COMPARISON OF MUSCLE ACTIVATION DURING ELLIPTICAL TRAINER, TREADMILL AND BIKE EXERCISE

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ABSTRACT: The purpose of this study is to compare muscle activation during elliptical trainer (ET), treadmill (TM) and bike (B) exercise. Twenty three voluntary and healthy male athletes (age, 20.65±1.65 years; weight, 74.21±7.21 kg; height, 180.69±5.31 cm; Body Mass Index, 22.4±1.5) participated in our study.
Study protocol was decided for three days. Measures were taken by using elliptical trainer on the first day, treadmill on the second day and bicycle device on the third. Exercise devices were run with 65% metabolic pulse for six minutes and at the end of the sixth minute, surface electrodes were placed on Biceps Brachii, Triceps Brachii, Pectoralis Major and Trapezius of upper extremity muscle and on Gastrocnemius, Vastus Lateralis, Rectus Femoris and Gluteus Maximus of lower extremity muscles and Electromyography (EMG) activities were measured. According to the finding of the study, it has been found out that all of the measured upper extremity muscle were more activated by elliptical trainer compared to treadmill and bike exercise ($p<0.05$). Also, it has been found out that Gastrocnemius and Gluteus Maximus of lower extremity muscle were more activated by treadmill compared to other exercise devices ($p<0.05$). Rectus Femoris muscle was more activated by elliptical trainer compared to bike exercise ($p<0.05$). EMG results of Vastus Lateralis did not show any statically differences ($p>0.05$).
In conclusion, due to the advantage of more upper extremity muscle activation, it has been thought that elliptical trainer is a device to be able to be used in rehabilitation and exercise science.

KEY WORDS: elliptical trainer, treadmill, bike, muscle activation

INTRODUCTION

Exercise is constantly gaining popularity. It has been widely used especially in the fields of sporting performance and rehabilitation. We are provided with new information with the help of testing methods and scientific researches in sports. Therefore, various exercises equipments are used in the developed performance testing protocols. Besides the science of sports, various exercise equipments are also used in the fields of medicine and rehabilitation [4].

Along with the developing technology, the designs of equipments used for exercising have increased and more sophisticated exercise equipments have been produced. Especially, treadmill and bike have important places among other exercise equipments.

Treadmill and bike allows us to observe the severe and broad movements applied in a narrow area, and by this way, enables us to make tests and kinematic analyses [1]. There are some testing methods using treadmill and bike to predict the aerobic and anaerobic capacities. Rhythmic leg movements have an important place in the researches to analyze the lower extremity functions, nerve control, rehabilitation and the science of sports [10].

Elliptical trainer, new equipment compared to these devices, has been gaining popularity in sport centers in recent years as alternative exercise equipment [6, 9, 7, 13, 12]. Elliptical trainer enables both lower and upper extremity muscles to act synchronously. In elliptical trainer, low body movement acts together with upper body in a static conversion and step movement [16]. Elliptical trainer creates a different movement trajectory when compared to treadmill and bike. Muscle recruitment activity is different when using the elliptical trainer, treadmill and bike. [5]. The person doing exercise on elliptical trainer should be aware of having to involve his both lower and upper extremities while using the device in order to get an optimal physical response [2]. It may be thought that more muscles are activated on elliptical trainer as more body parts involve in movement [18].

Determine the muscles used predominantly during the exercise on these three equipments may contribute to the regulation of available performance tests or the tests scheduled to be performed on these equipments. Besides, determining in which muscle groups the equipments are used more efficiently for rehabilitation and treatment may help treatment be more successful.

MATERIALS AND METHODS

Subjects: Twenty-three healthy volunteers among the students in School of Physical Education and Sports participated in the study. The mean age of the students participated in the study was 20.65±1.65 years, weight 74.21±7.21 kg, height 180.69±5.31 cm, and the mean body mass index was 22.4 ±1.5. Body mass index values were calculated using {weight (kg) /height^2 (m^2)} [8].

