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A Statistical Review Of Physical Recovery As Limiting Factor For The Performance Of Track & Field Sprinters And Distance Runners

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ABSTRACT

Background: The physical and mental training fatigue imposes internal and external stress on athletes which needs to be recovered through diversified techniques including the application of physiological and psychological recovery strategies to attain optimal performance from elite professional track & field athletes.

Objectives: The main objective of the study was to determine the differences in number of training sessions per week and its effects on the performance of elite track & field sprinters and distance runners.

Methodology: This was 8 weeks experimental study in which total 40 professional / semi-professionals, aged between 18-35 years (20) athletes participated in each group of distance runners (5000m) and sprinters (100m). Five (male / female) athletes were distributed into four different strata / groups in each category. Eight weeks intervention training program was implemented at Pakistan Sports Board, in a controlled training environment. To measure the physical muscular recovery, the four strata A, B, C & D were allocated (90 minutes training) intervention for five sessions, seven session, nine and eleven sessions per week respectively. Athletes with any trauma, injury and medical issues were also excluded from the study. Above 35 years and below 18 years including the coaches and officiating staff were also excluded. Additional three athletes were allocated to each group / strata to replace the injured if any during intervention. Moreover, the results non-replaced additional athletes were not counted during analysis. The pre-post analysis of interventions was conducted through Minitab and SPSS-25 version.

Results: The fitness and actual event performance (pre-post) intervention results showed significant difference in both the track & field categories. The null hypothesis of both the sports events were rejected on the basis of results of one sample t-test (p-value<0.005). Thus the impact of eight weeks intervention showed existence, significant difference in both sprinters and distance runners performance. Only two athletes from group C and one athlete from group D couldn't complete the intervention program due to illness & injuries, which were replaced by the additional athletes.

Conclusion: The study concludes that eight week physiological training intervention significantly not only improved the fitness capacity of distance runners and sprinters but also improved the actual event performance due to fitness gains in different strata / groups accordingly.

KEYWORDS: Endurance, Distance Runners, Sprinters, VO2max, Cardiovascular, Optimal & Peak Performance.

2. Introduction:

The concept of training load and recovery for performance in sports has not developed all of sudden; rather it has been refined systematically with experience and experiments with the passage of time (Halson, 2014). In ancient times, the trainers and coaches had been preparing athletes to attain highest athletics performance. However in early 1900s, the exercise physiologists started applying skills & strategies associated with exercise and adaptation to training. Progressively the evidence based research explored the mechanism behind muscular contraction, breakdown and recovery of energy through mitochondrial process including fatigue and motor-coordination (Zhang et al., 2021). The main stream coaches usually adopt scientific approaches for better improvement in performance for sprinters and marathon runner athletes. The application of principles of biology particularly the principle of "dose and response" became more common in athletes having will to compete and win (Nakamura et al., 2020). The training through "dose and response" to attain optimal performance from elite professionals became more popular day by day. Besides the scientific approaches, training such as circuit training, interval training and aerobic training were adopted by the coaches to enhance the performance of professional athletes. Other allied strategies including recovery through nutrition, biomechanics and psychological measures were also added in the training to athletes for optimal performance. Athlete's body was exposed to different internal and external training loads before and during the competitions. They were observed during fatigue-inducing state resulting from physiological and psychological limits leading to a reduction in physical or mental performance. Fatigue was recognized through its consequences, such as lowered work output for a longer period of time in experienced base coaching all over the world. The understating of load and recovery by the professional trainers kept on improving to achieve the desired results. The discussions took place about the recovery period during training and between training sessions whether; be adequate or not to fulfill the muscular requirements to obtain optimal performances in track & field events. The sports scientists, coaches and trainers took a long time to understand the relation between fatigue and recovery amongst elite track & field performances. The comparison of improved results from first modern Athens Olympics in 1896 to recently concluded Tokyo Olympics 2020 have also strengthened the evidence about progressive improvement through physiological and psychological recovery strategies. Today's athletes are performing much better as compared to few decades back in sports history due to advancements in training techniques. Thomas Burke of United States won the gold medal in 100-meter race with the timings of 12.00 (seconds) in Athens Olympics 1896 and now the timings of Usain Bolt(Jamaica) in 100 meter is 9.58 (seconds) which fully endorsed the scientific approaches being implemented by coaches(Reardon et al., 2019). But room for improvement is still there with better understandings of scientific streaks and recovery strategies.

