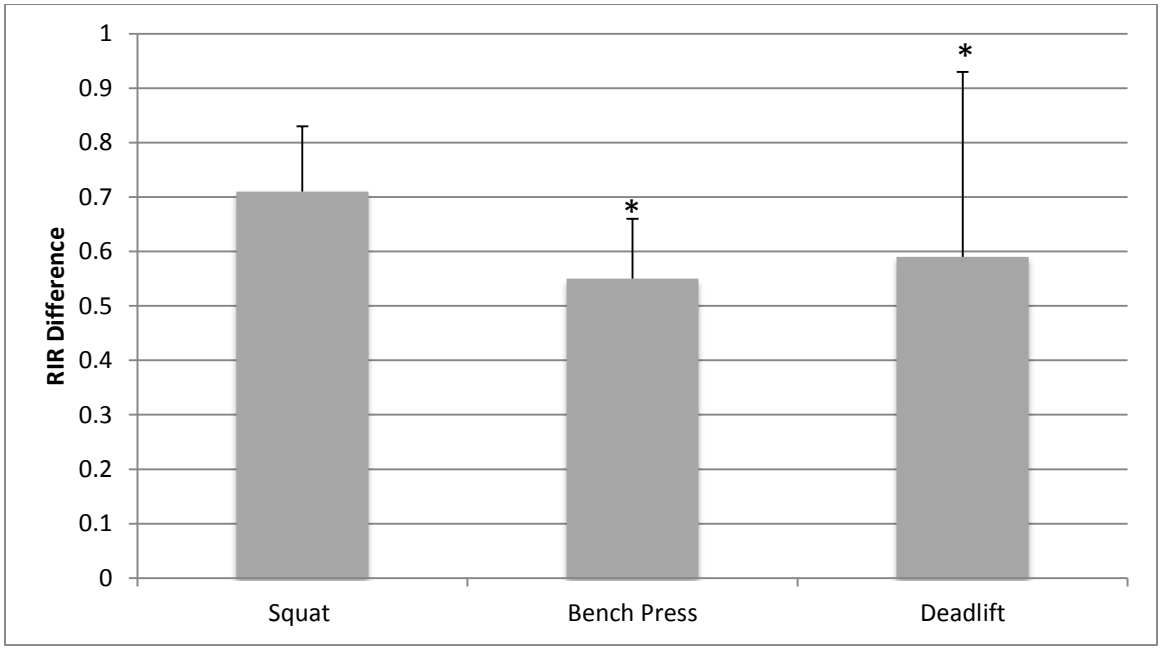
In the bench press, across all sets, the RIRDIFF (0.83 ± 0.31) was lower (i.e. more accurate) than in the squat (1.06 ± 0.66) at the called 6 RPE with a small effect size of 0.44. The deadlift (0.98 ± 0.44) showed similar RIRDIFF at a called 6 than in the squat (1.06 ± 0.66) with a trivial effect size of 0.14. Additionally, at the called 6 the deadlift (0.98 ± 0.44) showed a larger RIRDIFF than in the bench press (0.83 ± 0.31) with a small effect size of 0.39. At a called 9 RPE, the RIRDIFF was greater in the squat (0.71 ± 0.12) than in the bench press (0.55 ± 0.11) with a large effect size of 1.38. RIRDIFF at a called 9 RPE in the bench press (0.55 ± 0.11) was similar to the deadlift (0.59 ±0.34) with a trivial effect size of 0.16. Additionally, RIRDIFF in the deadlift (0.59 ±0.34) was lower than in the squat (0.71 ± 0.12) at the called 9 RPE with a moderate effect size of 0.50. These between lift comparisons are displayed in Figures 2 and 3.

Figure 2: Average RIRDIFF Between Lifts at 6 RPE



RPE= Rating of Perceived Exertion, RIRDIFF=Repetitions in Reserve Difference. Data are mean ± standard deviation. *Significantly less RIRDIFF than the squat and deadlift (i.e. more accurate).

Figure 3: Average RIR DIFF Between Lifts at 9 RPE



RPE= Rating of Perceived Exertion, RIRDIFF=Repetitions in Reserve. Data are mean ± standard deviation. *Significantly less RIRDIFF than the squat (i.e. more accurate).