Procedure and Measurements: Study protocol was decided as three days. Measurements were taken by using elliptical trainer on the first day, treadmill on the second day and bicycle equipment on the third day. The brand of elliptical trainer used as exercise equipment was Precor EFX 576i., OH, USA, treadmill was Sports Art T 650M (5HP) and bicycle device was Sports Art C51U. Each volunteer made warm-up activity for five minutes in order to adapt to the exercise equipment and for personal adjustments.

After five minutes warm-up activity, surface electromyography electrodes (Surface Electrode NM-3128, Nihon Kohden, Japan) were placed on the central parts of "Biceps Brachii, Triceps Brachii, Pectoralis Major and Trapezius" muscles of upper extremity on the left side of the body. Reference electrode was placed on the wrist area of the left arm for upper extremity measurement. Before placing the electrodes, in order to prevent the artifact, first, the skin was cleaned with intoxicated solution and shaved to make it smooth, then, paste was applied between the skin and electrodes (Elefix Electrode Paste) and electrodes and its cables were fixed with an adhesive tape.

After attaching the electrodes to the skin, the subjects worked on the exercise equipment for six minutes within the 65% of maximum velocity heart rate. Personal maximum heart rate values were calculated using Karvonen formula {220 – age} [11]. Pulse rate were taken by using Polar RS 400 Finnish infrared pulse measuring device. At the end of the sixth minute, EMG activities of the muscles on which surface electrodes had been placed were measured using electromyography device (500Hz) (Nihon Kohden-Neuropack MEB 5504 F/K, Japan).

After measuring the upper extremity muscles, same electrodes were placed on the central parts of left leg of lower extremity muscles; "Gastrocnemius, Vastus Lateralis, Rectus Femoris and Gluteus Maximus". At the same time, lower extremity reference electrode was placed on the ankle of left leg. The subjects exercised on the same exercise equipments within the 65% of maximum heart rate velocity for six minutes and at the end of the sixth minute, the action potential amplitudes of muscles were measured on millivolt (mV) value.

Statistics: One-way ANOVA test was used in analyzing the electromyography values obtained from these muscles during the exercises on the elliptical trainer, treadmill and bicycle equipments and differences among groups were analyzed using Scheffe test, a Post hoc test. The level of significance used in this study was $p<0.05$.

RESULTS

In this section, in order to compare the muscle activations during elliptical trainer, treadmill and bicycle exercises, examined the statistical analyses of amplitude values obtained by using electromyography, which are the indicators of action potentials of eight different muscle groups (Biceps Brachii, Triceps Brachii, Pectoralis Major, Trapezius, Gastrocnemius, Vastus Lateralis, Rectus Femoris, Gluteus Maximus) and the findings obtained as a result of these analyses.

According to the ANOVA test results of EMG values obtained from muscles while using different exercise equipment; during elliptical trainer, treadmill and bicycle exercises, remarkable statistical differences were found in the muscles of upper extremity;

TABLE I. MEAN DISTRIBUTION OF EMG VALUES OF DIFFERENT MUSCLE GROUPS DURING ELLIPTICAL TRAINER, TREADMILL AND BIKE EXERCISES

		Sum of Squares	df	Mean Square	F	Sig.
Biceps Brachii	Between Groups	31.611	2	15.805	26.949	.000
	Within Groups	38.709	66	.587		
	Total	70.320	68			
Triceps Brachii	Between Groups	10.877	2	5.439	38.900	.000
	Within Groups	9.228	66	.140		
	Total	20.105	68			
Pectoralis Major	Between Groups	22.769	2	11.385	57.088	.000
	Within Groups	13.162	66	.199		
	Total	35.932	68			
Trapezius	Between Groups	7.476	2	3.738	31.550	.000
	Within Groups	7.819	66	.118		
	Total	15.295	68			
Gastrocnemius	Between Groups	12.282	2	6.141	10.282	.000
	Within Groups	39.418	66	.597		
	Total	51.700	68			
Vastus Lateralis	Between Groups	1.353	2	.676	1.969	.148
	Within Groups	22.676	66	.344		
	Total	24.029	68			
Rectus Femoris	Between Groups	7.792	2	3.896	3.663	.031
	Within Groups	70.197	66	1.064		
	Total	77.989	68			
Gluteus Maximus	Between Groups	1.382	2	.691	5.247	.008
	Within Groups	8.694	66	.132		
	Total	10.076	68			