The recovery may be defined as short-term, mid-term or long-term restoration of neuromuscular process for performance. The recovery between training session and intervals between training

repetitions can bring positive improvements in individuals and team sports if utilized and executed by the trainers and coaches at correct time before peaking the athletes. The correct understanding of recovery strategies including well planned macro cycle training program on the onset of the periodization also help to reduce chances of injuries during competition phase (Bompa & Buzzichelli, 2019).Systematically planned and comprehensively gauged workload will allow trainers and coaches to quantify the better adopted approach for athletes. Most of the researchers and trainers are of the opinion that during periodization, overtraining may lead to overtraining syndrome (OTS) and major injuries before and during competition.. But the most important factor is the close interaction between trainers and athletes for close observation all time, which can easily reduce the chances of (0TS) & injuries (Cadegiani & Kater, 2019). Most of the South Asian countries including Pakistan, India, Bangladesh and Afghanistan still don't give due weightage to psychological or mental training to professional athletes. As compared to South Asian countries, the European countries adopted the advance and systematic versions of training and brought improvements in team and individual sports. The training pattern of sprinters and distance running athletes is totally endurance based without measuring and implementing the muscular recovery in developing countries which needs to be re-addressed by the professional trainers & coaches (Grgic et al., 2018).The main objective of this research is to examine the physical recovery as limiting factor for the performance of track & field sprinters (100m) and (5000m) distance runners.

3. Literature Review

The philosophy of exercise training and its positive or negative effects on athletes' body has manipulated the performance of elite professionals before centuries. Sports experts and trainers kept on influencing training load with different experiments to improve the performance of athletes(Black et al., 2017). The19th century witnessed, when physiologists applied skill and physiology related subjects to improve the sports performance of professional athletes(Hut et al., 2021). Meanwhile, the evidence based scientific research including the muscle contraction, regeneration; fatigue and recovery for optimal performance were also added into training by sports scientists. Heat tolerance and acclimatization to hot environment were also understood and included in periodization. The application of exercise physiology was became permanent feature of sports training in 1970 with goals to improve performance(Black et al., 2017). It was the time when trainers realized the importance of scientific understanding and application of principles of training in sports particularly in track & field. This new concept and scientific approach to training opened new window of opportunities for experts to understand the principles of circuit training, endurance training, aerobic and anaerobic forms of training exercise (Delgado et al., 2020). Moreover, few other performance enhancement strategies were also introduced and implemented like recovery through nutrition and sports psychology (Johnson et al., 2011). The concept of exercise training and its implication entered in new era to achieve optimal performance in late 1980s and adopted in training by advance sports nations to produce better results. The science involved in training especially exercise physiology, biomechanics and mental therapy is becoming authentic and evident on each passing day thus; bringing excellent effects in competitive sports.

The science of exercise training has revolutionized the sports performance for the last 40-50 years speedy as compared to old ancient Olympics in 776 BC at Greece (Pawik et al., 2019).

The paramount principle of training which affects the performance of athletes is the overload(Suchomel et al., 2016). This important facet of training methodology was researched and studied systematically fifty years ago and refined for optimal performance by the trainers(Cadegiani & Kater, 2019). This principle forms the basis of training programs and professional sports periodization. The application of overload coincided with understanding of physiological and adaptation of athlete's body with the great exposure to stress and strain during training (Timpka et al., 2022). Due to increase in training load during training, muscular hypertrophy occurs due to activation of protein synthesis pathways. This process is slow and may take several weeks which must be understood by the trainers to improve the performance of athletes with passion (Grgic et al., 2018).

Moreover the overtrading not only causes injuries to athletes but also decreases the performance of professional athletes. The concept of overtraining is directly proportional to the recovery and performance of athletes. If trainers fail to provide required mental and physical recovery to athletes then it will adversely affect the performance in competitive sports(Cadegiani & Kater, 2019).