RELATIONSHIPS

The specific r- and p-vales for all relationships can be seen in Tables 7,8,9, and 10. Training age was negatively and significantly related to RIRDIFF at the called 6 RPE in the bench ($r=-0.35$, $p=0.04$), called RPE 6 in the deadlift ($r=-0.52$, $p<0.01$), all called RPE 6s ($r=-0.40$, $p<0.01$), and all called 9 RPEs ($r=-0.22$, $p=0.03$) indicating that more years of training experience were potentially associated with more accurate prediction of RIR. Similarly, greater RPE experience was significantly related to lower RIRDIFF at all called 9 RPEs and the called 6 RPE in the bench press, indicating that more frequency usage of RIR-based RPE was associated with improved accuracy. Additionally, Wilks score was negatively and significantly correlated at all conditions except for called 6 RPE in the squat and called 6 RPE in the bench press meaning those with a higher Wilks are more accurate at predicting RIR. Total repetitions performed were positively and significantly related to RIRDIFF at all conditions regarding a called 6 RPE indicating that more repetitions per set were associated with less accurate RIR prediction.

Table 7: Relationships Between Training Age and RIRDIFF

	TA S RPE 6	TA S RPE 9	TA B RPE 6	TA B RPE 9	TA D RPE 6	TA D RPE 9	TA All RPE 6	TA All RPE 9
R-value	0.10	0.18	0.35*	0.21	0.52*	0.22	0.40*	0.22*
P-Value	0.54	0.27	0.04*	0.25	<0.01	0.25	<0.01*	0.03*

TA: Training Age, S=Squat, B=Bench, D=Deadlift, RPE = Rating of Perceived Exertion, RIRDIFF= Repetitions in Reserve Difference, *Significant Relationship. #Relationship Approached Significance. These correlations show the relationship between the repetitions performed across all four sets combined in an exercise with the combined RIRDIFF across all four sets.

Table 8: Relationships Between RPE-RIR Experience and RIRDIFF

	REX S RPE 6	REX S RPE 9	REX B RPE 6	REX B RPE 9	REX D RPE 6	REX D RPE 9	REX All RPE 6	REX All RPE 9
R-value	0.12	-0.33*	-0.39*	-0.42*	-0.23	-0.33#	-0.17#	-0.40*
P-Value	0.47	0.04*	0.02*	0.02*	0.18	0.08#	0.08#	<0.01*

REX=RPE Experience, S=Squat, B=Bench, D=Deadlift, RPE = Rating of Perceived Exertion, RIRDIFF= Repetitions in Reserve Difference, *Significant Relationship. #Relationship Approached Significance. These correlations show the relationship between the repetitions performed across all four sets combined in an exercise with the combined RIRDIFF across all four sets.

Table 9: Relationships Between Wilks Score and RIRDIFF

	W S RPE 6	W S RPE 9	W B RPE 6	W B RPE 9	W D RPE 6	W D RPE 9	W All RPE 6	W All RPE 9
R-value	-0.15	0.48*	0.17	0.60*	0.58*	0.73*	0.22*	0.65*
P-Value	0.36	<0.01*	0.33	<0.01*	<0.01*	<0.01*	0.02*	<0.01*

W=Wilks Score, S=Squat, B=Bench, D=Deadlift, RPE = Rating of Perceived Exertion, RIRDIFF= Repetitions in Reserve Difference, *Significant Relationship. #Relationship Approached Significance. These correlations show the relationship between the repetitions performed across all four sets combined in an exercise with the combined RIRDIFF across all four sets.

Table 10: Relationships Between Total Reps and RIRDIFF

	TR S RPE 6	TR S RPE 9	TR B RPE 6	TR B RPE 9	TR D RPE 6	TR D RPE 9	TR All RPE 6	TR All RPE 9
R-value	0.34*	-0.05	0.56*	0.22	0.30#	-0.01	0.76*	0.15
P-Value	0.03*	0.76	<0.01*	0.23	0.08#	0.96	<0.01*	0.14

TR=Total Reps, S=Squat, B=Bench, D=Deadlift, RPE = Rating of Perceived Exertion, RIRDIFF= Repetitions in Reserve Difference, *Significant Relationship. #Relationship Approached Significance. These correlations show the relationship between the repetitions performed across all four sets combined in an exercise with the combined RIRDIFF across all four sets.

V. DISCUSSION

The aim of this study was to examine the accuracy of intra-set RIR-based RPE in the squat, bench press, and deadlift. Our first hypothesis was supported by our data showing that RIR was more accurately predicted the closer to failure. However, our second hypothesis that RIR predictions would improve in the latter sets was only partially supported. Specifically, squat and deadlift RIR predictions were more accurate during set four than set one, however, surprisingly bench press RIR predictions were more accurate during set one compared to set four. Finally, we hypothesized that RPE accuracy would be similar between lifts; however, this hypothesis was not supported as bench press was more accurate than both squat and deadlift at the called 6 RPE, while both bench press and deadlift RIR predictions were more accurate than squat predictions at the called 9RPE. Overall, our results suggest that RIR-based RPE ratings improve in accuracy as proximity to failure increases in the squat, bench press, and deadlift. Further, our study provides novelty by demonstrating for the first time the accuracy of RIR-based RPE in the deadlift (Table 4).