Biceps Brachii (F=26,949, p<.05), Triceps Brachii (F=38,900, p<.05), Pectoralis Major (F= 57,088, p<.05), Trapezius (F= 31,550, p<.05) and in the muscles of lower extremity; Gastrocnemius (F=10,282, p<.05), Rectus Femoris (F= 3,663, p<.05), and Gluteus Maximus (F=5,247, p<.05). The values obtained from Vastus Lateralis (F= 1,969, p>.05) from lower extremity muscles are not statistically significant (Table 1).

According to Scheffe test results of EMG values obtained from upper extremity muscles during elliptical trainer, treadmill and bicycle exercises; it has been observed that the highest EMG value for Biceps Brachii, Triceps Brachii, Pectoralis Major and Trapezius muscles were obtained during elliptical trainer exercise. These upper extremity muscles values during elliptical trainer exercise are statistically remarkably higher (p<.05) than those obtained during treadmill and bicycle exercise. There are no significantly statistical differences between these upper extremity muscles values during treadmill and bicycle exercises (p>.05), (Table 2).

According to Scheffe test results of EMG values obtained from Gastrocnemius and Gluteus Maximus from lower extremity muscles during elliptical trainer, treadmill and bicycle exercises, it has been observed that the highest EMG value for Gastrocnemius and Gluteus Maximus muscles were obtained during treadmill exercise. Gastrocnemius and Gluteus Maximus values during treadmill exercise are statistically significantly higher (p<.05) than those obtained during elliptical trainer and bicycle exercises. There are no statistically significant differences between Gastrocnemius and Gluteus Maximus values during elliptical trainer and bicycle exercises (p>.05), (Table 3).

According to Scheffe test results of EMG values obtained from rectus femoris from lower extremity muscles during elliptical trainer, treadmill and bicycle exercises; elliptical trainer has more rectus femoris values compared to bicycle exercise. This value is statistically on a significant level (p<.05). Rectus femoris values between treadmill and elliptical trainer and between treadmill and bicycle exercise are not statistically significant (p>.05), (Table 3).

According to Scheffe test results of EMG values obtained from vastus lateralis from lower extremity muscles during elliptical trainer, treadmill and bicycle exercises; there are no statistically significant differences between vastus lateralis values during elliptical trainer, treadmill and bicycle exercises (p>.05), (Table 3).

TABLE 2. MEAN DISTRIBUTION OF EMG VALUES OF UPPER EXTREMITY MUSCLES DURING ELLIPTICAL TRAINER, TREADMILL AND BIKE EXERCISES.

	Exercise devices (I)	Exercise devices (J)	Mean Difference (I-J)	Std. Error	Sig.
Biceps Brachii	Treadmill	Bike	.04783	.22583	.978
		Elliptical Trainer	-1.41130	.22583	.000
	Bike	Treadmill	-.04783	.22583	.978
		Elliptical Trainer	-1.45913	.22583	.000
	Elliptical Trainer	Treadmill	1.41130	.22583	.000
		Bike	1.45913	.22583	.000
Triceps Brachii	Treadmill	Bike	-.01391	.11026	.992
		Elliptical Trainer	-.84913	.11026	.000
	Bike	Treadmill	.01391	.11026	.992
		Elliptical Trainer	-.83522	.11026	.000
	Elliptical Trainer	Treadmill	.84913	.11026	.000
		Bike	.83522	.11026	.000
Pectoralis Major	Treadmill	Bike	.04217	.13169	.950
		Elliptical Trainer	-1.19696	.13169	.000
	Bike	Treadmill	-.04217	.13169	.950
		Elliptical Trainer	-1.23913	.13169	.000
	Elliptical Trainer	Treadmill	1.19696	.13169	.000
		Bike	1.23913	.13169	.000
Trapezius	Treadmill	Bike	.09826	.10150	.628
		Elliptical Trainer	-.64391	.10150	.000
	Bike	Treadmill	-.09826	.10150	.628
		Elliptical Trainer	-.74217	.10150	.000
	Elliptical Trainer	Treadmill	.64391	.10150	.000
		Bike	.74217	.10150	.000

TABLE 3. MEAN DISTRIBUTION OF EMG VALUES OF LOWER EXTREMITY MUSCLES DURING ELLIPTICAL TRAINER, TREADMILL AND BIKE EXERCISES.