There are various methods and techniques used by trainers and coaches to identify the overtraining or fatigue levels among athletes during pre-competition or in competition phases. The most famous methods are retrospective questionnaires, training booklets, physiological screening through different tests and direct observation method and psychological screening of athletes (Freitas et al., 2014) and (Gharbi et al., 2016). A good trainer or coach keeps close surveillance and visual observation on professional athletes especially during pre-competition and competition phases to inculcate mental therapy intervention for optimal performance at all levels (Killer et al., 2017). Most of the time the indicators of overtraining are visible but occasionally these are invisible due to individualization principle.It's the duty of sports psychologists and experts to observe and identify through scientific questionnaires(Zaras et al., 2021).

4. Materials and Methods

Data: Total 40 athletes were distributed (20 each) in track & field sporting events i.e. sprinters (100m) and long distance (5000m). Each sports event athletes were further distributed into equal four strata A, B, C & D (five each) respectively. The pre-post intervention fitness and actual event performance tests were conducted to analyze the eight weeks' impact on the performance.

Methods: Both descriptive and Inferential Statistical techniques are considered to explore / analyze the data. As a summary statistics, Mean$\pm$ SD along with few graphical views used to initially explore the data. Normality of the data is determined by Kolmogorov-Smirnov and Shapiro-Wilk tests. Inter and intra strata comparisons were explored through Two Samples Wilcoxon Test. Analysis of variance (ANOVA) was considered for both sports sprints and distance runners. On the basis of ANOVA results, post-hoc tukey is also implemented. Pre experiment screenings were also carried out of all the respondents to assess fitness conditions.

For overall analysis two well-known statistical software Minitab and SPSS (v-25) are considered / used.

5. Results

To conduct this research, data have been collected from national/ international track & field athletes whereas the research was conducted at Pakistan Sports Board Islamabad. Thus, the respondents were distributed into four types of strata / groups in which (90 minutes) training sessions were provided to all four strata's:

Strata A: conducted 5 training sessions (90 minutes) per week
StrataB: conducted 7 training sessions (90 minutes) per week
StrataC: conducted 9 training sessions (90 minutes) per week
StrataD: conducted 11 training sessions (90 minutes) per week
The duration of intervention training was of 8 weeks for all strata/ groups respectively. Besides these, the data have been collected from 40 athletes (males and females), 20 from each group of sprinters (100m) and distance runners (5000m) of track & field. The null and alternative hypotheses of the study are:

H_0: The number of training sessions per week and recovery period is not associated with the performance of track & field sprinters and distance runners.
H_A: The number of training sessions per week and recovery period is associated with the performance of track & field sprinters and distance runners.

5.1 Normality of data

Initially, the normality of the data is tested before moving towards the other statistical tests. For this purpose, two normality tests: Kolmogorov-Smirnov and Shapiro-Wilk tests of normality are considered (see, Table 1).

Table 1: Kolmogorov-Smirnov and Shapiro-Wilk tests of normality of Event / Groups

Events	Measuring Unit	Kolmogorov-Smirnova		
		Estimated value	df	p-value
Sprinters	Seconds	0.241	20	.198*
Long Racers	Minutes	0.281	20	.072*

Table 1 represents that data of the sports events from all four stratas (Sprinters and Long racers) is normally distributed because in both cases the p-value (> 0.005).

5.2: Two Samples Wilcoxon Test

To evaluate the Pre-Post intervention significance w.r.t gender for sprinters (100m) and long racers (5000m), comparison is carried out on the basis of strata (A, B, C & D). Thus, the two samples Wilcoxon test of unequal number of observations has been applied which forms the following the null & alternative hypothesis:
H_0:The pre-post intervention difference w.r.t gender is zero
H_A:The pre-post intervention difference w.r.t gender is not zero
This statement has been tested and evaluated at 5% level of significance for all track and field events (see,Table 2).

Table 2: The results of Two Samples Wilcoxon testfor pre-post-performance comparison of sprinters and distance racers

Track & Field Events	Status	Gender	n	Mean± SD	P-Value
Sprinters (Seconds)	Pre	Male	12	10.87±0.11	<0.001
		Female	08	12.68±0.07	
	Post	Male	12	10.68±0.14	<0.001
		Female	08	12.41±0.18	
Long Racers (Minutes)	Pre	Male	08	15.67±0.33	<0.001
		Female	12	20.46±0.55	
	Post	Male	08	15.23±0.50	<0.001

		Female	12	19.79±0.69	

Table 2 showed that both the track and field events sprinters and long racers have a significant pre-post intervention performance w.r.t gender because; the p-value is less than the level of significance ($\alpha = 0.05$) in all cases. Thus all null hypotheses corresponding to both track and field events are rejected, representing that athletes have improved their fitness and actual event post-performance significantly.

