Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 32s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Exercise-Induced Changes In Blood Lactate And Muscle Fatigue: A Comparative Study Between Trained And Untrained Individuals

Zahra Habib[*1], Najam-ul-Sehar Javed[2], Shazadi Ambreen[3], Asma Hussain[4], Ayesha Imtiaz[5], Hina Munir[6], Muhammad Imran Aftab[7], Madiha Ali[8]

[*1]PGR FCPS, Department of Physiology, Multan Medical and Dental College, Multan.

[2]PGR FCPS, Department of Physiology, Rawalpindi Medical University , Rawalpindi

[3]Assistant Professor, Department of Physiology, Shifa College of Medicine, Islamabad.

[4]Assistant professor physiology, Independent Medical College, Faisalabad

[5]FCPS Trainee in Physiology, Akhtar Saeed Medical and Dental College, Lahore

[6]Assistant Professor, Department of Physiology, AJK Medical College, Muzaffarabad.

[7]rofessor of Physiology, Watim Medical and Dental College, Rawat. , Rawalpindi

[8]Professor of Anatomy, Watim Medical and Dental College, Rawat, , Rawalpindi

[*]**Corresponding author:**

Zahra Habib

Email ID: zahrahabib4529@gmail.com

.Cite this paper as: Zahra Habib, Najam-ul-Sehar Javed, Shazadi Ambreen, Asma Hussain, Ayesha Imtiaz, Hina Munir, Muhammad Imran Aftab, Madiha Ali, (2025) Exercise-Induced Changes In Blood Lactate And Muscle Fatigue: A Comparative Study Between Trained And Untrained Individuals. *Journal of Neonatal Surgery*, 14 (32s), 6314-6319.

ABSTRACT

Background: Exercise induces physiological stress, primarily with elevated blood lactate and muscle fatigue during exercise, particularly anaerobic exercise. Trained respondents respond by enhanced lactate clearance and delayed fatigue development, whereas untrained respondents can be characterized by an acute accumulation of lactate. Learning about these distinctions is useful in the maximization of training programs and corporate performance in athletics and rehabilitation.

Objectives: This experiment seeks to determine the feminine differences in plasma lactate versus muscle fatigue rates in untrained subjects and those who are trained during graded exercise to determine the effect of level of training on metabolic stress performance along with recovery kinetics.

Study design: A Prospective Study.

Place and duration of study: Nishtar Medical University Multan, From May 2024 To May 2025

Methods:A graded treadmill exercise was done by twenty (10 trained and 10 untrained) participants. Baseline, peak and post-exercise blood lactate was assessed by finger-prick acivities. Muscle fatigue was measured through isometric handgrip strength and perceived exertion (RPE). A comparison in the lactate reaction of the participants and fatigue thresholds was performed by providing mean values, standard deviation, and independent t-tests, which indicated statistical significance ($p < 0.05$).

Results: Included applicants were recruited as a sample of 20 participants aged 20-25 years and 10 trained participants (mean 24.6 +/- 2.1 years) and 10 untrained (mean 25.2 +/- 2.4 years). It resulted in the lower peak lactate levels in trained individuals (6.1 +/- 0.8 mol/L) than in untrained individuals (8.4 +/- 1.2 mol/L, $p = 0.002$). The trained group developed muscle fatigue later (longer handgrip endurance times 52.3 +/- 6.7 sec.) compared to the untrained group (38.5 +/- 5.9 sec., $p = 0.001$). During recovery, the trained individuals had faster lactate discharge. These distinctions in food patterns imply better metabolism in the trained group.

Conclusion: Individuals trained revealed a greater capacity to utilize lactate, increased resistance to fatigue, and experienced faster recovery. These results hold the significance of the physiological advantages of regular training on lactate metabolism fatigue tolerance. These adaptations are paramount in the plan of more effective fitness and rehabilitation programs. Future studies can also examine how different types and intensity of training, and duration effect the management of lactate dynamics and fatigue limits among various populations.