	Exercise devices (I)	Exercise devices (J)	Mean Difference (I-J)	Std. Error	Sig.
Gastrocnemius	Treadmill	Bike	.90609	.22789	.001
		Elliptical Trainer	.88348	.22789	.001
	Bike	Treadmill	-.90609	.22789	.001
		Elliptical Trainer	-.02261	.22789	.995
	Elliptical Trainer	Treadmill	-.88348	.22789	.001
		Bike	.02261	.22789	.995
Vastus Lateralis	Treadmill	Bike	.33391	.17285	.163
		Elliptical Trainer	.09913	.17285	.849
	Bike	Treadmill	-.33391	.17285	.163
		Elliptical Trainer	-.23478	.17285	.403
	Elliptical Trainer	Treadmill	-.09913	.17285	.849
		Bike	.23478	.17285	.403
Rectus Femoris	Treadmill	Bike	.16217	.30412	.868
		Elliptical Trainer	-.61783	.30412	.135
	Bike	Treadmill	-.16217	.30412	.868
		Elliptical Trainer	-.78000	.30412	.043
	Elliptical Trainer	Treadmill	.61783	.30412	.135
		Bike	.78000	.30412	.043
Gluteus Maximus	Treadmill	Bike	.28783	.10703	.032
		Elliptical Trainer	.31130	.10703	.019
	Bike	Treadmill	-.28783	.10703	.032
		Elliptical Trainer	.02348	.10703	.976
	Elliptical Trainer	Treadmill	-.31130	.10703	.019
		Bike	-.02348	.10703	.976

DISCUSSION

The obtained results evidenced that, upper extremity muscles Biceps Brachii, Triceps Brachii, Pectoralis Major and Trapezius were more activated during elliptical trainer exercise than treadmill and bike exercises. In accordance with the obtained results, Browder et al. used EMG device in measuring the muscle activations. Consequently, biceps brachii results obtained from elliptical trainer and were higher compared to those obtained from treadmill and bike exercises [3].

In our study, according to result of lower extremity muscles Gastrocnemius and Gluteus Maximus muscles were more activated during treadmill exercises than elliptical trainer and bicycle exercises. Rectus femoris muscle was more activated during elliptical trainer exercise than bike exercise. There are no statistically significant differences between vastus lateralis values during elliptical trainer, treadmill and bicycle exercises.

Literature researches aimed to compare the muscle activations on elliptical trainer, treadmill and bicycle equipments have indicated that there are limited numbers of studies related to this subject. In the literature, there are studies comparing mainly the physiological responses to exercise equipments.

In the study carried out by Mier and Feito in some physical responses were compared during elliptical trainer and treadmill exercises they declared that more energy could be consumed on elliptical trainer with the same heart rate as on treadmill. They also reported that this difference could arise from both legs' and arms' involving in action at the same time [15]. In a study done by Matsui et al.; it was reported that the results obtained from the tests on treadmill and bicycle exercises were actually the results aimed at only the lower extremity of the body [14]. In another study by Ross et al., they argued that elliptical trainer was more effective exercise equipment as it activated more muscle groups compared to treadmill exercise [17].

The results of these studies show parallelism with our study and elliptical trainer has more physiological affect on organism compared to other exercise equipments and upper extremity muscles also involve in action during the exercises done with this equipment.

CONCLUSIONS

In conclusion, elliptical trainer equipment is more advantageous to activate different muscle groups compared to treadmill and bicycle equipments so that elliptical trainer can be used in new performance test protocols because of its advantage to activate more upper extremity muscles and elliptical trainer can be considered as efficient equipment in the fields of rehabilitation and the science of exercise regarding the statistical results.

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