The present results confirm other recent findings (11,12,43) that RIR predictions are more accurate closer to failure as evidenced by the overall mean RIRDIFF (all lifts and sets averaged) being greater at the called 6 (0.96 ± 0.38) versus the called 9 RPE (0.58 ± 0.20). Importantly, even though our results support the improved accuracy closer to failure our results also show more accurate intra-set RIR predictions than both other similar studies (11) where there was an RIR of ±1 when subjects were 0-3 repetitions

from failure in the chest press and leg press, while Zourdos et al. 2018 (43) reported an RIRDIFF of 1.95 when subjects were asked to call an intra-set 9RPE in the squat at 70% of 1RM. When comparing the present squat data to 1.95 RIRDIFF from Zourdos et al. (43) we have reported an RIRDIFF of 0.71 ± 0.12 across all four sets at a called 9RPE and an RIRDIFF of 0.89 ± 0.60 and 0.60 ± 0.70 for the first and fourth sets, respectively. A likely explanation is that fewer repetitions in a set is related to more accurate RIR predictions (43) but they reported 14±4 repetitions in the set used for RIR predictions, while the present study had an average of 8±3 repetitions across all four squat sets.

Interestingly, in the squat and deadlift RIRDIFF was more accurate at set four vs. set one at both the called 6 and 9 RPEs. It is likely that RIR accuracy improved in set four vs set one because fewer repetitions were performed in set four. Repetitions decreased by 50% from 12± 2 to 6±2 from set one to four in the squat and from 11±4 to 6±2 in the deadlift. However, a small effect of 0.32 showed that bench press RIR predictions were more accurate in set one vs. set four. A potential explanation for this phenomenon is that subjects performed only 10±1 repetition on the first set of bench press compared to 12 and 11 repetitions on the first set of the squat and deadlift, thus with fewer repetitions performed per set the bench press lends itself to greater intra-set RIR accuracy even on the first set. It is also possible that since the bench press does not train as much total musculature as the squat and deadlift, lower repetition sets cease more abruptly, which led to inaccurate RPE calls on set four due to subjects believing they could do more repetitions than in actuality. In support, subject 6 had the most inaccurate RIR prediction on bench press set four with an RIRDIFF of 3 by calling a 6 RPE after rep four and then only completing one more repetition.

The accuracy in RIR varied between the types of exercises with greater accuracy found in the bench press compared with the squat (ES=0.44) and deadlift (ES=0.39) at a called 6 RPE and in the bench press vs. the squat (ES=1.38) and deadlift vs. the squat (ES=0.50) at the called 9 RPE. As previously stated more repetitions per set may negatively impacts intra-set RIR predictions across various RPEs (43), possibly due to a greater degree of both metabolic and neuromuscular fatigue in higher repetitions sets vs. lower repetition sets which may cloud the ability of an individual to assess RIR. In the present study, the average repetitions performed across all four sets 7±2 in the bench press, 8±3 in both the squat, and deadlift, thus the fewer repetitions performed in the bench press and lower variance (i.e. lower standard deviation) may explain the increased RPE accuracy. Even though bench press seems to be the most accurate of the three disciplines tested, squat and deadlift RIR were both predicted with precision. To date no study has examined the accuracy of intra-set RPE in the deadlift. We have observed accurate RIRDIFFs on the deadlift including 0.98 and 0.59 at the called 6 and 9 RPEs across all four sets on the deadlift. Further, the most accurate RPE call during any set for any exercise occurred on set four in the deadlift, which resulted in an RIRDIFF of 0.29±0.49. Thus, our data is the first to support the usage of RIR-based RPE to accurately gauge intra-set deadlift fatigue.