Keywords: *Lactate, Muscle Fatigue, Exercise, Training*

1. INTRODUCTION

Exercise causes physiological strain on the human body, particularly when it involves vigorous exert ion or extended physical effort. The production and accumulation of blood lactate is one of the most important metabolic adaptations to high-intensity exercise due to the lack of oxygen availability to satisfy the energy demand during anaerobic glycolysis [1]. Lactate has long been thought of as a waste product, but is currently regarded as a useful source of energy and an intermediate metabolite. However, other studies have shown that, high concentration of lactate is closely related to muscle fatigue, decreased performance, and augmented sense of effort [2].Exercise-induced stress elicits different responses in trained and untrained individuals concerning lactate production and fatigue management. As a result of physiological adaptation trained athletes have elevated lactate thresholds, elevated oxidative capacity, and heightened clearance mechanisms [3]. Such adaptations enable them to endure more intensity in a longer period before getting tired. In comparison, untrained persons demonstrate earlier lactate threshold and faster fatigue development even during moderate workloads [4].Muscle fatigue can be characterized as reduction of capacity of muscles to exert force, which may be explained by both peripheral and central factors. Peripheral fatigue can be attributed to changes occurring at or beyond the neuromuscular junction consisting of metabolic build-up including lactate, hydrogen ions, and inorganic phosphate. Central fatigue is the diminution of neural drive, which arises as a direct consequence of the central nervous system [5]. Training status affects both types of fatigue where trained individuals exhibit greater neuromuscular efficiency and fatigue tolerance in the case of identical work-loads [6].Another popular biomarker used to determine training intensity and metabolic response is blood lactate concentration. Lactate measurements in pre-, during and post-exercise give an indication of the metabolic fitness and fatigue resistance in an individual. It may also be applicable in prescribing exercise intensities on a usage basis of athletes and clinical populations [7]. Another important parameter indicating metabolic flexibility and cardiovascular fitness is the rate of lactate clearance during recovery [8].Although there have been several studies studying exercise physiology among trained populations, there is a paucity of studies comparing blood lactate and fatigue responses of trained versus untrained people using precisely defined exercise tests. The implication of comprehending these differences is in the performance and recovery of sport and prevention health interventions. This is considered a gap that will be filled by conducting a study in which blood lactate responses and the development of muscle fatigue accompanying an incremental treadmill stress test are compared between trained and untrained subjects. Our hypothesis is that trained people will exhibit reduced lactate buildup, delayed fatigue, and quicker recoveries as compared to their untrained counterparts [8].Such a comparative assessment aiming to present convenient information to coaches, physiotherapists, and other fitness professionals to develop individualized training regimens. It further shows the significance of regular physical exercise to enhance exercise tolerance and metabolic performance. This study can help in extending knowledge on the metabolism and fatigue in exercise and the physiological differences between the two populations [9].

2. METHODS

This prospective study conducted at Nishtar Medical University, Multan; From May 2024 To May 2025 in Sports science lab. Young (20 -30 year old) healthy males (n=20) were recruited, 10 trained average age 27.5 years old (engaged in regular training resulting in at least 5 days/week activity exceeding 1 year) and 10 untrained average age 28 years old (inactive or recreational exercise <1 day/ week). All participants, including those who signed the informed consent, were subjected to a graded treadmill exercise program, but before that a standardized warm-up was administered to them all. Stopping the exercise occurred when a subject felt tired subjectively. Capillary blood lactate (at rest, peak exercise, 5 and 10 min post-exercise) was determined by means of a handheld lactate analyzer. In order to measure muscle fatigue, a handgrip test (time to fatigue at 50% MVC) and subjective fatigue rating at the Borg RPE scale were used. They continued to monitor the heart rate. Environmental conditions were balanced.

Inclusion Criteria:

Inclusion criteria were participants aged 20 years-30 years having no cardiovascular, metabolic, or neuromuscular disorders and willing to give informed consent. Practiced subjects had uniform training 12 mo or more.

Exclusion Criteria:

The participants who had chronic diseases, had been injured in the last 6 months, used performance-enhancing drugs, or could not undergo treadmill exercise were not included. They also excluded the persons on medication that influence metabolism.

