12-1-2013

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Citation Information

Bazyler, Caleb D.; Sato, Kimitake; Wassinger, Craig A.; Lamont, Hugh S.; and Stone, Michael H.. 2013. The Efficacy of Partial Squats on Measures of Strength and Explosiveness: An Exploratory Study. *Proceedings of the Coaching and Sport Science College*, Johnson City, TN. https://docs.google.com/uc?export=download&id=0B4OghIA6MdpMdkhiT0hPZUpMRms

The Efficacy of Partial Squats on Measures of Strength and Explosiveness: An Exploratory Study

THE EFFICACY OF PARTIAL SQUATS ON MEASURES OF STRENGTH AND EXPLOSIVENESS: AN EXPLORATORY STUDY

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INTRODUCTION: Partial-lifts are often incorporated into strength and conditioning programs (Clark et al. 2011, Harris et al. 2000). The proposed benefits of partial lifts include improved strength at the terminal range of motion (ROM) and weak portions of a movement, a substitute for full ROM exercise during rehabilitation, injury prevention, enhanced metabolic adaptations, increased training volume, training variation, and enhanced sport performance (Clark et al. 2011, Massey et al. 2004). Only a few studies directly examine the efficacy of partial lifts in improving maximal strength, and the findings are conflicting (Massey et al. 2004, Pinto et al. 2012). Additionally, some studies used untrained subjects while evidence indicates that partial-lifts, if effective, would benefit lifters with previous training experience (Clark et al. 2011, Massey et al. 2004). Observations by the authors indicate that many strength-power athletes, including weightlifters and powerlifters, integrate partial movements into their training. The purpose of this study was to examine the effects of two different training modalities, full ROM training (F) and full ROM plus partial ROM training (FP). Our hypotheses were: (1) both groups would improve from pre to post-intervention on all dynamic and isometric variables measured; (2) FP would improve to a greater extent than F at measurements associated with maximum effort at the terminal ROM (1-RM partial-squat, 120° isometric squat peak force, RFD and impulse scaled).

METHODS: Subjects recruited were 18 recreationally trained college-aged males with at least one year of resistance training experience on the squat (≥1.3 * body mass). Pre-intervention squat 1-RM was similar to previous studies: 146.8 ± 23.0 kg (Harris et al. 2000). Nine subjects in the F group (age 20.8 ± 2.0 years, height 176.4 ± 6.3 cm, body mass (BM) 84.9 ± 10.9 kg) and nine subjects in the FP group (age 20.7 ± 1.9 years, height 177.6 ± 8.1 cm, BM 86.1 ± 8.9 kg) completed the study. Prior to participating, all subjects completed a health history questionnaire and signed an informed consent (East Tennessee State University's Institutional Review Board). Subjects were matched according to absolute and relative 1-RM squat from pre-intervention testing and assigned to a group. One group performed full ROM squats, whereas the other performed full and partial ROM squats at 100° knee angle (Table 1). Prior to the intervention, subjects were familiarized with partial-squats and isometric squats to minimize learning effects and to record bar heights and knee angles for subsequent testing and training. Subjects were required to complete >80% of the programmed volume load to be included in the data analysis.

Dynamic warm-up followed anthropometric measurements. The 1-RM squat was tested first followed by 1-RM partial-squat at 100° knee angle (measured in the sagittal plane using the greater trochanter, the lateral condyle of the femur, the head of the fibula, and the lateral malleolus as bony landmarks). Back squat depth was determined as the top of the leg at the hip joint being below the knee. The bar was set on safety pins at a height corresponding to 100° of knee flexion for partial squats as determined during the familiarization sessions. Subjects performed the concentric portion of the squat to lockout then lowered the bar back down to the safety pins.