As anticipated, our data revealed greater training age to be associated with improved intra-set RIR prediction during some conditions (Table 7). This conclusion parallels Zourdos et al. (44) and Ormsbee et al. (27) who reported experienced lifters to record more accurate RPEs at a 1RM compared to novice lifters in the squat and bench press. However, in contradiction with Zourdos et al. (43) our data shows that the more

experience with using RIR-based RPE itself, were related to more accurate RPE ratings. Specifically, Zourdos et al. (43) did not show RPE experience to be related to rating accuracy during a 70% set to failure in the squat, while the present data observed greater RPE experience to be significantly related or approaching significance to lower RIRDIFF at all called 9RPEs (squat: r=-0.33; bench press: r=-0.42, deadlift: r=-0.33) and the called 6RPE in the bench press (r=-0.39) (Table 8). Importantly, the RIRDIFF was lower at the called 6RPE on the bench press was lower than both the squat and deadlift, which may account for the improved accuracy with more RPE experience. Further, the discrepancy between the present data and Zourdos et al. (43) may be due to the present study asking subjects if they "use RPE all the time", "frequently", "sometimes", "have used it a few times", or "never used it" as opposed to Zourdos et al. just asking how many years subjects used RPE; thus the assessment in the present study might have been more sensitive. We are also the first to observe that a greater Wilks score (greater relative strength) is related to more accurate RPE ratings (Table 9). It is likely that individuals with a higher Wilks score also have a higher training age, which explains these findings.

A limitation of this study is that it only examined trained males therefore we cannot be certain if females would have similar intra-set RPE accuracy. Additionally, it is possible that RIR accuracy was influenced by the verbal indication; in that subjects could have terminated the set in order to correspond with their own prediction. Finally, the present study only used the conventional deadlift, thus it is not known if RPE accuracy would be similar in the sumo deadlift, however, it is important to note that the current study is the first to analyze accuracy of the RIR-based RPE scale in any deadlift style.

In summary, the current data shows the most accurate RIR predictions to date in the literature. Across all sets, and in all three exercises, the RIRDIFF was low (i.e. ≤1) demonstrating precise RPE ratings. When taking into account multiple factors including: a high training status (6.4 years), a high intensity tested (80% of 1RM) leading to less reps in a set, subjects reporting that they used RPE frequently prior to the study, and a Wilks score >300, it is not surprising that the subjects provided accurate RIR predictions.

Practically, our results show that athletes can use RIR-based RPE to accurately assign load in a resistance training program. Using RPE in lieu of percentage of 1RM or RM zones allows for athletes to equate for between individual effort since it is well-known that the amount of repetitions at the same relative percentage of 1RM is highly variable (5)and due to energy levels fluctuating on a day-to-day basis. Indeed, Helms et al. (16) found a small advantage for squat and bench press strength over an eight-week training period in favor RIR-based RPE load assignment compared to percentage of 1RM load assignment. Our data suggest that the deadlift can effectively be programmed with RPE in a similar fashion to the squat and bench. It must be noted that RIR-based RPE may not be accurate for all individuals or all types of programming when training status, relative strength, and relative intensity are taken into account. However, in trained lifters at higher intensities (i.e. closer proximity to failure) the use of RIR-based RPE to facilitate acute loading changes or for long-term load prescription can be recommended for the squat, bench press, and deadlift.

APPENDICES

APPENDIX A: APPROVAL LETTER

FAU
FLORIDA ATLANTIC UNIVERSITY

Institutional Review Board
Division of Research
777 Glades Rd.
Boca Raton, FL 33431
Tel: 561.297.1383
fau.edu/research/researchint

Michael Whitehurst, Ed.D., Chair

DATE:	January 24, 2018
TO:	Michael Zourdos, Ph.D.
FROM:	Florida Atlantic University Health Sciences IRB
IRBNET ID #:	1162153-2
PROTOCOL TITLE:	[1162153-2] Time Course of Muscle Damage and Intra-Set Repetitions in Reserved Based Rate of Perceived Exertion Accuracy in the Squat, Bench Press, and Deadlift
PROJECT TYPE:	*New Project*
ACTION:	APPROVED
APPROVAL DATE:	January 24, 2018
EXPIRATION DATE:	January 24, 2019
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # *B4*

Thank you for your submission of Response/Follow-Up materials for this research study. The Florida Atlantic University Health Sciences IRB has APPROVED your *New Project*. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

- This study is approved for a maximum of ***40*** participants.
- It is important that you use the approved, stamped consent documents or procedures included with this letter.
    - Protocol (stamped)
    - Consent Form (stamped)
    - Medical History Form (stamped)
    - Physical Activity Questionnaire (stamped)
- ****Please note that any revision to previously approved materials or procedures, including modifications to numbers of subjects, must be approved by the IRB before it is initiated.** Please use the amendment form to request IRB approval of a proposed revision.
- All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All regulatory and sponsor reporting requirements should also be followed, if applicable.

the appropriate adverse event forms for this procedure. All regulatory and sponsor reporting requirements should also be followed, if applicable.

- Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.
- Please note that all research records must be retained for a minimum of three years.

- **This approval is valid for one year.** A Continuing Review form will be required prior to the expiration date if this project will continue beyond one year.

