Relationship between Blood Lactate, Load and Load Volume in Weight Lifters

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Abstract

The purpose of this study was to observe the relationship between effects of different workload and load volume (i.e. 3 RM, 6 RM, 9 RM) of power clean on blood lactate production in female weight lifters. A total of six weight lifters with mean age, height and weight of 20.5 ±2.8 years, 161± 6.5cm and 70±7.4Kg respectively volunteered to participate in this study. Each subject's blood lactate was measured at rest and after 3RM, 6RM & 9RM with the help of a digital portable lactate analyzer (Lactate Scout) and the data were analyzed using Mean ±SD, T-test and correlation (Pearson).The maximum mean of relative absolute and %percent increase of blood lactate was 8.7±2.3mmol and 370.0±109.3% (3RM) followed by 7.4±2.0mmol & 349.8±112.0% (6RM) and 5.33±1.96mmol &33.3±81.3% (9RM).The difference in blood lactate at rest and after the execution of different work load volume was statistical significantly ($p < .05$). Insignificant correlation was found between the load lifted, load volume and posttest blood lactate in 3 RM, 6 RM and 9 RM. But when the data of different work load volume pattern was pooled together, there was a statistical significant negative correlation between load volume, posttest blood lactate ($r = -0.63$, $p<.01$), relative absolute ($r = -0.61$ $p<.01$) and percent increase in blood lactate ($r = -0.57$, $p<.05$). It was concluded that the blood lactate response depends upon the maximum absolute load lifted by the weight lifters as compared to the volume of load lifted. In other words, we can say that blood lactate production was largely dependent on the percentage of 1RM lifted.

Key words: Lactate, 1RM, Power clean

Introduction

Glycolysis is the conversion of glucose to pyruvate in order to generate ATP. The process primarily occurs in the cytosol, where glycolytic enzymes are in abundance. Sixteen steps of this process have been identified and the primary enzymes involved in this process are phosphofrucktokinase (PFK), phosphate dehydrogenase, and lactate dehydrogenase (LDH) *(Brooks et al., 2005)*. One fate of pyruvate is oxidation that can yield additional ATP. This process also takes place in the mitochondria, where pyruvate is converted to acetyl CoA. Acetyl CoA enters Kreb's cycle to be oxidized to carbon dioxide. Eventually, ATP is formed as electrons are transferred to oxygen. This process is known as aerobic respiration *(Bergeron, 1991)*. Under very high energy demands, the NADH and H^+ must be converted to NAD^+ to allow glycolysis to continue. In this situation the available pyruvate is reduced to lactate to facilitate the rapid regeneration of NAD^+ and the continued rapid production of ATP via glycolysis. This process facilitates continuous glycolysis but results in less ATP generation and increased lactate production *(Wassermann et al., 1986)*. The interaction between fast and slow glycolysis is a major determinant of human performance during prolonged and/or strenuous activities. Metabolic reactions required to provide energy during such activities create acidic conditions due to the production of lactic acid and associated increase in H^+ *(Gollnick et al., 1986; Brooks 1986).* It is necessary to list that, lactate production is higher in type II muscle fibers and during the recruitment of large to intermediate motor units *(Jones & Ehrsam, 1982)* as can occur in the Olympic style weight lifting techniques such as the clean and jerk, power cleans and the snatch. Working at the intensity which facilitates significant lactate is important to improve lactate tolerance. Little is done to evaluate the relationship between the effects of load, load volume of Olympic style lifts and lactate production in female weightlifters. Hence, due to the lack of referring literature, this study utilized only female weightlifters as participants.

