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A Comparative Electromyographical Investigation of L1 and L5 paraspinal muscles during two variations of back and front Squats

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Abstract
This study aimed at muscles activation analysis of lower back (erector spinae) L1 Paraspinal and L5 Paraspinal muscles while performing two types of squats, i.e. front (full & half) and back (full & half) squats. Ten male weight lifters (21.6 ± 2.22 years) performed 1 repetition of four different squats. The maximum voluntary contraction (MVC) was recorded with the help of biograph infinity software (EMG). Surface ElectroMyoGraphy (SEMG) was used for measuring muscle electrical activity that occurs during muscle contraction. The four different squats were back full squat (BFS), back half squat (BHS), front full squat (FFS) and front half squat (FHS). The results of the study reveal that no statistical differences were found in comparing the two types of squats (Back and Front). It means both the squats have similar pattern of muscle activation in lower back (erector spinae) with same load.

Keywords: Electromyography, Muscle activation, Erector Spinae, Front and Back Squat

1. Introduction
The squat has been the most important yet most poorly understood exercise in the training arsenal for a very long time. The full range of motion exercise known as the squat is the single most useful exercise in the weight room, and our most valuable tool for building strength, power, and size. The squat is so effective an exercise because of the way it uses the muscles around the core of the body. Much is made of core strength, and fortunes have been made selling new ways to train the core muscles. A correct squat perfectly balances all the forces around the knees and the hips, using these muscles in exactly the way the skeletal biomechanics are designed for them to be used, over their anatomically full range of motion. The postural muscles of the lower back, the upper back, the abdominals and lateral trunk muscles, the costal (ribcage) muscles, and even the shoulders and arms are used isometrically. Their static contraction supports the trunk and transfers kinetic power from the prime movers to the bar. The trunk muscles function as the transmission while the hips and legs are the engine [7].

The back and front squat are popular exercises prescribed to strengthen the lower-limb musculature [2]. Research to date has focused largely on parameters of back squat performance, [4] with little attention given to its front variation [3].Traditionally, the terms "squat" and "back squat" have been used synonymously. However, "squat" can apply to a number of lower-body exercises such as body-weight squats, front squats, and split squats, just to name a few. Each of these variations has different effects on the joints and muscles in the legs [10]. This is exemplified by the popularity of the back squat as a way of loading the lower extremities in flexion/extension patterns, common to many sporting actions [6]. In addition, the back squat places a demand on the torso musculature and, in particular, the erector spinae to maintain a neutral spine [8].

The purpose of the squat is to train the muscles around the knees and hip joints, as well as to develop strength in the lower back, for execution of basic skills required in many sporting events and activities of daily living. Athletes and persons concerned with fitness regularly perform the back squat; the front squat is performed much less often. Although both squats effectively work the lower back, hip, and leg muscles, there are slight variations in technique and muscular involvement. In addition, the maximum amount of weight an individual can lift varies between the two techniques, with increased capacity possible for the back squat [5].

The aim of this study was to analysis the muscle activity of lower back (erector spinae) L1 Paraspinal and L5 Paraspinal muscles while performing two types of squats, i.e. front (full & half) and back (full & half) squats.

2. Materials and Methods
2.1 Subjects
Ten weight lifters from weightlifting match practice group (Lakshmibai National Institute of Physical Education, Gwalior, M.P) who were experienced at performing front and back squats, averaging 21.6 ± 2.22 years of age, were recruited as a sample to be included in the study. More specifically, each participant met our stringent requirement of at least 1 year of experience in both lifts used a minimum of two time per week each in their regular weight training programs. The average height and mass of the subjects were 169.6 ± 4.83 cm and 72.6 ± 3.92kg, respectively. Purposive sampling technique was used for the selection of the subjects. All subjects were free from injuries that would have limited their ability to perform the squatting techniques described below. Each participant provided informed consent prior to participation in any testing procedures.

