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ASSESSMENT OF DIFFERENT POWER PARAMETERS ON SQUAT AND LEG PRESS: CONSIDERATIONS FOR POWER DEVELOPMENT

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The purpose of this study was to investigate different power parameters in Squat and Leg press exercises, considering joint angle. Trained male subjects (n=8) were submitted to a load progression. The force, knee amplitude, and velocities were collected using a force plate, an electrogoniometer and a linear velocity transducer. The results pointed out that: i) the optimum angle for peak power depends on exercise intensity (%RM), and that relationship is more evident in the Squat exercise; ii) mean propulsive power was the best power parameter predictor for both exercises concerning the relative load that maximized mechanical power output; iii) light loads are ideal to produce high peak power values at knee angles near 90º for Squat and Leg Press; iv) heavy loads are ideal to produce high PP values at knee angles near 170º for Squat and Leg Press.

KEY WORDS: Power, Optimum angle, resistance training.

INTRODUCTION: Muscular power output is considered fundamental to successful performance in many athletic and sporting activities. Consequently, a great amount of research has investigated methods to improve power output and its transference to athletic performance (Cronin & Sleivert, 2005).
Currently, isometric, isoinertial and isokinetic regimen are employed in power assessment. Each form has its supporters and detractors. However, it is recognized that isokinetic and isometric assessment have little resemblance to isoinertial resistance training and sporting performance characteristics (Cronin & Sleivert, 2005). It is also widely known that most people who train to increase power, have limited or no access to dynamometry (particulary isokinetic equipment). This adds importance to the findings of isoinertial research, as a reliable reference to practitioners, coaches and scientists.
During power assessment different parameters have been used, the most common being the peak power (PP), mean power (MP) and mean propulsive power (MPP). These parameters can be used to determine a central variable considered important to power (P) and performance in explosive tasks, that variable is the training load that maximizes the mechanical power output (Pmax) of muscle (Baker, Nance, & Moore, 2001; Cronin & Sleivert, 2005; Sanchez-Medina, Perez, & Gonzalez-Badillo, 2010). For bench press exercise Pmax is dependent on the exact P parameter used in its determination (Sanchez-Medina, Perez, & Gonzalez-Badillo, 2010). This means that it can vary if one uses PP, MPP or MP. Therefore it is essential to understand the implications of the use of each P parameter for P assessment and development. Another aspect often ignored in literature for measuring muscle power, is the joint angle at which it occurs. The purpose of this study was to investigate different P parameters in Squat (S) and Legpress (LP) exercises, considering joint angle.

METHODS: Eight strength trained males (age: 20.6±3.2 years old; height 1.78±0.08m; body mass: 74.8±14.9kg) took part on this study. The force developed, knee joint angle, and velocities were collected using a force plate (Bertec 4060-15), an electrogoniometer (Penny+Gilles) and a linear velocity transducer (T-Force Dynamic Measurement System), synchronized and sampled at 1000Hz (MP100 data acquisition system). Informed consent was obtained from the subjects according with the ethical committee of the Faculty of Sport

of the University of Porto. The S exercise was executed in a Multipower smith machine (Multipower Fitness Line) and the LP in a standard 45º LP machine.
All subjects underwent a load progression in each exercise (≈20%RM – 100%RM), carrying out a minimum of 6 loads. Between each load a recovery of 3 to 5min was established. For standardization purposes, the eccentric phase of the movement was controlled by the instructor. When the bar reached a pre-established point (knee joint≈90º), the subjects were instructed to lift the load at maximum possible velocity. Only the repetitions that did not varied more than 5º, were selected for analysis. After each repetition subjects were informed about velocity and P developed. The S and LP tests were carried out in 2 different sessions, separated by more than 96h planned in a randomized manner.
Standard statistical methods were used for the calculation of means, standard deviations (SD). Relationship between exercise intensity (%RM) and power parameters outputs was studied by fitting second-order polynomials to data. Relationship between knee angle and %RM at which PP occurred was studied by linear regressions.