Materials & Methods

The design of this study required participants to perform different work load volume of power clean (3 RM, 6 RM, 9 RM) in Olympic style. Six trained female weight lifters (N=6) between the ages of 17 and 25 years volunteered for this study. Olympic style lifts training session and subsequent blood lactate analysis were conducted at the Gymnasium Hall, Department of Sports, Punjabi University Patiala Campus. Participants performed one volume pattern on each day. Three total days were required for each participant to complete the study. A rest period of 48 hours was observed between the training days. Participants refrained from taking curd/lassi or whey/fermented milk in the last 2-3 hours and participating in any heavy physical activity (except activity of daily living) within 24 hours of the testing day. Blood lactate was analyzed at the beginning and at the end of every session using a digital portable lactate analyzer (Lactate Scout). The device required only 0.5 microliters (µl) whole blood. The blood was drawn from the tip of the index finger.

Statistical Analysis: Data was analyzed using Mean ±SD, T-test and Correlation (Pearson) with the help of statistical software SPSS version 16.0 (free trial, SPSS Inc, Chicago). The alpha level of significance for the data analysis was $p<0.05$.

Results

The mean age, height and weight of the female weightlifters was 20.5±2.8 years, 161±6.5cm and 70.0±7.4kg respectively. The mean load lifted for three repetitions (3RM), six repetitions (6RM) and nine repetitions (9RM) was 53.3 Kg ±12.1 Kg, 30.0Kg±7.7Kg and 32.5 Kg±5.2 Kg respectively. Thus, the maximum load lifted was during 3RM followed 9 RM and 6RM. In addition, the total load volume of each volume pattern was calculated (Volume =Set*load*repetitions). The mean load volume for volume pattern-3RM, 6RM and 9RM was 155.0 Kg ± 37.5Kg, 180.0Kg ± 46.4Kg and 292.5 Kg ± 47.1 Kg. Thus, the maximum volume of load was during 9RM followed by 6RM and 3RM (Table1). According to the literature, 3RM for the resistance training exercises is estimated to be 93% of 1RM while 6RM and 9RM are at 85% and 77% respectively *(Baechle & Earle 2008).* The mean blood lactate levels for volume pattern-3RM was 2.3±0.2mmol/l prior to exercise and 11.1± 2.3 mmol/l after the completion of one set of three repetitions.

The mean blood lactate level for volume pattern-6RM was 2.2±0.3 mmol/l prior to exercise and 9.5±1.7mmol/l after the completion of one set of six repetitions. The mean blood lactate levels for volume pattern-9RM was 2.28± 0.2 mmol/l prior to the exercise and 7.6 ±2.0 mmol/l after the completion one set of nine repetitions (Table1).

Table 1.Descriptive Statistics of Female Weight Lifters

Age years	Height cm	Weight kg	Load Pattern	Load kg	Load Volume kg	Blood Lactate PreTest, mmol	Blood Lactate PostTest, mmol	Relative Absolute Increase mmol	Relative %Percent Increase
			3RM	53.3±12.1	155.0±37.5	2.3±0.2	11.1±2.3	8.7±2.3**	370.0±109.3**
20.5±2.8	161±6.5	70.0±7.4	6RM	30.0±7.7	180.0±46.4	2.2±0.3	9.5±1.7	7.4±2.0**	349.8±112.0**
			9RM	32.5±5.2	292.5±47.1	2.2±0.2	7.6±2.0	5.3±1.9**	233.3±81.3**

** Significant at p<0.01, *significant at p<0.05

It was found that before the start of execution of different work load pattern, the mean blood lactate of female weight lifters were in a normal range that is 2.38±0.21mmol (3RM), 2.21±0.36 mmol (6RM), and 2.28±0.27 mmol (9RM). Further, It was found that the maximum mean of relative absolute and percent increase value of blood lactate was 8.71±2.38 mmol and 370.06±109.38 % (3RM) followed by 7.45±2.02 mmol & 349.81±112.09 % (6RM) and 5.33±1.96 mmol & 33.31±81.32% (9RM) (Table1). Table 2 shows the relationship among the load, load volume, blood lactate posttest, relative absolute and percentage increase of blood lactate. Non-significant correlation was found between the load lifted and blood lactate posttest (r=-0.35), relative absolute (r =-0.34) and percent (r =-0.23) increase in blood lactate for 3RM. Similarly non-significant relationship was found between load volume and blood lactate posttest (r=-0.35), relative absolute (r=-0.36) and percent (r=-0.29) increase in blood lactate for 3RM. However, there was a significant positive correlation between blood lactate posttest and subsequent relative absolute (r=0.99, p<.01) and percent increase in blood lactate (r= 0.92, p<.05).