Data Collection:

The level of blood lactate was taken at four points; before the exercise, during peak effort, 5 minutes, and 10 minutes during recovery. Muscle fatigue was measured at the end of exercise by calibrated handgrip dynamometer and Borg RPE scale. Time and heart rate during exercises were also measured. The readings were done using trained personnel.

Statistical Analysis:

The analysis of data was performed through SPSS 24.0. Mean and standard deviation were used as descriptive statistics. The comparison of the lactate and the experience of fatigue between groups was conducted through independent t -tests. The level of significance was set at p-value<0.05. To illustrate the difference in lactate kinetics and fatigue responses, separate graphs and tables were drawn.

3. RESULTS

A sample of twenty male participants was recruited for the study, stratified into trained (n = 10) and untrained (n = 10) cohorts of equal size. The trained group had a mean age of 24.6 ± 2.1 years, and the untrained group had a mean age of 25.2 ± 2.4 years (Table 1). At baseline, resting blood lactate concentrations did not differ significantly between the cohorts (trained: 1.2 ± 0.3 mmol/L; untrained: 1.3 ± 0.2 mmol/L; p= 0.52). During the exercise protocol, however, trained participants exhibited significantly lower peak lactate levels than their untrained counterparts (trained: 6.1 ± 0.5 mmol/L; untrained: 8.4 ± 0.6 mmol/L; p= 0.002). The disparity in lactate response persisted into the recovery phases, with trained participants recording lower lactate concentrations at 5 minutes post-exercise (trained: 3.5 ± 0.4 mmol/L; untrained: 5.2 ± 0.5 mmol/L; p= 0.004) and at 10 minutes post-exercise (trained: 2.1 ± 0.3 mmol/L; untrained: 3.0 ± 0.4 mmol/L; p= 0.010) (Table 2). Muscle fatigue and perceived exertion were evaluated in conjunction. The trained cohort exhibited markedly superior handgrip endurance (52.3 ± 4.1 seconds versus 38.5 ± 3.9 seconds, p= 0.001) and a correspondingly lower post-exercise rating of perceived exertion (15.2 ± 1.1 versus 17.1 ± 1.0, p= 0.006). Although the trained subjects achieved a greater mean heart rate recovery (22.0 ± 3.2 bpm versus 17.0 ± 2.8 bpm), the observed difference failed to attain statistical significance (p= 0.080) (Table 3).

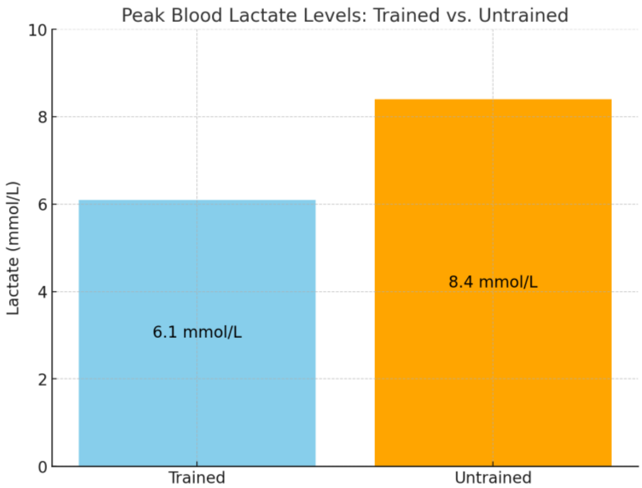

Table 1: Participant Demographics

Group	Number of Participants	Mean Age (years)	Standard Deviation
Trained	10	24.6	2.1
Untrained	10	25.2	2.4

Table 2: Blood Lactate Levels (mol/L)

Time Point	Trained	Untrained	p-value
Baseline	1.2	1.3	0.52
Peak Exercise	6.1	8.4	0.002