If you have any questions or comments about this correspondence, please contact Danae Montgomery at:

Institutional Review Board
Research Integrity/Division of Research
Florida Atlantic University
Boca Raton, FL 33431
Phone: 561.297.1383
researchintegrity@fau.edu

* Please include your protocol number and title in all correspondence with this office.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within our records.

APPENDIX B: INFORMED CONSENT

ADULT CONSENT FORM

Consent Form Version & Date: Version 2.0: January 23rd, 2018.

1) **Title of Research Study:** Time Course of Muscle Damage and Intra-Set Repetitions in Reserved Based Rate of Perceived Exertion Accuracy in the Squat, Bench Press, and Deadlift

2) **Investigator(s):** Michael C. Zourdos, Ph.D., CSCS, Daniel J. Belcher, B.A., CSCS, Colby A. Sousa, B.S., CSCS, Joseph P. Carzoli, B.S., CSCS.

3) **Purpose:** The purpose of this research study is to assess muscle damage and intra-set RPE accuracy in the squat, bench press and deadlift

4) **Procedures:** If you choose to participate in this study you will be required to complete the following assessments among 17 laboratory visits over 3.5 weeks:

- Refrain from all exercise for at least 48 hours prior to day one and will abstain from any additional exercise or excessive physical activity throughout the duration of the study
- Refrain from the use of any nutritional supplements, recovery modalities (foam rolling, massage, etc.), and any unnecessary over-the-counter medications throughout the duration of the study
- One repetition maximum (1RM) strength in the squat, bench press, and deadlift
- Four sets to volitional failure with 80% 1RM in the squat, bench press, and deadlift one time each on separate weeks
- Three sets of five repetitions with 70% 1RM in the squat, bench press, and deadlift on four separate occasions
- Two single repetitions with 70% 1RM in the squat, bench press, and deadlift six total times for each exercise over three weeks
- Body composition by skinfold caliper (chest, abdomen, thigh)
- Verbally call out at "6" when you believe you can only perform four more repetitions and a "9" when you believe you can only perform one more repetition during each of the four volitional sets to failure
- Joint range of motion assessments at the knee and elbow six times each week over three weeks
- Delayed onset muscle soreness assessments through mild palpations of the quadriceps, hamstrings, and chest via an algometer six times for each site over three separate weeks
- Measurements of both arm and leg swelling with a tape measurer six times for each site over three separate weeks
- Six blood collections each week consisting of two 10 ml samples (20 ml total) each draw for analyses of creatine kinase and lactate dehydrogenase from a prominent vein on the front area of the arm.
- Fast (no food or drink except for water) for at least two hours prior to all blood collections

All measurements will be conducted by the principal investigator or graduate assistants working within the Muscle Physiology Laboratory (i.e. the principal investigator will not always be present). For the first visit, you will be required to complete an informed consent form, training history questionnaire, and medical history form followed by anthropometric (height, body mass, upper arm length, forearm length, and total arm length) and body composition (skinfolds; chest, abdomen, thigh) measurements.

Participant Initials _____

Afterwards, you will complete a standardized five-minute dynamic warm-up routine designed to increase the body's core temperature and prepare the muscles for exercises that will be performed. Following the warm-up, you will complete a squat-specific warmup (20% projected 1RM x 5, 50% x 3, 60% x 1, 70% x 1, 80% x 1, % x 1). Next, one-repetition maximum (1RM) testing for the squat will begin. All 1RM tests will be administered with accordance to the National Strength and Conditioning Association (NSCA) guidelines, and all exercises will be performed to the rules set by the United States of America Powerlifting (USAPL). After determining the 1RM in the squat, a five-minute rest period will precede a bench-specific warmup (same protocol described for squat-specific warmup), followed by a 1RM test for the bench press. Upon determination of 1RM in the bench press, a five-minute rest period will precede a deadlift-specific warmup (same protocol described for squat-specific warmup), followed by a 1RM test for the deadlift. All 1RM attempts will be separated by 3- to 5-minute rest periods. Next, 48 hours following 1RM testing, you will perform a light training session for each lift (3 sets of 5 repetitions at 70% of 1RM). There will be five minutes of rest between sets during the light training session.

The following three weeks will be conducted in the following manner for each the squat, bench press, and deadlift being performed on separate weeks in a randomized order. On day one of week two (72 hours after the week one light training session) you will perform four sets to volitional failure at 80% of 1RM on one of the three exercises. Additionally, immediately prior to and following the four sets to failure, along with 24, 48, 72, and 96 hours later, indirect markers of muscle damage, and performance fatigue will be assessed.