Table 2.Correlation among load, load volume & blood lactate response of 3RM

	Blood Lactate PostTest	Relative Absolute Increase in Blood Lactate	Relative % Increase in Blood Lactate
Load,kg	-0.35	-0.34	-0.23
Load Volume,Kg	-0.35	-0.36	-0.29
Blood Lactate PostTest, mol	-	0.99**	0.92**
Relative Absolute Increase in Blood Lactate, mol		-	0.95**

** significant at p<0.01, * significant at p<0.05

Table 3 shows the non-significant correlation between the load lifted and blood lactate posttest (r=-0.18), relative absolute(r=--0.01) and percent (r=-0.03) increase in blood lactate for 6RM. Similarly, non-significant relationship was found between load volume and blood lactate posttest (r=-0.18), relative absolute(r=-0.01) and percent(r=-0.03) increase in blood lactate for 6RM.However, there was a significant positive correlation between blood lactate posttest and subsequent relative absolute (r=0.98, p<.01) and percent increase in blood lactate (r = 0.89, p<.05).

Table 3.Correlation among load, load volume & blood lactate response of 6RM

	Blood Lactate PostTest	Relative Absolute Increase in Blood Lactate	Relative % Increase in Blood Lactate
Load, kg	-.18	-.01	-.03
Load Volume, Kg	-.18	-.01	-.03
Blood Lactate PostTest, mol	-	.98**	.89*
Relative Absolute Increase in Blood Lactate, mol		-	.90*

** significant at p<0.01, * significant at p<0.05

Table 4 shows the non-significant correlation between the load lifted and blood lactate posttest (r=-0.51), relative absolute (r=-0.55) and percent (r=-0.60) increase in blood lactate for 9RM. Similarly non-significant relationship was found between load volume and blood lactate posttest (r=-0.51), relative absolute(r=-0.55) and percent (r=-0.60) increase in blood lactate for 9RM. However, there was a significant positive correlation between blood lactate posttest and subsequent relative absolute (r =0.99, p<.01) and percent increase in blood lactate (r = 0.91, p<.05).

Table 4.Correlation among load, load volume & blood lactate response of 9RM

	Blood Lactate PostTest	Relative Absolute Increase in Blood Lactate	Relative % Increase in Blood Lactate
Load, kg	-.51	-.55	-.60
Load Volume, Kg	-.51	-.55	-.60
Blood Lactate PostTest, mol	-	.99**	.91*
Relative Absolute Increase in Blood Lactate, mol		-	.95**

** Significant at p<0.01, *significant at p<0.05

Table 5 shows the relationship among the load, load volume, blood lactate posttest, relative absolute and percentage increase of blood lactate of pooled data. Non-significant correlation was found between the load lifted and blood lactate posttest (r=0.20), relative absolute(r=0.19) and percent (r=0.12) increase in blood lactate. However there was a significant negative relationship between load volume and blood lactate posttest (r=-0.63, p<.01), relative absolute(r= -0.61, p<.01) and percent (r= -0.57, p<.05) increase in blood lactate. A significant positive correlation was also found between blood lactate posttest and subsequent relative absolute (r=0.99, p<.01) and percent increase in blood lactate (r=0.91, p<.05).