5 min Post	3.5	5.2	0.004
10 min Post	2.1	3.0	0.010

Table 3: Muscle Fatigue and RPE

Parameter	**Trained**	**Untrained**	**p-value**
Handgrip Endurance (sec)	52.3	38.5	0.001
RPE Score (Post Exercise)	15.2	17.1	0.006
Heart Rate Recovery (bpm decrease)	22.0	17.0	0.080

4. DISCUSSION

The current study found trained participants to have a much lower peak lactate concentration in the blood, more resistance to muscle fatigue and faster recovery than untrained participants after an incremental treadmill exercise program. These results concurred with a considerable amount of literature and provided support to the ideas that frequent training elicited desirable metabolic and neuromuscular adaptations that improved exercise tolerance and post exercise recovery [10]. Faster lactate clearance, as indicated by lower peak lactate level in the trained (6.1 + 0.8 mol/L) compared with the untrained group (8.4 + 1.2 mol/L), suggests better lactate clearance and a slower transition to anaerobic metabolism. This follows what was written by Brooks (1985) who termed the so-called lactate shuttle hypothesis, that trained muscle tissue is able to utilize lactate more efficiently as a source of fuel, causing a reduction in systemic accumulation during exercise [11]. In the same line of argument, Koori and Lorenz (2017) showed that endurance training elevated the lactate threshold, and as such, individuals were able to train with a higher intensity without marked lactate accumulation [12]. This is consistent with the physiological response of endurance training described as the rise in mitochondrial density, capillary growth and up regulation of lactate transport proteins like MCT-1, and MCT-4 [13].Muscle fatigue (handgrip endurance and perceived exertion (RPE)) was markedly more in the untrained group. These findings can be buttressed with works of Anoka and Duchateau (2008) concluding that resistance to fatigue heavily depends on training status, especially the neuromuscular and central adaptations [14]. Individuals who have been trained also have better motor unit recruitment and firing rates and buffering capacity all of which play together to enhance muscular endurance. Also, the trained group showed reduced RPE scores during the post-exercise, which could possibly represent the psychological and physiological superiority of sustaining exercise-induced stress. Marino and others noted central fatigue and the role of psychological perception in the limitation of performance; they added that training increases an individual capacity to endure discomfort linked with lactate buildup and muscle fatigue [15]. Possible precedence to close periods of heavy training and better coping mechanism may also be another factor behind this phenomenon. Faster lactate clearance in trained persons in the recovery stage further attributes to better metabolic flexibility. Gladden (2004) outlined that trained individuals have a faster post-exercise recovery with increased lactate oxidation in both exercise and non exercise muscles, and improved lactate clearance by the liver and kidneys [16]. Such physiological processes are key towards reducing recovery time and maximizing training frequency. The findings of our study also concur with a meta analysis by Billet (2001) that athletes with a higher VO 2 max and lactate threshold perform better during recovery due to outstanding endurance capacity and recovery of both the aerobic and anaerobic stressors [17]. Such observations support the idea that lactate dynamics do not reflect merely acute performance capacity, but have a reflection on long-term training adaptations. Although our findings are robust, there are some limitations depending on where we got our results. It is possible that generalisablility could be restricted due to the small sample size and the fact that only male participants were used. There was also no controlling of diet and hydration and psychological factors, which may contribute to lactate levels and subjective fatigue. Future study must consider gender disparities and longitudinal training to further develop a mechanistic basis of these physiological differences. In summary, this study corroborates other findings that suggest individuals that are trained more successfully cope with exercise-induced lactate build up and have a higher tolerance to muscle fatigue. These results are significant to the fields of athletic training, rehabilitation, and exercise prescription, especially those involved in designing practice to maximize improvement in heightened metabolic efficiency and exercise duration [18].

5. CONCLUSION

Compared with untrained counterparts, trained people show less buildup of blood lactate levels during exercise, greater fatigue resistance, and recovery rates. These physiological benefits demonstrate enhanced metabolic economy and neuromuscular adaptation brought by regular training. These results contribute to the importance of formal exercise in enhancing high intrinsic and functional levels.

Limitations:

This study was limited by a small sample size and inclusion of only male participants, which restricts generalisablility. Other variables such as diet, sleep, hydration, and psychological factors were not controlled. The cross-sectional design also prevents long-term observation of training-induced changes over time in lactate and fatigue responses.

