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GENERAL ARTICLE

The Effect of Combined Training on Rowing Ergometer Performance in Rowers

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The ethical committee report stating that the experimental research conducted is in accordance with the "Declaration of Helsinki on Ethical Principles in Medical Research on Humans" was approved by the Manisa Celal Bayar University Faculty of Medicine Health Sciences Ethics Committee (Decision number: 20.478.486). .

Abstract

Strength and endurance have an important place in rowing performance. Short-term and high-intensity training methods provide more effective development than traditional strength and endurance training. In this study 24 male participants, ages between 18-22 yrs, actively involved in the rowing team at the Naval Academy were included. Participants were randomly divided into 2 groups as 12 subjects and 12 controls. Anthropometric measurements, heart rate, strength and rowing ergometer tests of the subject group were performed before and after the 8-week training period. The control group only participated in the measurements in the first and last week. Resting heart rate, right-left handgrip strengths, back strength, leg strength, ReMaxP, ReMeanP, Re500m, Re1000m, Re1500m, and Re2000m variables of the subject group were significant in favour of the post-test. The control group also had significant differences in favour of the post-test for the same variables except for Re500m. When the two groups were compared, significant differences were found in favour of the subject group for right-left handgrip strengths, back strength, leg strength, ReMeanP, Re500 m. Conclusively, it could be said that the strength and endurance developments of athletes who use a combined training program are better and the performance and training levels of rowers can be increased.

Introduction:

Rowing is a sport that is performed in various boat classes on the water in different age, weight, and gender categories and requires struggle with nature (Nolte, 2011). In rowing, competitions generally take place over 2000m and are completed between 5.30 and 8 minutes depending on the performance level of the athletes (Nilsen, *et al.*, 2002). Considering the distance and duration of rowing, strength and endurance should be developed in combination. The strength and endurance of rowers are generally aimed to be improved by long-term low-intensity endurance training and strength training with single-joint exercises or machines (Secher & Valianitis, 2007). However, there are also studies showing that multi-joint strength exercises and high-intensity interval training lead to more effective results in a short time (Milanovi *et al.*, 2015; Gormley *et al.*, 2008; Helgerud, et al., 2007). In such studies, motor skills such as balance and agility are also supported along with core muscles during sportive movements (Gentil *et al.*, 2017; Haff & Tripllet, 2015).

Rowing ergometers have features that help athletes perform their rowing training with a similar movement pattern when weather conditions are unsuitable, and trainers can design training programs by observing the performances of the athletes (Vogler, 2007).

With this information, this study aimed to examine the effects of the combined training program on individual performance levels of rowers.

Materials and methods:

The present study is experimental research conducted over 8 weeks. The participants were informed about the applications and tests to be carried out before the study. An informed consent form was obtained from the participants.

The sample group consisted of 24 healthy male participants between the ages of 18-22, who actively rowing at the National Defense University Naval Academy and did not have any disability. Participants were divided into

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groups as subject group (n=12) and control group (n=12). Before the test, the height (Ade brand tape measure, Germany) and body compositions (Tanita BC-418, America) of the participants were measured. The heartbeat counts of the participants during rest and exercise were measured with a telemetric heart rate monitor worn on the chest and watches worn on the wrist (Garmin, USA). Handgrip, back, and leg strengths were performed using a dynamometer (Takai, Japan). Each strength measurement was performed 3 times. American origin Concept-II Brand Model-D rowing ergometer, which is the most preferred in scientific researches, was used in the study. It also has high validity and reliability and works through air resistance.

Training programs were applied to the subject and control groups 4 days a week (2 days strength training, 2 days rowing ergometer) for 8 weeks. The first 10 minutes of training were warm-up sessions (running and stretching exercises). After the training, cool-down exercises were done. The exercises used are given in Table 1, Table 2, Table 3, and Table 4.

Table-1: Subject Group 8 week Strength, Core Training

Exercise	Sets	Intensity	Repeats	Rest (sec)
Squat	2-3-4	60-70 %	12-8-10	60-90
Deadlift	2-3-4	60-70 %	12-8-10	60-90
Barbell Shoulder Press	2-3-4	60-70 %	12-8-10	60-90
Bent Over Row	2-3-4	60-70 %	12-8-10	60-90
Bench Press	2-3-4	60-70 %	12-8-10	60-90
Plank –Side Plank	2-3-4	Body wt.	Max	60-90
Russian Twist	2-3-4	Body wt.	Max	60-90
Bicycle Cycle	2-3-4	Body wt.	Max	60-90

Table-2: Subject Group HIIT Training (Rowing Ergometer)

Sets	Intensity	Time (sec)	Rest (sec)	Rest between sets (min)
3-5	75-90%	90	30	3
3-5	75-90%	60	30	3
3-5	80-90%	45	30	3
3-5	80-90%	30	30	3

Table 3.Control Group Strength Training

Exercise	Sets	Intensity	Repetitions	Rest (sec)
Dumbbell Chest Press	2-3-4	60-70%	12-8-10	60-90
Lat Pull Down	2-3-4	60-70%	12-8-10	60-90
Dumbbell Shoulder Press	2-3-4	60-70%	12-8-10	60-90
Arnold Biceps Curl	2-3-4	%60-70	12-8-10	60-90
Dumbbell Triceps Extension	2-3-4	%60-70	12-8-10	60-90
Leg extension	2-3-4	%50-60	12-8-10	60-90
Leg curl	2-3-4	%50-60	12-8-10	60-90
Sit-up	2-3-4	Body wt.	Max	60-90
Hyperextension	2-3-4	Body wt.	Max	60-90

Table-4: Control Group Endurance Training (Rowing Ergometer)

Sets	Intensity (%)	Distance (m)	Rest (min)
2-4	50-70%	500m	3
2-4	50-70%	1000m	3
2-4	50-70%	1500m	3
2-4	50-70%	2000m	3

The evaluation of the data obtained from the research was made using the SPSS 22.0 Program and the level of significance was accepted as $p < 0.05$. For the changes between the first and last tests of the subject and control groups, the Wilcoxon signed-rank test was used. Mann-Whitney U test was used to compare the subject and control group.