Table 5.Correlation among load, load volume & blood lactate response of pooled data

	Blood Lactate PostTest	Relative Absolute Increase in Blood Lactate	Relative % Increase in Blood Lactate
Load,kg	.20	.19	.12
Load Volume,Kg	-.63**	-.61**	-.57*
Blood Lactate PostTest, mol	-	.99**	.91**
Relative Absolute Increase in Blood Lactate, mol		-	.94**

** Significant at p<0.01, *significant at p<0.05

Thus, results of this study suggests that further research work should be taken with volume pattern consist of three sets with three repetitions, the results such study may more deeply and widely interpret the production of blood lactate in response to different work load volume pattern. In addition, when the relative increase in blood lactate was analyzed, it was observed that higher load is associated with higher lactate response as 3RM showed mean relative increase of

370.06±109.38% as opposed to mean relative increase of 349.81±112.09 % and 233.31±81.32 in work load volume pattern 6RM and 9RM respectively (Table 1).

Discussion

In the present study, it was observed that lactate response is largely dependent on the percentage of 1RM lifted. This is in line with propositions put forward by *Reynolds et al, (1997)* who analyzed long term effects of resistance training on lactate response and proposed that blood lactate response is largely dependent on percentage of 1RM lifted. To corroborate the association between higher lactate response and load; *Robergs et al, (1991)* concluded that the rate of glycogenolysis was twofold greater during leg extension at 70% of 1RM than 50% of 1RM, possibly due to the greater involvement of Type II muscle fibers. While findings of these studies give clear indications that lactate response in resistance exercise is largely dependent on load. *Rozenek et al, (1993)* observed that, in bench press exercise when numbers of repetitions are constant; there is an association between elevated blood lactate response and higher volume. This study analyzed the volume of bench press exercise performed for 10 repetitions at 50% and 70% of 1RM. Mean 1RM for this study was at 87.4 kg. Therefore, 10 repetitions performed at 70% of 1RM measured the volume of 611.8 kg. Mean blood lactate response generated at this volume was 9.5mmol/l which is higher than mean lactate response generated at 50% of 1RM (2.5mmol/l). These observations are similar to the present study in which 3RM work load volume pattern with smallest number of repetitions (i.e. three) but highest amount of load percentage has yielded greatest lactate response. The literature indicates that lactate production occurs more in Type II muscle fibers and in larger muscle groups *(Robergs et al, 1991; Jones & Ehrsam, 1982)*. In regards to the aforementioned findings, it is important to revisit the process of energy production through glycolysis. *Bergeron (1991)* reported that glycolysis results in the formation of pyruvate, $NADH^+$, H^+ and ATP. While ATP is used for energy production; pyruvate, $NADH^+$ and H^+ is further processed through aerobic respiration and electron transfer chain, respectively. When the rate of energy requirement exceeds electron diffusion, pyruvate is converted to lactate. However, in intense exercise and continued energy demand, the rate of lactate production exceeds oxidation and lactate accumulates. Thus, this study confirms that lactate accumulation is closely associated with increased energy demand. It is possible that the 3RM work load volume patterns in this study overwhelmed the aerobic capacity, which may have resulted in exceedingly higher blood lactate response. Less time spent while performing higher percentage of 1RM work load (3RM) may be another determinant contributing to the elevated lactate response in volume patterns performing greater repetitions. This indicates that resistance training with enhanced lactate production coupled with an aerobic activity to increase lactate clearance may work to enhance lactate tolerance. However, further research is required to determine the efficacy of resistance-only training to improve lactate tolerance. This finding can be important in athletic settings as most field sports such as football, hockey and tennis feature continuous, intense activity which can elicit greater lactate response.The results of this study indicate that Olympic style weight lifting can stimulate sufficient lactate production in order to overload the lactate clearance mechanism. However, the limited numbers of participants in this study limit the validity of the results. Moreover, the effects of different volume patterns with similar rest periods on lactate production are yet to be evaluated.

Conclusion: It was concluded that the blood lactate response depends upon the maximum absolute load lifted by the weight lifters as compared to the volume of load lifted. In other words, it can be said that blood lactate production was largely dependent on the percentage of 1RM lifted.

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