These indirect markers of muscle damage will consist of the following: elbow and knee joint ROM, upper leg and upper arm swelling, quadriceps, hamstring, and chest delayed onset muscle soreness (DOMS), and blood will be collected for serum creatine kinase (CK) and lactate dehydrogenase (LDH). Following the exercise specific warm-up and prior to performance of the four failure sets, performance fatigue will be measured by changes in average concentric velocity during two, single repetitions with 70% of that week's tested exercise immediately prior to and after the damaging protocol and again at 24, 48, 72, and 96 hours post-training. For clarity, blood will be collected at each time point in which the indirect markers are assessed. A trained technician will perform all blood sampling by inserting a 21-gauge butterfly needle into a superficial vein of the upper arm. At each blood draw two tablespoons of blood will be collected into specific collection tubes for subsequent analysis. After blood samples are collected serum will be stored in a -80 degree Celsius freezer for further analysis. Further, you will be asked to fast for two hours prior to each blood draw. Specifically, this means you will not eat or drink anything for the two hours prior to a blood draw, except for water.

During each set to volitional failure, you will be asked to verbally provide the rating of perceived exertion (RPE) values of "6" and "9" when you feel they are occurring during the four sets to volitional failure and again following each lifting set during each session. Further, during each set of every session the Open Barbell System (Squats and Science, Brooklyn, NY) linear position transducer will record average concentric velocity, peak concentric velocity, peak concentric power, and average eccentric velocity.

Following the assessments of damage and fatigue markers at 96 hours post-training, you will then perform a light training session on the two exercises which were not used in that week's damaging bout to avoid detraining on those exercises. Then, you will have 72 of rest before returning to the laboratory for week three. Weeks three and four will serve exactly as week two except the damaging bout will be performed with a different exercise.

Participant Initials _____

For the squat, you will stand straight with your hips and knees locked, and the barbell placed across your upper back/shoulders. You will then descend with the bending of the knees until the top of your leg at the hip joint is below the top of your knee. Then you will return to your starting position upon your own volition.

For the bench press, you will lay chest up on a flat bench with a barbell in your closed hands. You will then descend with the bending of the elbows until the bar touches your chest in a controlled manner. Then you will return to your starting position upon your own volition. During the multiple repetition sets, you must refrain from bouncing the weight off of your chest at the bottom of each repetition.

For the deadlift, you will lift the barbell from the floor using a conventional deadlifting technique. You will lift the barbell in a vertical plane until your knees and hips are locked, and your shoulders are pulled back. You will then return the barbell to the floor in a controlled manner. During the multiple repetition sets, you must keep your hands gripped on the barbell at all times and the weight cannot bounce of off the floor between repetitions. A timeline of all procedures can be seen in Table 1 below.

Finally, participation in this study will in no way affect your grade in any course.

5) Risks:

Anytime you engage in exercise there are some inherent risks including: muscle strains, soreness, or joint aches. Since you will perform resistance exercise, the muscle soreness caused by muscle damage may be experienced for up to 96 hours.

If muscle soreness does occur, the investigators will assure that you can meet the movement standards before proceeding with data collection; however, risk of injury is always present during resistance exercise.

If an injury does occur you will notify the principal investigator if present, if not you will notify a graduate research assistant whom will immediately notify the principal investigator. The principal investigator will then stay in consistent contact with you in regards to your well-being. If serious injury or an emergency situation occurs during training, the investigators will immediately contact student health services if you are a student and if you are not a student the investigators will call your primary care physician or 911 if necessary.

Additionally, there are possible minor risks anytime there is a collection of blood or bodily fluids. These risks include: infections, fainting, inflammation near the skin, collection site soreness and bruising, and unintended needle sticks. To minimize the possibility of these events, all blood collections will be

performed by a trained phlebotomist. The collection site will be sterilized with an alcohol swab prior to collection and a new single use sterile needle and collection tube will be used for each collection and opened in front of you. Additionally, new sterile latex gloves will be used for each collection as well and applied in front of you. Any collection site soreness or bruising that may occur should subside within 48-72 hours.

Finally, there is a risk of breach of confidentiality, however, to minimize this risk a code number will be assigned to you and only Dr. Michael Zourdos, Ph.D., CSCS will keep a record with your name and code number, in a locked file drawer. The computer with the recorded data will be password protected so there will be no access to electronic data. All data (hard copy and computer) will be destroyed in 10 years.