2.2 Experimental Approach to the Problem
To compare the EMG response between front and back squats, subjects performed 1 repetition of front (full & half) and back (full & half) squats, with surface electrodes positioned over the 2 muscle (L1 Paraspinal and L5 Paraspinal). A familiarization session was carried out 1 week before testing for knowing 1 RM of the participants. The four different squats were back full squat (BFS), back half squat (BHS), front full squat (FFS) and front half squat (FHS). The subjects were asked to warm up (jogging) for 3-5 minutes at the beginning of the session. Their one-repetition maximum (1RM) was determined by having the participants lift approximately four to five short sets of both front (full & half) and back (full & half) squats (order chosen randomly) at increasing loads until reaching their maximum load. They were allowed to rest for 5 minutes between sets, or until they felt sufficiently rested, and then they were asked to repeat the above steps for determining 1RM, this time performing the other squat variation. Each squat protocol consisted of performing one repetition with a load equivalent to 70% of 1-RM. This load was fixed for all the front (full & half) and back (full & half) squats. It is done to see the muscles activation difference in front and back squat with the same load (70% of 1-RM). Surface ElectroMyoGraphy (SEMG) is a non-invasive technique for measuring muscle electrical activity that occurs during muscle contraction and relaxation cycles. The SEMG signal generated by the muscle fibers is captured by the electrodes, then amplified and filtered by the sensor before being converted to a digital signal by the encoder. It is then sent to the computer to be processed, displayed and recorded by the Infiniti software. The MyoScan-Pro sensor's active range is from 20 to 500 Hz. It can record SEMG signals of up to 1600 microvolts (μV), RMS. A/D Converter (Encoder; ProComp Infiniti) has 2 channels (C and D) sampling at 256 samples per second.

2.3 Data collection
The participants performed 1 repetition of each squats one by one. Sufficient recovery time was provided to the participants after completing each exercise.
On the testing day, maximum muscle activation was recorded with the help of Biograph infinity version 5.0 (Electromyography Software). After shaving and applying the abrasive cream to the electrodes, the EMG electrodes were placed parallel to the muscle fiber on two locations (i.e. channel C for L5 Paraspinal and channel D for L1 Paraspinal). Raw EMG signals were recorded using a 15 foot optic fiber wire that is directly connected to A/C encoder. A 20 mega pixels extended video camera was synchronized with the EMG software (Biograph infinity version 5.0), to find out the maximum voluntary contractions (MVCs) of the selected muscles at the time of performing the exercises. Myoscan-pro sensor with triode electrode was used.

2.4 Statistics
The descriptive statistics (mean, standard deviation, skewness, kurtosis etc.) and Shapiro-Wilk's test was used for testing the assumption of normality and to know the nature of data. All data are presented as mean with standard deviations. Paired t - test was used to detect mean differences between squat. For this purpose Statistical Package for Social Science (SPSS) version 20.0 was used. The level of significance was set at 0.05.

3. Results and discussion
As a guideline, a skewness value more than twice its standard error indicates a departure from symmetry. Since none of the variables skewness is greater than twice its standard error, hence all the variables are symmetrically distributed. Similarly, the value of kurtosis for the data to be normal of any of the variable is not more than twice its standard error of kurtosis hence none of the kurtosis values are significant. In other words the distribution of all the variables is meso-kurtic.
Further for testing the normality Shapiro - Wilks test was used. It compares the scores in the sample to a normally distributed set of scores with the same mean and standard deviation. If the test is non-significant (p>.05) it tells that the distribution of the sample is not significantly different from a normal distribution (i.e. it is probably normal) and vice - versa. Here from table - 1 we can see that none of the variables p - value is less than.05, hence the data is normally distributed.

Table 1: Descriptive Statistics and Test of Normality

	Back Squat				Front Squat			
	Full Squat		Half Squat		Full Squat		Half Squat	
	L1	L5	L1	L5	L1	L5	L1	L5
Mean	609.10	446.70	583.00	420.20	621.20	462.70	601.20	448.10
Std. Error of Mean	19.99	24.49	29.10	17.60	28.80	32.06	25.03	19.39
Std. Deviation	63.23	77.46	92.04	55.68	91.09	101.41	79.15	61.32
Skewness	-1.158	.899	-.464	-.579	-.876	-.206	-.376	.507
Std. Error of Skewness	.687	.687	.687	.687	.687	.687	.687	.687
Kurtosis	.565	.289	-.467	-.949	-.980	-1.317	-1.102	-1.073
Std. Error of Kurtosis	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334
Shapiro – Wilk (p- value)	.140	.383	.626	.203	.193	.367	.602	.368