RESULTS AND DISCUSSION: The mean knee angle at which PP occurred for the LP and S varied between 131.7±4.0º to 154.2±8.5º, and 74.6±16.1º to 128.0±8.3º respectively (Table 1). Hence, PP occurs at higher knee angles in the LP compared to S. Figure 1 shows the regression between the knee angle at which PP occurred and %RM in LP (R^2=0,27) and in the S (R^2=0,59). Meaning that PP is attained at different knee angles depending on the %RM used. Therefore, the optimum angle for PP depends on %RM used, and that relationship is more evident in the S exercise.

Table 1
Joint angles at which PP occurred for each subject

	LP		S	
	Minimum knee angle (º) at PP	Maximum knee angle (º) at PP	Minimum knee angle (º) at PP	Maximum knee angle (º) at PP
Subject 01	129,3	147,8	57,6	117,0
Subject 02	127,7	152,8	110,9	133,6
Subject 03	138,4	155,4	76,5	142,5
Subject 04	126,1	138,5	69,1	124,9
Subject 05	131,8	159,6	70,3	128,8
Subject 06	135,2	167,5	63,9	129,6
Subject 07	131,7	156,9	78,5	118,1
Subject 08	133,1	154,9	70,1	129,6
Mean	131,7	154,2	74,6	128,0
Sd	4,0	8,5	16,1	8,3

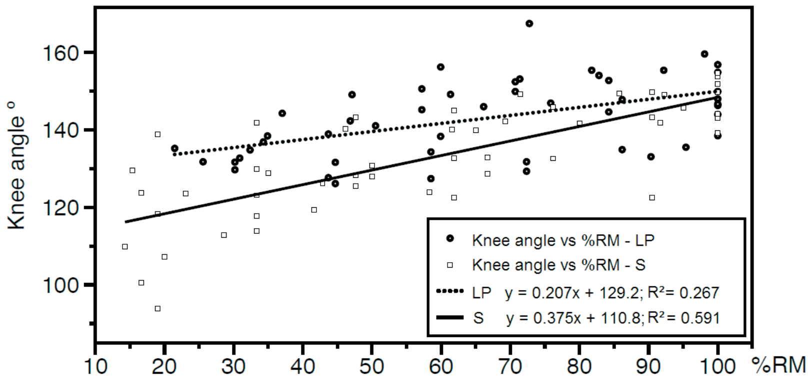

Figure 1: Relationship between knee angle at PP and %RM for LP and S.

In both exercises, the Pmax obtained was different for each parameter used. In the LP the values were: PP – 45,65% RM, MPP – 42,34%, MP - RM 59,11%; and for S: PP – 52,44% RM; MPP – 27,76% MR and MP - RM 42,36% (Figure 2). This clearly suggest that Pmax was dependent on the parameter used in both exercises, as has been demonstrated in literature (Sanchez-Medina, Perez, & Gonzalez-Badillo, 2010) for the bench press.

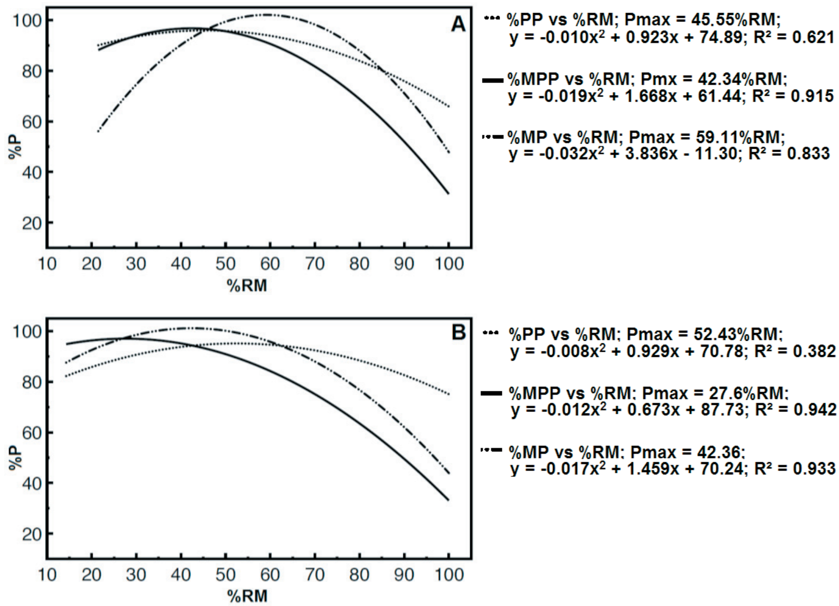

Figure 2: Relationship between P outputs (%PP, %MPP, %MP) and %RM. A – LP; B – S.