Participant Initials _____

6) Benefits:

The potential benefits to you are:

- Free measurements of body composition and 1RM testing
- Access to calibrated training equipment that is approved by and used within the International Powerlifting Federation (IPF) competitive events

7) Compensation for Injury:

If you are injured or get sick as a result of the study procedures, you should obtain medical treatment and then notify the study Principal Investigator. Payment for this medical treatment is not available from the study researchers. You, or any available health insurance you have, will be billed for this treatment. Your health insurance company may not pay for treatment of injuries as a result of your participation in this study. Also, no funds are available to pay any wages you may lose if you are harmed by this study.

Further, if an injury or illness does occur in the laboratory during the study the investigators will cease study participation and contact student health services immediately.

8) Data Collection & Storage:

Potentially identifiable information about you will consist of a medical history questionnaire and research data sheets. Data are being collected only for research purposes. All personal identifying information will be kept in password-protected files and a code number will be used for identification purposes. Data records will be kept in a locked file cabinet in an office within the department of Exercise Science and Health Promotion. Although results of this research may be presented at meetings or in publications, identifiable personal information pertaining to participants will not be disclosed unless required by law.

9) Contact Information:

- If you have questions about the study, you should call or email the investigator(s), Michael C. Zourdos, at (561)-297-1317 or mzourdos@fau.edu.

- If you have questions or concerns about your rights as a research participant, contact the Florida Atlantic University Division of Research, Research Integrity Office at (561) 297-1383 or send an email to researchintegrity@fau.edu.

10) Consent Statement:

"I have read or had read to me the information describing this study. All my questions have been answered to my satisfaction. I am 18 years of age or older and freely consent to participate. I understand that I am free to withdraw from the study at any time without penalty. I have received a copy of this consent form.

Printed Name of Participant: _____

Signature of Participant: _____ Date: _____

Printed Name of Investigator: _____

Signature of Investigator: _____ Date: _____

Participant Initials _____

APPENDIX C: HEALTH HISTORY QUESTIONNAIRE

Florida Atlantic University

Medical History Form

Demographics:

Name: _____ Sport: _____ Pos.: _____

Date: _____ Age: _____ Birth Date: ____/____/____

Family History:

Has anyone in your immediate family had any of the following: Please circle yes or no.

Heart Disease	Yes	No	Diabetes	Yes	No
High Blood Pressure	Yes	No	Cancer	Yes	No
Stroke	Yes	No	Tuberculosis	Yes	No
Sudden Death (before 50)	Yes	No	Asthma	Yes	No
Epilepsy	Yes	No	Gout	Yes	No
Migraine Headaches	Yes	No	Marfan's Syndrome	Yes	No
Eating Disorder	Yes	No	Sickle Cell	Yes	No

Personal History:

1. Have you ever been hospitalized? Yes No
   Have you ever had surgery? Yes No
   Are you presently under a doctor's care? Yes No
   Please explain and give dates for all "Yes" answers: _____
   _____
   _____

2. Please list any medications you are currently taking and for what conditions. _____
   _____

3. Please list any known allergies. _____
   _____

4. Have you ever had a head injury / concussion? Yes No
   Have you ever been knocked out or unconscious? Yes No
   Have you ever had a seizure, "fit", or epilepsy? Yes No
   Have you ever had a stinger, burner, or pinched nerve? Yes No
   Do you have recurring headaches or migraines? Yes No
   Pleas explain and give dates of "Yes" answers: _____
   _____
   _____
   _____

5. Have you ever had the chicken pox? Yes No
   If yes, at what age? _____

6. Have you ever had the mumps or measles? Yes No

7. Do you have a history of asthma? Yes No

8. Are you missing an eye, kidney, lung, or testicle? Yes No

9. Do you have any problems with your eyes or vision? Yes No

10. Have you ever had any other medical problems (mononucleosis, diabetes, anemia)? Yes No

11. Have you ever taken any supplements for improved performance? Yes No

12. Are you presently taking any supplements for diet or performance? (creatine, protein, etc.)? Yes No
    If Yes then what substance? _____

1

13.What is the lowest weight you have been at in the last year _____,
highest _____? What is your ideal weight _____?

14. Do you have any trouble breathing or do you cough during or after practice? Yes No

15. Have you ever had heat cramps, heat illness, or muscle cramps? Yes No

16. Do you have any skin problems (itching, rashes, acne)? Yes No

Explain all "Yes" answers for questions 5 – 16: _____
_____
_____
_____
_____
_____

17. Have you ever passed out during or after exercise? Yes No
Have you ever been dizzy during or after exercise? Yes No
Have you ever had chest pain during or after exercise? Yes No
Have you ever had high blood pressure? Yes No
Have you ever been told you have a heart murmur? Yes No
Have you ever had racing of you heart or a skipped heart beat? Yes No
Has anyone in your family died of heart problems or a sudden death before the age of 50? Yes No
Have you ever had high cholesterol Yes No
Have you ever had an EKG or echocardiogram? Yes No

Explain all "Yes" answers for question 17: _____
_____
_____
_____
_____

18. Have you ever sprained / strained, dislocated, fractured, or had repeated swelling or other injury of any bones or joints? Explain any "Yes" answers.