5.3 Analysis of Inter-Strata Performance

In each Track & Field event of sprinters (100 m) and distance runners (5000 m), initially, the pre-post intervention difference is displayed through boxplots for the appraisal of performance (see, Figure 1).

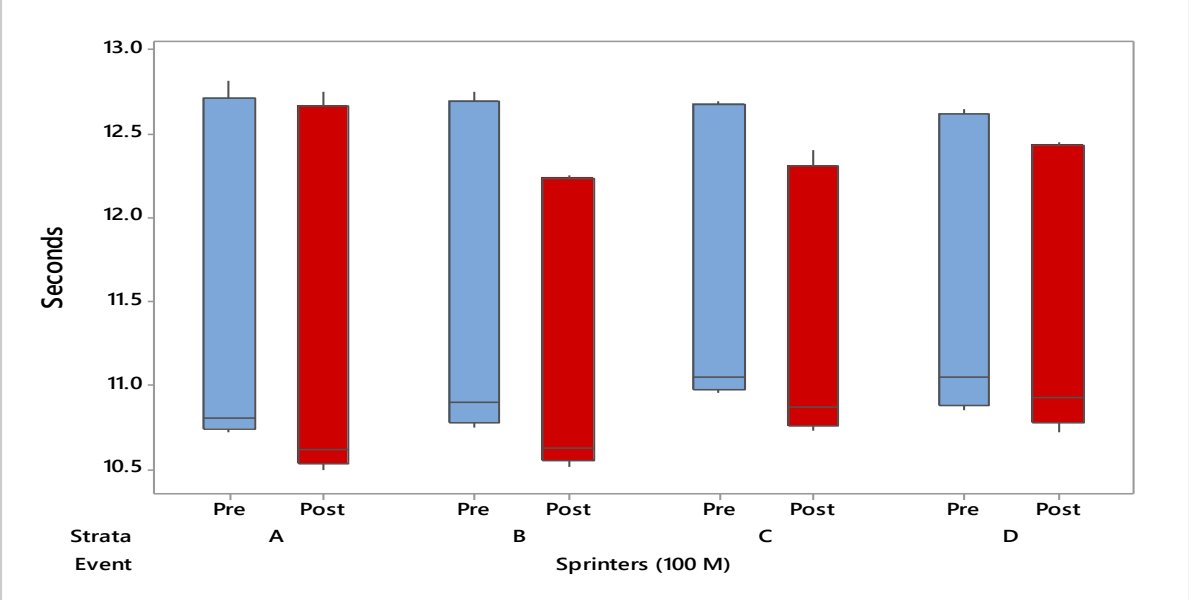

Figure 1: The Pre-post intervention of each strata of Sprinters (100 shown through Boxplots

The figure 1, representing the pre-post intervention difference of each strata of Sprinters (100m), in seconds through boxplot(minimum value, Q1, median, Q3 and maximum value). Overall, there is a decreasing trend from pre to post intervention due to decrease in timings which is ultimately showing the improvement of performance. Overall strata A and B showed more improvement as compared to strata C and D respectively.

