Blood Lactate Response to Different Workload Patterns in Female Weight Lifters

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Abstract

The purpose of this study was to observe the effects of different workloads (i.e. volume patterns-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, weight and BMI of 20.50 ±2.88 years, 161± 6.55 cm,70±7.45Kg and 26.81±1.78 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, ANOVA and Scheffe. 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).The difference in blood lactate at rest and after the execution of different work load pattern was statistical significantly ($p < .05$). 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 in this study it was observed that blood lactate response was largely dependent on percentage of 1RM.

Key words: Lactate, Power Clean, 1RM, Olympic Style

Introduction

Typically, lactate production takes place in the presence of anaerobic energy production while lactate utilization requires oxygen *(Bridges et al., 1991).* Hence, training for improvement in lactate tolerance typically includes activities which facilitate enough stimuli for concurrent lactate production and utilization. Current training practices for improving lactate tolerance in athletes is highly influenced by aerobic activities and the combination of aerobic and resistance training *(Dudley & Fleck, 1987).*Thus, the risk of muscle loss is greater when aerobic training is used as a tool for improving lactate tolerance *(Eniseler, 2005).* This obstacle can be avoided if resistance training is modified and used as an intermittent activity to enhance concurrent lactate production and clearance, without exposing an athlete to the negative effects of excessive aerobic training. A study was conducted to evaluate the effects of high intensity resistance training on the performance of distance runners *(Hamilton et al., 2006).* The participants were divided in to two groups. In this 5-week long study, the control group performed their usual competitive-phase training while the experimental group replaced part of their training with explosive jumps and short treadmill sprints. This study observed an improvement in 1500 m speed; 800 m speed, 5 km outdoor time trial speed and lactate threshold speed without compromising baseline muscle strength. It is necessary to recite 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 therefore; the use of explosive training is consistent with the training goal in question. In order to close the gap between research and application, it is important to evaluate the effects of high volume explosive training on lactate production as a prelude to the evaluation of high volume explosive training on lactate tolerance during continuous intermittent activities. Little is done to evaluate the effects of Olympic style lifts 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 volume of power clean (3 RM, 6 RM, 9 RM) in Olympic style. Thus, trained six 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

Statistical analysis was performed with SPSS version 16.0 (free trial, SPSS Inc, Chicago). Repeated measure ANOVA and Scheffe Post hoc was used. In the present study, work load pattern was the independent categorical variable which had three different groups in form of three volume patterns that is 3RM, 6RM & 9RM, thus, use of the test of ANOVA to test the hypothesis of this study is justified. The alpha level of significance for the data analysis was $p<0.05$.

Results & Discussion

This study primarily focused on effects of different work loads on blood lactate response in female weight lifters. Since, exercise volume determines the degree of physiological demand, it was hypothesized that blood lactate response will increase for each increase in volume pattern or intensity of the exercise. Six healthy female weightlifters (20.50 years ±2.88) from the population of female weightlifters of Punjabi University participated in the study. The mean weight lifted for three repetitions (3RM) was 53.33 Kg ±12.11 Kg. The mean weight lifted for six repetitions (6RM) was 30.00Kg±7.74Kg. The mean weight lifted for nine repetitions (9RM) was 32.50 Kg±5.24 Kg (Table1). In addition, the total volume of each volume pattern was also calculated (Volume =Set*load*repetitions). The mean volume for volume pattern-1 (3RM) was 155.00 Kg ± 37.55Kg. The mean volume for volume pattern-2 (6RM) was 180.00Kg ± 46.47Kg. The mean volume for volume pattern-3 (9RM) was 292.50 Kg ± 47.19 Kg (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)*. However, it has been suggested that the Olympic style lifts require a lower relative RM due to the relationship between force and velocity *(Newton et al., 1996; Knuttgen & Kraemer 1987)*. The mean blood lactate levels for volume pattern-1 (3RM) was 2.38±0.21mmol/l prior to exercise and 11.10± 2.34 mmol/l after the completion of one set of three repetitions. The mean blood lactate levels for volume pattern-2 (6RM) was 2.21±0.36 mmol/l prior to exercise and 9.55±1.75 mmol/l after the completion of one set of six repetitions. The mean blood lactate levels for volume pattern-3 (9RM) were 2.28±0.27mmol/l prior to the exercise and 7.61±2.07mmol/l after the completion one set of nine repetitions (Table 1).