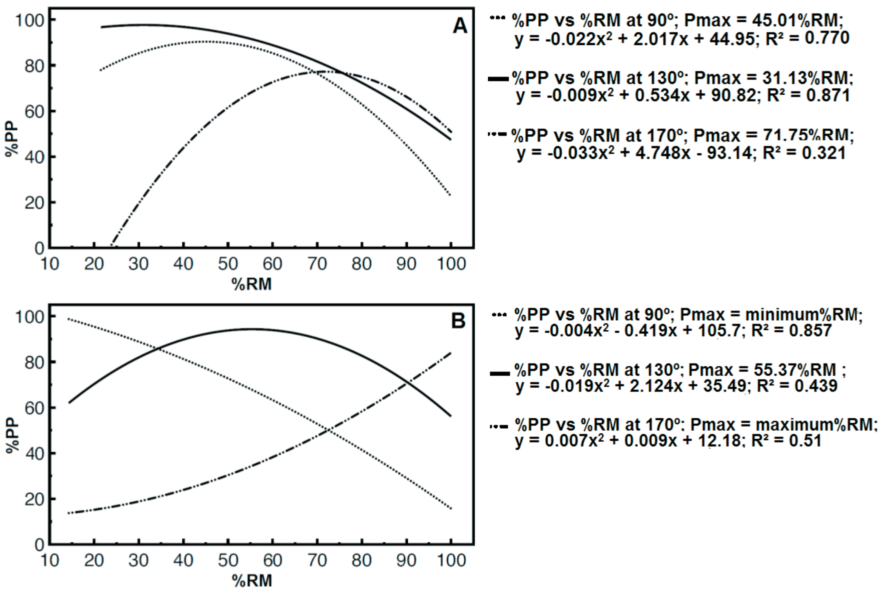

Figure 3: Relationship between %PP occured at different knee angles and %RM. A – LP; B – S.

The correlation between %MPP and %RM can be seen in Figure 2. The best associations between P and %RM, where obtained through MPP for LP (R^2=0,92) and for S (R^2=0,94) respectively. These results suggest MPP as the best P parameter predictor for both exercises relative to Pmax.
However, PP is the only parameter that allows one to determine at which angle PP occurs. No other P parameter can be used to study the relationship between P and %RM for each knee joint angle, as can be seen in Figure 3.
The same Figure shows that for a 90º knee angle, the highest values of PP are attained with light loads in S (<30%RM) and with moderate to light loads in the LP (<60%RM). However, at a 170º knee angle, PP occurs with higher %RM in S (>80%RM) and LP (60-90%RM). These findings suggests that light loads (<30%RM) are ideal to produce high PP values at angles near 90º for the S, and for LP with loads inferior to 60%RM.
To produce high PP values at angles near 170º, heavier loads are ideal for S (>80%RM) and LP (>65-90%RM). To the best of our knowledge the literature disregard the angle at which PP occurs. However we believe that the knowledge of this information seems to be important, since it allows to adjust the training intensity to specific requirements of an athlete, regarding the joint angle at which PP should occur. Also, it brings a contribution to understand possible training effects, resulting from the use of light loads versus high loads.

CONCLUSION: The main conclusions of this study were: i) PP occurs at higher knee angles in the LP compared to S; ii) the optimum angle for PP depends on %RM used, and that relationship is more evident in the S exercise; iii) Pmax was dependent on the parameter used in both exercises; iv) MPP was the best P parameter predictor for both exercises relatively to Pmax; v) PP is the only parameter that allows studying the influence of joint angles in the relationship between Power and %RM; vi) light loads are ideal to produce high PP values at knee angles near 90º for S and LP; vii) heavy loads are ideal to produce high PP values at knee angles near 170º for S and LP. The results highlight the importance of studying the joint angle at which P is attained, to better understand the relationship between P and %RM.

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