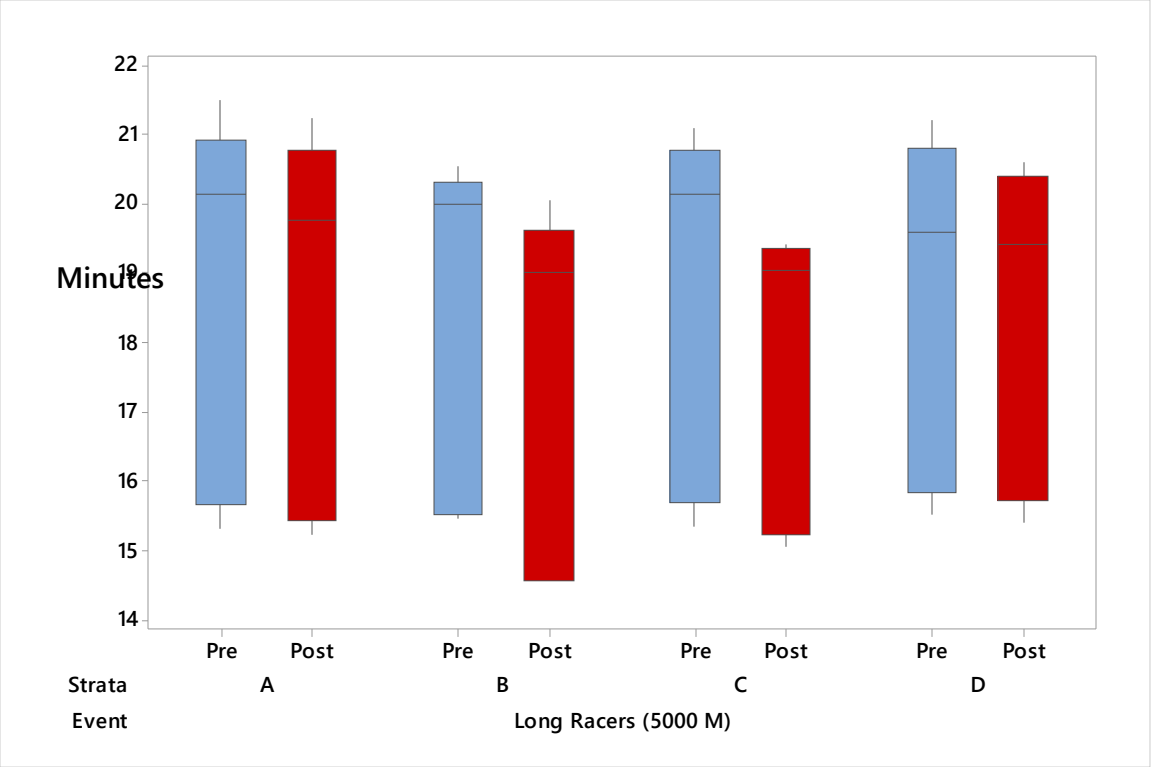

Figure 2: The Pre-post intervention of each strata of Long Racers (5000m). The boxplots representing the pre-post intervention difference of each strata of Long Racers (5000m) in minutes, through five number summaries (minimum value, Q1, Median, Q3 and Maximum value). Overall, there is a decreasing trend from pre to post intervention due to decrease in timings which ultimately shows the improved performance trend amongst endurance runners. Overall strata B showed the highest improvement followed by strata C, D and A respectively.

5.4. Analysis of Variance

The analysis of variance (ANOVA) test has been considered to compare the equality of four strata (A, B, C & D) for pre-post intervention differences. The null hypothesis undertaken is as follows:

H_0:The pre-post intervention differencesfor all four starta are equal

H_A: The pre-post intervention differencesfor all four starta are not equal

At 5% level of significance, the components of Combined ANOVA (see, Table 4) to evaluate the significance of four Strata (A, B, C & D) for sprinters and long Racers are as follows:

Table 4: Combined ANOVA table to evaluate the significance of four Strata (A, B, C & D) for Track & Field (Sprinters & Long Racers)

Sports Events	Source	df	Sum of Squares	Mean Squares	F-value	R^2	P-Value
Sprinters (100m)	Event	3	0.132	0.0441	4.25	44.34%	0.022
	Error	16	0.166	0.0104			
	Total	19	0.299				
Long Racers	Event	3	2.311	0.7703	7.02	56.83%	0.003
	Error	16	1.756	0.1097			

	Total	19	4.066				

Results of combined ANOVA table (see, table 4) showed that all four Strata (A, B, C & D) are significantly different as p-value<0.05 for track and field (Sprinters & Long Racers). The values of coefficient of determination (R^2) are 44.34% & 56.83%, for Sprinters & Long Racers respectively representing goodness of fit of the analysis of variances for all strata.