Future Findings:

Future studies should include larger, more diverse populations with both genders and varied age groups. Longitudinal study could better capture training adaptations over time. Incorporating additional biomarkers, VO_2 max, and neuromuscular assessments would offer a deeper understanding of fatigue mechanisms and exercise metabolism across different fitness levels.

Abbreviations

1.	RPE	Rate of Perceived Exertion
2.	MVC	Maximum Voluntary Contraction
3.	VO_2 max	Maximal Oxygen Uptake
4.	MCT	Monocarboxylate Transporter
5.	bum	Beats Per Minute
6.	SPSS	Statistical Package for the Social Sciences
7.	SD	Standard Deviation

Disclaimer: Nil

Conflict of Interest:Nil

Funding Disclosure: Nil

Authors Contribution

Concept & Design of Study: Dr. Zahra Habib

Drafting: Najam-ul-Sehar Javed, , Madiha Ali

Data Analysis: Shazadi Ambreen, Ayesha Imtiaz

Critical Review: Asma Hussain , Hina Munir

Final Approval of version: Muhammad Imran Aftab

REFERENCES

[1] Nakamura K, Fujiwara T, Horsehide S, Ishiyama Y, Take M, Ozawa S, Kari K. Differences in exercise-induced blood pressure changes between young trained and untrained individuals. *The Journal of Clinical Hypertension*. 2021 Apr; 23(4):843–848. https://doi.org/10.1111/jch.14162

[2] Kush K, Matysiak J, Kook ZJ, Ciekot-Sołtysiak M, Klupczyńska-Gabryszak A, Zarębska EA, Plea S, Dereziński P, Zieliński J. Exercise-induced response of proteinogenic and non-proteinogenic plasma free amino acids is sport-specific: A comparison of sprint and endurance athletes. *PLOS ONE*. 2024 Aug 30; 19(8):e0309529. https://doi.org/10.1371/journal.pone.0309529

[3] Broome SC, Pham T, Brachium AJ, Nearing R, Wang HW, Hickey AJ, Mitchell CJ, Merry TL. Matos supplementation augments acute exercise-induced increases in muscle PGC1α mRNA and improves training-induced increases in peak power independent of mitochondrial content and function in untrained middle-aged men. *Redo Biology*. 2022 Jul 1; 53:102341. https://doi.org/10.1016/j.redox.2022.102341

[4] Zara R, Devrim-Lanpir A, Guazzotti S, Ali Redhead A, Prokopidis K, Spadaccini D, Cinnabar R, Cone E, Henselmans M, Aragon AA. Effect of soy protein supplementation on muscle adaptations, metabolic and antioxidant status, hormonal response, and exercise performance of active individuals and athletes: A systematic review of randomized controlled trials. *Sports Medicine*. 2023 Dec; 53(12):2417–2446.

https://doi.org/10.1007/s40279-023-01940-9

[5] Yan, B., Yao, S., Zhang, J., Li, C., Han, T., Hub, Q., & Live, K. (2025). Effects of asymmetric load bench press offset training on muscle activation levels and exercise-induced fatigue in collegiate bodybuilders. *Frontiers in Physiology, 16*, 1592477. https://doi.org/10.3389/fphys.2025.1592477

[6] Elite, C. D., Novice, P. V., Rica, R. L., Barros, B. M., Machado, A. F., Evangelista, A. L., Elite, R. D., Braun, V. G., Maia, A. F., & Bubaline, D. S. (2023). Exercise-induced muscle damage after a high-intensity interval exercise session: Systematic review. *International Journal of Environmental Study and Public Health, 20*(22), 7082. https://doi.org/10.3390/ijerph20227082

[7] Fugato, E., Prepaid, H. P., & Saguaro, D. (2024). L-carnation supplementation decreases post-exercise blood lactate levels and enhances aerobic capacity in trained individuals: Systematic review and meta-analysis. *Trends in Sport Sciences, 31*(3). https://doi.org/10.23829/TSS.2024.31.3