Table 1. Descriptive Statistics of Female Weight Lifters

	Mean	Std. Deviation
Age	**20.50**	**2.88**
Height	**1.61**	**6.55**
Weight	**70.00**	**7.45**
BMI	**26.81**	**1.78**
Load 3RM,Kg	**53.33**	**12.11**
Load 6RM,Kg	**30.00**	**7.74**
Load 9RM,Kg	**32.50**	**5.24**
Load Volume 3RM, Kg	**155.00**	**37.55**
Load Volume 6RM, Kg	**180.00**	**46.47**
Load Volume 9RM, Kg	**292.50**	**47.19**
Pretest Blood Lactate of 3RM,mmol/l	**2.38**	**0.21**
Post test Blood Lactate of 3RM,mmol/l	**11.10**	**2.34**
Relative Absolute of Blood Lactate 3RM, mmol/l	**8.71**	**2.38**
Relative Percent of Blood Lactate 3RM,%	**370.06**	**109.38**
Pretest Blood Lactate of 6RM,mmol/l	**2.21**	**0.36**
Posttest Blood Lactate of 6RM,mmol/l	**9.55**	**1.75**
Relative Absolute of Blood Lactate 6RM, mmol/l	**7.45**	**2.02**
Relative Percent of Blood Lactate 6RM,%	**349.81**	**112.09**
Pretest Blood Lactate of 9RM,mmol/l	**2.28**	**0.27**
Posttest Blood Lactate of 9RM,mmol/l	**7.61**	**2.07**
Relative Absolute of Blood Lactate 9RM, mmol/l	**5.33**	**1.96**
Relative Percent of Blood Lactate 9RM,%	**233.31**	**81.32**

It was found that the maximum load lifted was 53.33±12.11 Kg (during 3RM) followed by 32.50±5.24 Kg (9RM) and 30.00±7.74 Kg (6RM). But the maximum volume of load was 292.50±47.19 Kg,(9RM);180.00±46.47Kg (6RM) and 155.00±37.55 Kg (3RM). Further, 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/l (3RM), 2.21±0.36 mmol/l(6RM) and 2.28±0.27mmol/l (9RM). After the successful execution of different workloads by the weightlifters, it was found that the maximum mean value of blood lactate was 11.10±2.34 mmol/l (3RM), 9.55±1.75 mmol/l (6RM) and 7.61±2.07 mmol/l (9RM).

Table 2. Mean ±SD of Blood lactate response before & after the performance of different work loads

	Blood lactate (mmol)					
Workload pattern→	**1(3RM) Load: 53.33±12.11kg**		**2(6RM) Load: 30.00±7.74 kg**		**3(9RM) Load: 32.50±5.24 kg**	
Age(years)↓	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
20 ±2	**2.38±0.21**	**11.10±2.34****	**2.21±0.36**	**9.55±1.75****	**2.28±0.27**	**7.61±2.07****

Pre- blood lactate levels prior to the beginning of exercise; Post- blood lactate levels after the completion of exercise, **significant at $p < 0.01$

Table 3 shows mean of relative absolute and percent increase in blood lactate response to different workload pattern. It was found that the maximum mean of relative absolute and percent increase value of blood lactate was 8.71±2.38 mmol/l and 370.06±109.38 % (3RM) followed by 7.45±2.02 mmol/l & 349.81±112.09 % (6RM) and 5.33±1.96 mmol/l and 33.31±81.32% (9RM).

Table 3. Mean ±SD of Relative increase in blood lactate response to different workload pattern

	Blood lactate (mmol)					
Workload pattern→	1(3RM) Load: 53.33±12.11 kg Volume: 155.00±37.55 kg		2(6RM) Load: 30.00±7.74 kg Volume: 180.00±46.47 kg		3(9RM) Load: 32.50±5.24 kg Volume: 292.50±47.19 kg	
Age(years)↓	Absolute (mmol)	Percent increase (%)	Absolute (mmol)	Percent increase (%)	Absolute (mmol)	Percent increase (%)
20 ±2	8.71±2.38	370.06±109.38	7.45±2.02	349.81±112.09	5.33±1.96	233.31±81.32

Relative Absolute & Percent increase in blood lactate levels after the completion of different work load pattern

Thus, maximum blood lactate production was observed in a 3RM workload pattern in which weightlifters had lifted maximum load (53.33±12.11 Kg). So, 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 in this study it was observed that blood lactate response was largely dependent on percentage of 1RM lifted.

Table 4: Analyses of Variance of Blood lactate before & after various workloads among different groups

		Sum of Squares	Mean Square	F
Blood Lactate Pre test, mmmol	Between Groups	.08	.04	.49
	Within Groups	1.28	.08	
Blood Lactate Post test, mmol	Between Groups	36.54	18.27	4.25*
	Within Groups	64.38	4.29	
Relative Absolute Increase of Blood Lactate , mmol	Between Groups	35.06	17.53	3.84*
	Within Groups	68.41	4.56	
Relative Percent Increase of Blood Lactate , mmol	Between Groups	65365.75	32682.87	3.14*
	Within Groups	155721.47	10381.431	

*significant at p<0.05

The results of analysis of variance (Table 4) showed that the variance in the mean value of blood lactate pre test (F=0.49) among different workload pattern was not statistical significant. But, the variance in the mean value of blood lactate post test (F=4.25, p<0.05), relative absolute (F=3.84, p<0.05) and percent (F=3.14, p<0.05) increase in blood lactate among different workload pattern was statistical significant.