Kinetic variables were measured on 0.45 m x 0.91 m dual force platforms affixed side by side (Rice Lake, WI) sampling at 1,000 Hz. Testing was performed at 90° and 120° with the bar placed across the back in the same position used in training. Following warm-up, the tester instructed subjects to push as fast and as hard as possible for at least two maximal attempts. Subjects were tested at the same time of the day for both test days. The force-time curve data were smoothed using an 11-point moving average (all data points equally weighted) and analyzed with Labview software (ver. 2010, National Instruments, Austin, TX, USA). A 2x2 (group by time) repeated measures ANOVA, paired sample t-test and one-way ANOVA were run to determine within and between group differences for all dependent variables. Due to the paucity of research on partial ROM training the present study was exploratory and a Bonferonni adjustment was not used to decrease the possibility of committing a type II error (Huberty & Morris, 1989). SPSS software version 20 was used to perform all statistical analyses (IBM Co., NY, USA).

Table 1: Strength Training Program

Phase	Week	Day 1	%1-RM	Day 2	% Reduction
Strength-Endurance and Familiarization	1	4 x 8	75-80%	3 x 8	10-15%
	2	4 x 8	77.5-82.5%	3 x 8	10-15%
	3	4 x 8	80-85%	3 x 8	10-15%
Pre-Testing	4	Dynamic		Isometric	
Strength Phase 1	5	3x5 or 6x5*	85-87%	3x5 or 6x5	10-15%
	6	3x5 or 6x5	86-88%	3x5 or 6x5	10-15%
	7	3x5 or 6x5	87-89%	3x5 or 6x5	15-20%
De-Load	8	3x3 or 6x3	75%	3x3 or 6x3	15-20%
Strength Phase 2	9	3x3 or 7x3**	88-90%	3x3 or 7x3	10-15%
	10	3x3 or 7x3	89-91%	3x3 or 7x3	10-15%
	11	3x3 or 7x3	90-92%	3x3 or 6x3	15-20%
Post-Testing	12	Dynamic		Isometric	

* F performed 6 x 5 on squats, FP performed 3 x 5 on squats and partial squats
** F performed 6-7 x 3 on squats, FP performed 3 x 3 on squats and partial squats

RESULTS: The repeated measures ANOVA revealed a statistical time effect; $F(1,15)=72.28$, $p<0.001$, partial $eta^2=0.82$ for 1-RM squat. 1-RM squat in F increased by 5.1% ± 4.5%, and in FP by 8.2% ± 2.1%. No group by time interaction was found for 1-RM partial-squat. A statistically significant time effect was found for 1-RM partial-squat; $F(1,15)=19.68$, $p<0.001$, partial $eta^2=0.59$. The 1-RM partial-squat in F increased by 10.2% ± 11.7%, and in FP by 14.9% ± 11.8% (Table 2).

Test-retest reliability using ICC for IPFa 90° and 120 ° was 0.97 and 0.98, respectively. A statistically significant time effect was found for IPFa 90° and IPFa 120° ($p<0.05$). Paired t-test results indicated that IPFa at 90° increased by 5.3% ± 4.5%, in the F group, and IPFa at 120° increased by 8.1% ± 8.4%, in the FP group (Table 2).

Test-retest reliability was determined to be ICC >0.92 for all impulse scaled time points measured. A statistically significant time effect was found for impulse scaled at all time points for both knee angles ($p<0.05$) except for 50 ms at 120°; $F(1,16)=4.27$, $p=0.06$, partial $eta^2=0.211$. Paired t-tests showed a statistically significant increase from pre-training in FP for all time points with 90° and 120° ($p<0.05$), but for F only at 250 ms with 120°, $p=0.049$, $eta^2=0.033$ (Figures 1 and 2).

Test-retest reliability for all RFD time points at 90° showed an ICC ranging from 0.74 - 0.9 and 200, 250 ms at 120° ranging from 0.76 - 0.94. RFD at 50 and 90 ms with 120° were excluded due to low test-retest reliability (ICC<0.7). There were no changes found for RFD at any time points measured in either group. A statistically significant group by time interaction was found for RFD at 200 ms with 120° of knee flexion; $F(1,16)=5.15$, $p=0.037$, partial $eta^2=0.24$. RFD at 200 ms with 120° in F increased by 17.9% ± 44%, $eta^2=0.030$ and decreased in FP by 4.6% ± 13%, $eta^2=0.007$; however, these changes were not statistically significant following post-intervention testing ($p>0.05$).