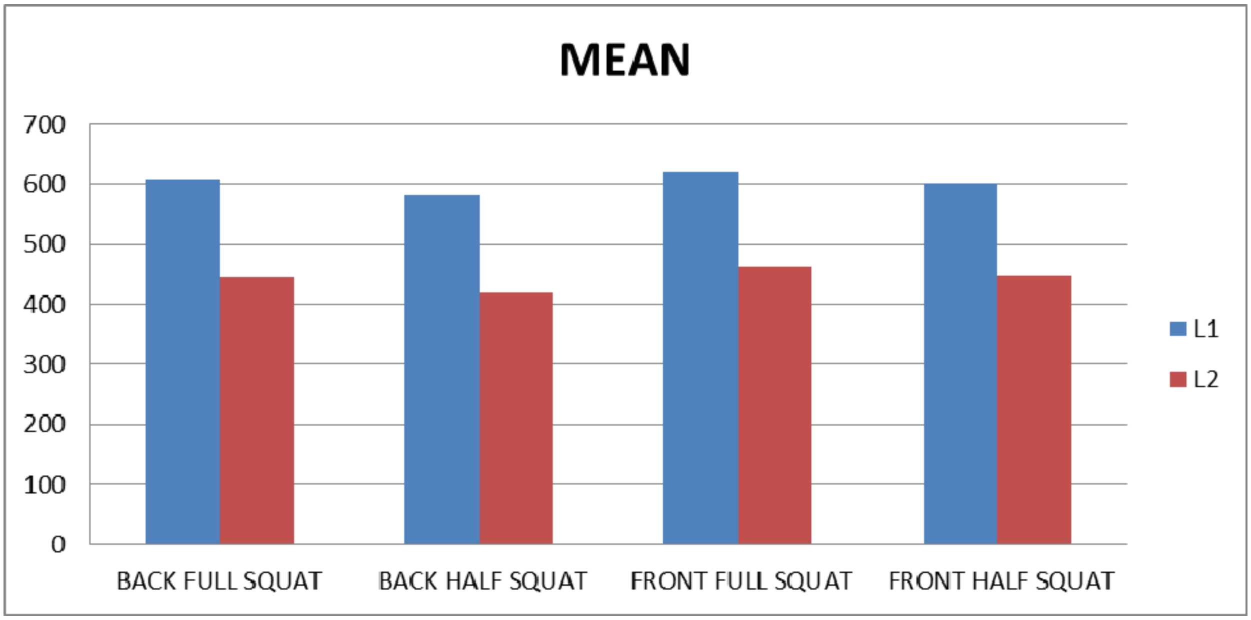

Fig 1: mean value of muscles activation (Lumber 1 paraspinal and Lumber 5 paraspinal) in four different squats

Figure 1 shows that the muscles activation of Lumber 1 paraspinal and Lumber 5 paraspinal muscles in all the four exercises were almost similar. But it can also be seen that in Back squat (full and half) with same load the muscles activation of both the muscles were less as compare to Front squat (full and half). Similarly, L 1 paraspinal muscles in all the four exercises shows greater muscles activation as compare to L 5 paraspinal muscles.

Table 2: A summary of the paired t - test among the two groups (i.e. Back Squat and Front squat), with regards to muscles activation in L1 paraspinal and L2 paraspinal muscles while performing each exercise (full and half squat)

Pair	Paired Differences			t	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean		
FFS – BFS (L1)	12.1000	106.35522	33.63247	.360	.727
FFS – BFS (L5)	16.0000	110.82820	35.04695	.457	.659
FHS – BHS (L1)	18.2000	105.50282	33.36292	.546	.599
FHS – BHS (L5)	27.9000	101.40946	32.06849	.870	.407

*Significant at 0.05 level Degree of freedom = 9

Bar position did not influence muscle activity in the current study. Similarly, Stuart *et al*. found that while comparing the muscle activity between front and back squat, equivalent EMG responses were found during both the lifts. The present study reveals that in case of front squat, slightly higher muscle activation (L1 and L2 paraspinal muscles) were found as compare to back squat with the same load. This result was supported by Gullett *et al*. in his study "A Biomechanical Comparison of Back and Front Squats in Healthy Trained Individuals" that the muscles tested were equally active during the front squat while lifting less mass, it is presumable that the same workout can be achieved with less compressive forces on the knee.

Furthermore, in back squat there are more chances of greater trunk lean while performing with heavy weights that would exhibit greater shear lumbar loading (Diggin *et al*., 2011) [3]. While in front squat this risk was minimum as greater trunk leaning is not possible because of the nature of technique. Ayers also supported that front squats can be used safely and effectively to strengthen the leg muscles surrounding and supporting the knee joint. For the general population and those who have knee and shoulder problems, the front squat is an excellent and safe alternative to the ever popular back squat.

4. Conclusion

This study attempted to assess the muscle activity of lower back (erector spinae) L1 Paraspinal and L5 Paraspinal muscles while performing two types of squats, i.e. front (full & half) and back (full & half) squats. The study reveals that no statistical differences were found in comparing the two types of squats. It means both the squats have similar pattern of muscle activation in lower back (erector spinae) with same load. However, in back squat one can take higher load but it also enhances the risk of injury in lower back as it increases the trunk leaning and also generates greater compressive force on the knee. Front squat as nature of its technique, it restricts the greater leaning of the trunk that creates less pressure on the lower back and also due to the lower load it reduces the risk of knee problem.

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