5.6Post HOC Tukey Pairwise Comparisons

Due to rejection of null hypothesis of equality of four strata, the inference after ANOVA is considered for the appraisal of pair wise comparison among these four strata. Thus Post Hoc Tukey test for pair wise comparison is applied.

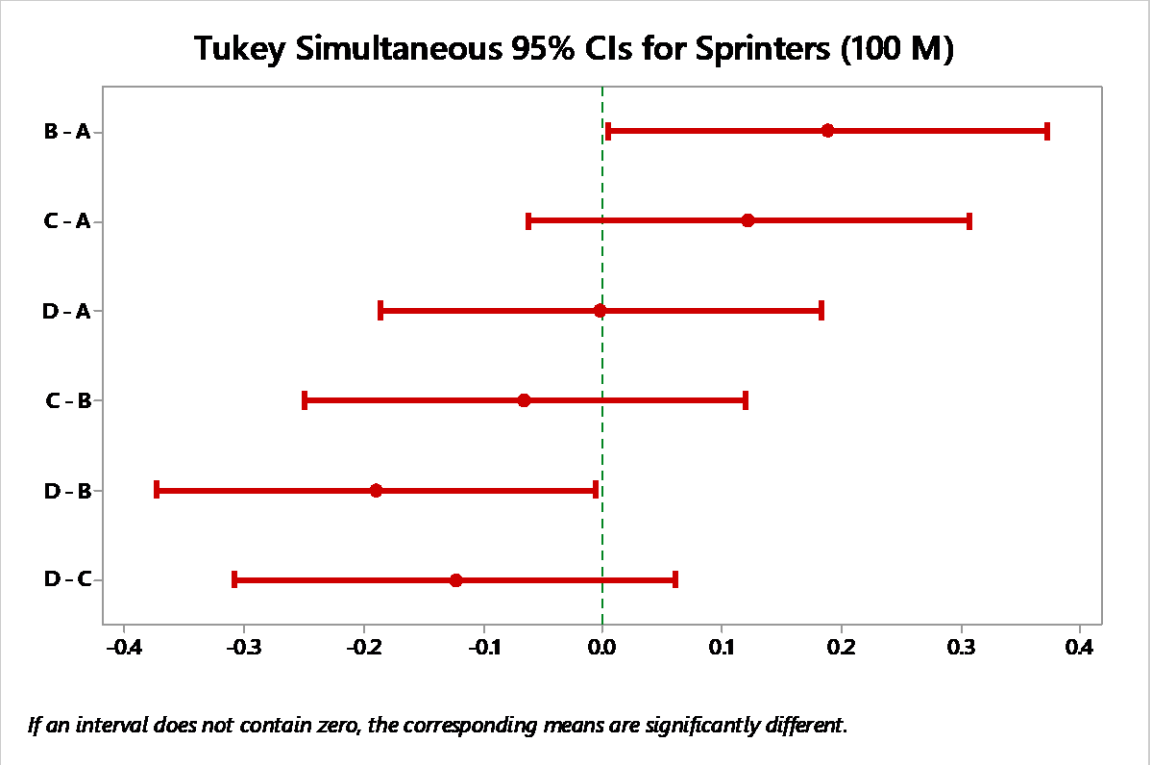

Figure 3: Post Hoc Tukey test for Pre-Post intervention differences of Sprinters (Seconds) to evaluate the pairwise comparison (A-B, A-C, A-D, B-C, B-D, C-D) of all four Strata has been reflected / highlighted.

Table: 5:Post Hoc Tukey test for Pre-Post intervention differences of Sprinters (Seconds) to evaluate the pairwise comparison (A-B, A-C, A-D, B-C, B-D, C-D) of all four Strata

Event	**Strata**	**N**	**Mean**	**Grouping**	
Sprinters (Seconds)	B	5	0.330	A	
	C	5	0.264	A	B
	A	5	0.142		B
	D	5	0.140		B

*Means that do not share a letter are significantly different.

The table 5 represents the comparison of all groups in-relation to significance levels of all available pairs. All the pairs show significant from each other except pair A-D which indicates less significant as compared to all others.