Table 2: 1-RM and IPFa Results

Variable	Group	Mean ± *SD* Pretest	Posttest	95% CI Pre	95% CI Post	p value	Eta^2
1-RM Squat (kg)	F	148.93 ± 23.71	156.58 ± 23.86	130.71-167.15	138.24-174.92	0.01	0.052
	FP	144.58 ± 22.28	156.49 ± 21.89	128.42-175.99	140.91-186.18	<0.001	0.071
1-RM Partial Squat (kg)	F	207.90 ± 30.76	229.16 ± 48.79	184.25-231.54	191.65-266.67	0.045	0.034
	FP	207.80 ± 32.69	238.74 ± 36.88	180.56-265.98	208.80-301.80	0.004	0.053
IPFa 90° (N/kg^2/3)	F	107.51 ± 6.96	113.16 ± 8.51	102.16-112.87	106.61-119.70	0.008	0.05
	FP	114.85 ± 13.60	116.32 ± 12.81	104.41-125.32	106.48-126.16	0.474	0.005
IPFa 120° (N/kg^2/3)	F	197.72 ± 38.24	201.45 ± 39.47	167.32-226.10	171.14-231.80	0.32	0.009
	FP	210.74 ± 35.13	227.74 ± 31.66	183.73-237.74	203.40-252.07	0.02	0.042

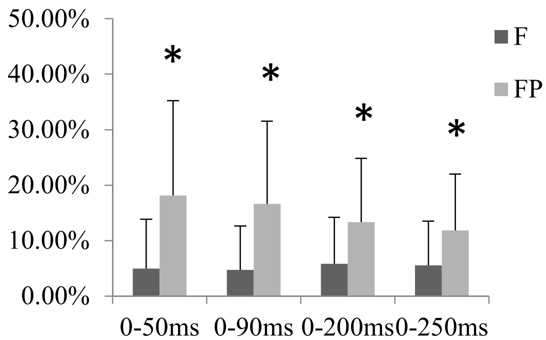

*Figure 1: Percent changes in impulse scaled at 90°. *p<.05, statistical change from pretest.*

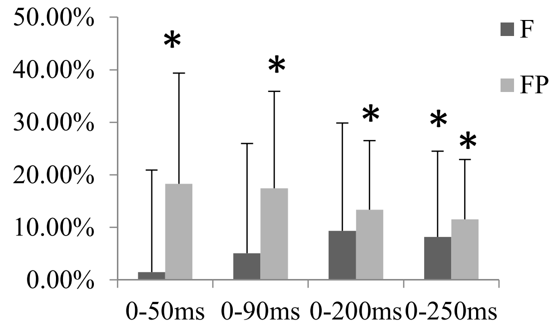

*Figure 2: Percent changes in impulse scaled at 120°. *p<.05, statistical change from pretest.*

DISCUSSION: These findings demonstrate that partial plus full ROM training can be an effective training modality for improving maximal strength. However, further research is needed to ascertain whether combined training is more effective than full ROM training alone. Although the subjects in the present study were not athletes, their strength level was comparable to previous research with athletes (Clark et al. 2011, Harris et al. 2000). Findings of the present study suggest that combined training may be more effective than full ROM training alone for improving early force-time curve characteristics. The larger effect sizes for IPFa 120° and impulse scaled with 120° in the FP group have implications for strength-power athletes. For example, the contact time for an elite sprinter is ~90 ms, the percent change for impulse scaled at 90 ms at a 120° knee angle was 17.4% vs. 5.1% in FP and F, respectively. For an elite sprinter, producing larger forces in that narrow time window may be the difference in winning versus losing.

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