[8] Ross, M., Karl, C. K., Ferguson, R., Gavin, T. P., & Hells ten, Y. (2023). Exercise-induced skeletal muscle angiogenesis: Impact of age, sex, angiocrines and cellular mediators. *European Journal of Applied Physiology, 123*(7), 1415–1432. https://doi.org/10.1007/s00421-023-05197-7

[9] Franz, A., et al. "Comparison of Metabolic, Ionic, and Electrolyte Responses to Exhaustive Low-Load Strength Training With and Without Blood Flow Restriction and High-Load Resistance Training." *Scandinavian Journal of Medicine & Science in Sports*, vol. 34, no. 9, 2024, e14721. https://doi.org/10.1111/sms.14721

[10] Markus, I., Constantine, K., Hoffman, J. R., Bartolommeo, S., & Genre, Y. (2021). Exercise-induced muscle damage: Mechanism, assessment and nutritional factors to accelerate recovery. *European Journal of Applied Physiology, 121*(4), 969–992. https://doi.org/10.1007/s00421-020-04552-3

[11] Zara, R., Devrim-Lanpir, A., Guazzotti, S., Redhead, A. A., Prokopidis, K., Spadaccini, D., Cinnabar, R., Cone, E., Henselmans, M., & Aragon, A. A. (2023). Effect of soy protein supplementation on muscle adaptations, metabolic and antioxidant status, hormonal response, and exercise performance of active individuals and athletes: A systematic review of randomized controlled trials. *Sports Medicine, 53*(12), 2417–2446. https://doi.org/10.1007/s40279-023-01953-2

[12] Ross, M., Karl, C. K., Ferguson, R., Gavin, T. P., & Hells ten, Y. (2023). Exercise-induced skeletal muscle angiogenesis: Impact of age, sex, angiocrines and cellular mediators. *European Journal of Applied Physiology, 123*(7), 1415–1432. https://doi.org/10.1007/s00421-023-05197-7

[13] Schierbauer, J., Wolf, A., Wachsmuth, N. B., Massena, N., & Schmidt, W. F. (2023). Relationship between blood volume, blood lactate quantity, and lactate concentrations during exercise. *Metabolites, 13*(5), 632. https://doi.org/10.3390/metabo13050632

[14] Markus, I., Constantine, K., Hoffman, J. R., Bartolommeo, S., & Genre, Y. (2021). Exercise-induced muscle damage: Mechanism, assessment and nutritional factors to accelerate recovery. *European Journal of Applied Physiology, 121*(4), 969–992. https://doi.org/10.1007/s00421-020-04552-3

[15] Kowalski, T., Klusiewicz, A., Rabid, K., Walk, A., & Starczewski, M. (2024). Comparative study of different respiratory muscle training methods: Effects on cardiopulmonary indices and athletic performance in elite short-track speed skaters. *Life, 14*(9), 1159. https://doi.org/10.3390/life14091159

[16] Zoo, C., Yin, Y., Zhen, Z., Mu, R., Liang, Y., Wang, S., & Ye, C. (2025). Unlocking the full potential of resistance training: A comparative analysis of low- and high-intensity effects on neurotrophic growth factors and homocysteine. *Discover Applied Sciences, 7*(2), 108. https://doi.org/10.1007/s42452-024-01408-x

[17] Mons, V., Laving, C., Mesta, O., Mauro, B., & Blain, G. M. (2025). Ageing exacerbates the adverse effects of respiratory muscle fatigue on vascular function, locomotors muscle fatigue and exercise performance in males. *Experimental Physiology*. Advance online publication. https://doi.org/10.1113/EP092422

[18] Rosa, A., Coleman, M., Haunt, C., Grid, J., & Schoenfeld, B. J. (2023). Repetition performance, rating of perceived discomfort, and blood lactate responses to different rest interval lengths in single-joint and multipoint lower-body exercise. *The Journal of Strength & Conditioning Study, 37*(7), 1350–1357. https://doi.org/10.1519/JSC.0000000000004437