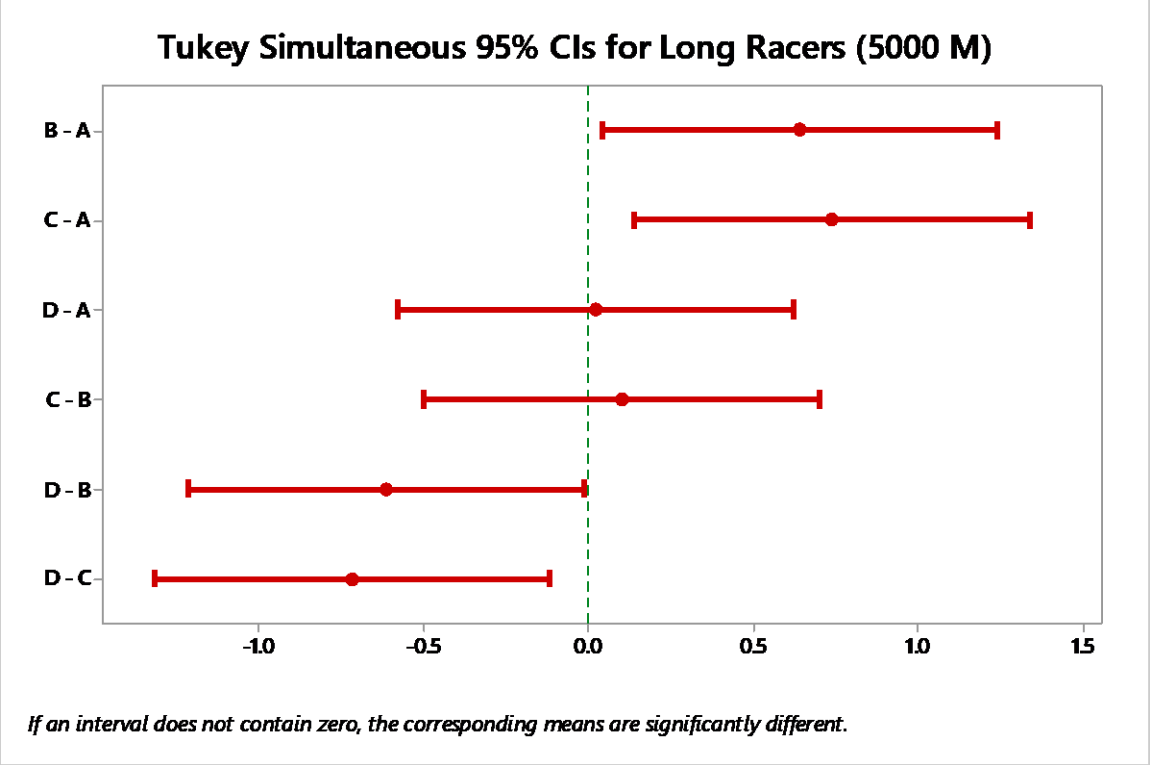

Figure 4: Post Hoc Tukey test for Pre-Post intervention differences of Long Racers (5000 M) to evaluate the pairwise comparison (A-B, A-C, A-D, B-C, B-D, C-D) of all four Strata have been indicated above.

Table 6: Post Hoc Tukey test for Pre-Post intervention differences of Long Racers (5000 M) to evaluate the pairwise comparison (A-B, A-C, A-D, B-C, B-D, C-D) of all four Strata

Event	Strata	N	Mean	Grouping	
Long Racers (Minutes)	C	5	0.964	A	
	B	5	0.864	A	
	D	5	0.248		B
	A	5	0.228		B

*Means that do not share a letter are significantly different.

The table 6 represents the comparison of all groups in-relation to significance levels of all available pairs. All the pairs show significant from each other except pair A-D which reflects less significant levels as highlighted in table and figure 4 above.

6. Discussion

The physical and mental recovery plays a vital role not only to maintain the peak performance of track and field athletes during competition but also have significant effects in improved world class performances. Due to illiteracy of the

coaches about the techniques and strategies of physical and mental recovery the performance of athletes not only decreases but also become the main cause of injuries especially during completion phases. The training methodology is considered of two folds. The first includes monitoring athlete's adaptation of stress during training to determine the recovery strategies; whereas the second is specific recovery technique to diminish the fatigue of training before competition. The physical recovery includes quality sleep, massage, active rest and hydration.