Further, the scheffe posthoc (Table 5) revealed that the difference was statistical significant at 0.05 level of blood lactate post test (3RM vs. 9RM), relative absolute (3RM vs. 9RM) and percent increase in blood lactate (3RM vs. 9RM). Results of this study shows a trend of decrease in blood lactate from volume pattern-1(3RM) to volume pattern-3 ((RM) after exercise and this may be due to that participants had done only one set of exercise instead of three sets with three repetitions. 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 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 2). It can be seen that there is a significant difference in relative blood lactate increase in all work load volume patterns.

Table 5. Scheffe Posthoc Multiple Comparison of Blood lactate before & after various workloads among different groups

Dependent Variable	(I) 1-3RM;2-6RM;3-9RM	(J) 1-3RM;2-6RM;3-9RM	Mean Difference (I-J)	95% Confidence Interval Lower Bound	Upper Bound
Blood Lactate Pre test, mmmol	1	2	0.16	-0.29	.62
		3	0.10	-0.35	.55
	2	3	-0.06	-0.52	.39
Blood Lactate Post test, mmol	1	2	1.55	-1.69	4.79
		3	3.48*	0.23	6.72
	2	3	1.93	-1.31	5.17
Relative Absolute Increase of Blood Lactate , mmol	1	2	1.26	-2.08	4.61
		3	3.38*	0.03	6.73
	2	3	2.11	-1.23	5.46
Relative Percent Increase of Blood Lactate , mmol	1	2	20.25	-139.39	179.89
		3	136.75*	-22.89	296.39
	2	3	116.50	-43.14	276.14

*Significant at the 0.05 level.

Discussion

A key finding of this study is the difference observed in blood lactate response to different volumes. Prior to analyzing the possible explanations for the findings, it is necessary to contemplate the study design. The work load volume of the exercise was the influential variable in measuring the lactate response. Various factors such as load, repetitions, time under tension and bar displacement among others influence the blood lactate *(Pauletto, 1986; Pauletto, 1985).* As discussed earlier, the percent load of estimated 1RM was less when associated with higher number of repetitions. Therefore, this study observed that lactate response is largely dependent on percentage of 1RM. *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, observations made in the present study, coupled with observations by *Gupta & Goswami (2001).* These observations are similar to the present study in which 3RM work load volume pattern with smallest number of repetitions (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). 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.

Conclusion

In conclusion, the results of this study indicates that blood lactate response in power clean movement is largely associated with percentage of 1RM work load volume as determined by number of repetitions and load. The power output can be another determinant of blood lactate response to power cleans; however, further study is required to support this observation. This study also concludes that, explosive movements, if performed; can impose greater demands on glycolytic capacity. Therefore, explosive activities can be used for greater improvement in energy production.

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References

Baechle, T. R., & Earle, R. W. (Ed.) 2008. *Essentials of strength training and conditioning*. Champaign, IL: Human Kinetics.

Bergeron, M. 1991. Lactic acid Production and clearance during exercise. *Nat. Stren. Cond. Assoc. J.* **13**(5), 47-54.

Bridges, C.R., Clark, III B. J., Hammond, R. L., & Stephenson, L.W. 1991. Skeletal muscle bioenergetics during frequency –dependent fatigue. *Am. J. Physiol.* **29**: 643- 651.

Dudley, G.A., & Fleck, S.J. 1987. Strength and endurance training: Are they mutually exclusive? *Sports Med.* **(4):** 79-85.

Eniseler, N. 2005. Heart rate and blood lactate concentrations as predictors of physiological load on elite soccer players during various soccer training activities. *J. Stren. Cond. Res*. **19(4):** 799-804.

Gupta, S., & Goswami, A. 2001. Blood lactate concentration at selected Olympic modes weight lifting. *Ind. J. Physiol. Pharmac.*, **45(2):** 239-244.

Hamilton, R., Paton, C., & Hopkins, W. 2006. Effects of high intensity resistance training on performance of competitive distance runners. *Int. J. Sports Physiol. Perform*. **1**: 40-49.

Jones, N., & Ehrsam, R. 1982 The Anaerobic threshold. *Exercise and Sports Science Review*, **10**, 48-83.

Knuttgen, H.G., & Kraemer, W.J. 1987. Terminology and measurement in exercise performance. *Journal of Applied Sports Science Research*, **1**, 1-10.

Newton, R., Kraemer, W.J., Hakkinen, K., Humphries, B.J., & Murphy, A.J. 1996. Kinematics, Kinetics and muscle activation during explosive upper body movements; implications for power development. *J. Appl. Biomech.*, **12**, 31-43.

Pauletto, B. 1985. Sets and Repetitions. *Nat. Strn. & Cond. Assoc. J.*, **7(6):** 67-69.

Pauletto, B. 1986. Intensity. *Nat. Stren. Cond. Assoc. J.*, **8(1),** 33-37.

Robergs, R. A., Pearson, D. R., Costill, D.L., Fink, W.J., Benedict, M.A., Lambert, C.P., & Zachweija, J.J. (1991). Muscle glycogynolysis during differ intensities of weight resistance exercise. *Journal of Applied Physiology* 70, 1700-1706.