Head/Neck	Yes	No	_____
Shoulder	Yes	No	_____
Elbow & arm	Yes	No	_____
Wrist, hand & fingers	Yes	No	_____
Back	Yes	No	_____
Hip / Thigh	Yes	No	_____
Knee	Yes	No	_____
Shin/Calf	Yes	No	_____
Ankle, foot, toes	Yes	No	_____

19. What is the average number of hours you sleep per night? _____

20. What time do you usually go to sleep at night? And, what time do you usually wake-up in the morning? _____

21. What time did you go to sleep last night and what time did you wake up this morning? _____

Would you like to speak further to the principal investigator regarding any topics or concerns? (i.e., nutrition, supplements, drugs, heart problems, weight loss/gain, sexual diseases, concussions, etc.,)? Yes No
If yes then what topic? _____

Please sign:
I hereby state that, to the best of my knowledge, my answers to the above questions are correct.

_____
Athlete's Signature Date Signed

1

APPENDIX D: PHYSICAL ACTIVITY QUESTIONNAIRE

Appendix A: Physical Activity Questionnaire

Think about all the exercise training in which you engage. Use that information to appropriately answer the following questions.

1. Have you competed before in strength competitions? If so, how often?

Yes or No If so, _____ times/year

   a. If yes to #1: How long have you been training for strength competitions?

   _____ years.

   b. If yes to #1: When you compete, which sport do you compete in (Powerlifting, Strongman, or Bodybuilding)?

   Event:_____

2. Are you currently engaged in a structured resistance-training program? If so, how long?

   Yes or No If so, _____ years

3. How many hours of resistance training do you perform on average each week?

_____ hours/week

4. How many times do you resistance train per week? Please indicate if you do more than once a day.

_____ days/week Average_____ times/day

5. How many times per week do you perform the following exercises?

   a. Barbell back squat: _____ times/week

   b. Barbell bench press: _____ times/week

6. How many years of experience do you have with following exercises? What is your estimated 1RM?

   a. Barbell back squat: _____ years; 1RM_____pounds

   b. Barbell bench press: _____ years; 1RM_____pounds

1. Please describe your average resistance training intensity based on your self-estimated maximum load.

_____ % your maximum

2. Do you incorporate any aerobic training? If so, how many times per week?

Yes or No If so, _____ times/week

3. Please describe your average aerobic training intensity on a scale below (as close as possible):

1 2 3 4 5 6 7 8 9 10

Very Light Light Moderate Intense Very Intense

4. Please best describe your occupation or daily activities other than your exercise training.

11. Do you have any coaching by a certified professional in general resistance training?

APPENDIX E: THE DAILY ANALYSIS OF LIFE DEMANDS FOR ATHLETES

OA/UNE Human Performance Lab

DALDA Questionnaire
Monitors state of well being and mood state

(a = worse than normal, b = normal, c = better than normal)

Part A

1.	a	b	c	Diet
2.	a	b	c	Home Life
3.	a	b	c	School/college/work
4.	a	b	c	Friends
5.	a	b	c	Sports Training
6.	a	b	c	Climate
7.	a	b	c	Sleep
8.	a	b	c	Recreation
9.	a	b	c	Health

Part B

1.	a	b	c	Muscle Pains
2.	a	b	c	Techniques
3.	a	b	c	Tiredness
4.	a	b	c	Need for rest
5.	a	b	c	Supplementary Work
6.	a	b	c	Boredom
7.	a	b	c	Recovery Time
8.	a	b	c	Irritability
9.	a	b	c	Weight
10.	a	b	c	Throat
11.	a	b	c	Internal
12.	a	b	c	Unexplained aches
13.	a	b	c	Technique Strength
14.	a	b	c	Enough Sleep
15.	a	b	c	Between Session Recovery
16.	a	b	c	General Weakness
17.	a	b	c	Interest
18.	a	b	c	Arguments
19.	a	b	c	Skin Rashes
20.	a	b	c	Congestion
21.	a	b	c	Training Effort
22.	a	b	c	Temper
23.	a	b	c	Swelling
24.	a	b	c	Likability
25.	a	b	c	Runny Nose

Number of "a" Scores: _____

Increase in "a" scores suggests
overreaching or overtraining.

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