During this experimental study, the data have been processed to determine the impacts and requirements of recovery on the performance of track and field sprinters (100m) and long racers (5000m) respectively. Initially the data was processed to compute descriptive measures of all demographic variables for all groups. Group-wise two samples Wilcoxon test was applied for assessing the significance of pre experiment performance to post experiment performances. The Pre-Post performance analysis of all groups is considered and six pair-wise comparisons of all groups are performed using the output of analysis of variance (ANOVA) and Tukey Post Hoc analysis were also performed on the rejection of null hypothesis of equality of all groups. Results based on two samples Wilcoxon test at 5% level of significance showed the p-value $0.001<0.05$ representing the rejection of null hypothesis and confirming the significance of post fitness scores. In addition to this, the comparisons of pre actual performance to post actual performance of sprinters and distance runner athletes were also analyzed.

The descriptive analysis of the sprinters pre-intervention performances using Mean $\pm$SD was 10.87 ± 0.11 (seconds) for male and 12.68 ± 0.07 (seconds) for females respectively; whereas the post-performance of male and female sprinters were 10.68 ± 0.14 (seconds) and 12.41 ± 0.18 (seconds) respectively. The performance of long racing athletes Mean $\pm$SDathletes pre-intervention for male and female were 15.67 ± 0.33 (minutes) and 20.46 ± 0.55 (minutes) respectively. Moreover, the post-performance Mean $\pm$SD was assessed for male and females as 15.23 ± 0.50 and 19.79 ± 0.69 (minutes) respectively. The VO2maxof strata B & D highlights the highest and lowest with values of 54.32 & 53.68 (mL / kg / min) respectively. The speed through (30m-Dash) of Strata B showed the highest improvement after intervention which is 4.02 (seconds) whereas the Strata-A indicates the lowest levels of the improvement which is 4.22 (seconds) respectively. Similarly the strata D improved more strength after intervention which is 73.65 kg through (Bench press), whereas the Strata C showed the least improvement after intervention which is 63.10 kg of (bench press) respectively.

The study also highlighted and evaluated the hypothesis of equality of means of pre-post fitness tests (VO2max, Speed & Strength). The p-value of ANOVA test is $0.001<0.05$ which represented that all pre-post fitness tests (Beep, Speed & Strength) are significantly different along with the value of coefficient of determination (R^2=98.99%) expressed that goodness of fit of the ANOVA.

In most of the relative studies, the fitness of track & field athletes is considered decisive factor even in today's competitive sports. Numerous studies are available to evaluate and compare the alignment and significance levels of recently conducted research work. According to investigation about VO2max pre-post experiment of (Al-Naemi et al., 2021), the results showed Mean ± SD in Age (years) 20.58 ± 1.3 and BMI (kg/m2) 22.15 ± 2.42. Moreover, the Mean ± SD of pre-post VO2maxis 39.77 ± 5.2 and 42.88 ± 3.7 (mL/kg/min) respectively with significance (0.001) level of improvements. To compare the improvement of an important aspect of muscular

fitness, the upper body strength (Bench Press) was analyzed through different latest studies. Conferring to study on the low load and strength gain (Kikuchi & Nakazato, 2017), in which 18 males (9 in each group). The pre and post experiment performance of bench press group was observed, (1RM, from 60.0 ± 12.1 kg to 65.0 ± 12.1 kg, p value (< 0.001), whereas in the push-up group (1RM, from 61.1 ± 12.2 kg to 64.2 ± 12.5 kg, with p-value (< 0.001) found significant respectively.

According to (Cheng et al., 2016), the running trials of 5000m athletes were significantly improved with AA trials by 2.98 ± 3.24 % with p-value (<0.019) respectively. Moreover, it was also investigated that recovery through amino acid including quality diet and quality sleep besides the mental therapy play considerable role in improved performances of middle and long racers athletes of track & field.

7. Conclusion

The research concludes that, eight weeks physiological training intervention significantly not only enhanced the fitness capacity of distance runners (5000m) and sprinters (100m) but also improved the actual performance due to fitness gains in different strata accordingly. This study could be extended in various forms like requirements of specific nutrition, high altitude and colder region effects on the performance of track and fields in future.

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