Results:

The demographic information of the subject and control groups is given in Table-5.

Table-5: Subject Vs Control group Demographic Info. (N=12)

Variables	Age (yrs)	Ht (cm)	Wt (kg)	BMI (kg/m²)
Control	19.91±1.16	175.16±4.46	73.47±7.72	23.95±2.12
Subject	20.50±1.24	176.87±3.11	77.40±7.28	24.77±2.01

Ht.= Height; Wt.= Weight; BMI=Body mass index

In the subject group, statistically significant differences were obtained in favour of post-test for resting heart rate, right-left handgrip strengths, back strength, leg strength, rowing ergometer maximum power (ReMaxP), rowing ergometer mean power (ReMeanP), rowing ergometer 500m duration (Re500m), rowing ergometer 1000m duration (Re1000m), rowing ergometer 1500m duration (Re1500m) and rowing ergometer 2000m duration (Re2000m) ($p < 0.05$). There were no statistically significant differences in other values (Table-6).

Table 6.Subject Group Pre and Post Test Results (n=12)

Variables	Pre test	Post test	z	p
Weight/Fat	10.78±3.75	10.02±3.05	-1.845	0.065
BMI (kg/m²)	24.7±2.01	24.96±1.45	-.590	0.555
Resting Heart Rate	79±13.3	75.16±11.51	-2.675	0.007*
Right handgrip strength (kg)	48.45±5.22	57.83±6.14	-3.059	0.002**
Left handgrip strength (kg)	47.46±6.49	54.25±6.74	-3.061	0.002**
Back strength (kg)	164.87±22.33	191.08±18.33	-3.062	0.002**
Leg strength (kg)	142.91±14.7	170.75±15.04	-3.063	0.002**
ReMaxP (watt)	437.66±41.58	466.66±22.44	-2.354	0.019**
ReMeanP (watt)	204.91±26.3	237.75±20.88	-3.061	0.002**
Re500m Time (min)	1.47±0.06	1.33±0.093	-2.982	0.003**
Re1000m Time (min)	3.63±0.28	3.39±0.10	-3.061	0.002**
Re1500m Time (min)	5.86±0.34	5.34±0.15	-3.061	0.002**
Re2000m Time (min)	7.88±0.40	7.33±0.31	-3.059	0.002**

In the control group, statistically significant differences were obtained in favour of the post-test for resting pulse rate, right-left handgrip strengths, back strength, leg strength, ReMaxP, ReMeanP, Re1000m, Re 1500m, and Re2000m ($p<0.05$). There were no statistically

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significant differences in other values (Table-7).

Table-7: Control Group Pre and Post Test Results

Variables	Pre-test	Post-test	z	p
Weight/Fat	8.12±3.60	7.9±3.05	-0.904	0.366
BMI (kg/m²)	23.95±2.12	24.11±1.89	-0.589	0.556
Resting Heart Rate (beats/min)	81.3±13.8	78.3±12.0	-2.128	0.033**
Right handgrip strength (kg)	48.3±7.29	51.6±6.87	-3.061	0.002**
Left handgrip strength (kg)	45.24±5.81	48.18±5.23	-2.903	0.004**
Back strength (kg)	155.8±20.7	163.0±20.01	-3.074	0.002**
Leg strength (kg)	148.08±18.76	152.08±18.7	-2.833	0.005**
ReMaxP (watt)	446.8±24.0	464.7±24.27	-3.061	0.002**
ReMeanP (watt)	208.8±21.17	217.8±17.28	-0.748	0.006**
Re500m (min)	1.57±0.21	1.64±0.29	-0.312	0.755
Re1000m (min)	3.69±0.21	3.50±0.19	-2.228	0.026**
Re1500m (min)	5.57±0.36	5.48±0.24	-2.826	0.005**
Re2000m (min)	7.81±0.47	7.59±0.31	-2.982	0.003**

ReMaxP: Rowing ergometer maximum power, ReMeanP: Rowing ergometer mean power, Re500m: Rowing ergometer 500m time, Re1000m: Rowing ergometer 1000m time, Re1500m: Rowing ergometer 1500m time, Re2000m: Rowing ergometer 2000m time.

As per Table-8, statistically significant differences were obtained in favour of the subject group in the variables of right-left handgrip strengths, back strength, leg strength, ReMeanP, and Re500m. No statistically significant differences were found in other variables

Table-8: Subject (Sub.) and Control (Con.) Group (n=12)

Variables	Group	Median	(25-75%)	z	p
Weight/Fat	Con.	7.2	5.97-9.32	-1.906	0.057
	Sub.	9.4	8.22-9.00		
BMI(kg/m²)	Con.	24.65	22.30-25.4	-1.09	0.272
	Sub.	24.9	24.0-26.2		
Resting Heart Rate (beats/min)	Con.	77.00	69.5-84.5	-.579	0.563
	Sub.	76.5	63.7-81.7		
Right handgrip strength (kg)	Con.	51.45	48.0-53.3	-2.01	0.035**
	Sub.	58.65	51.70-62.5		
Left handgrip strength (kg)	Con.	47.5	45.75-50.9	-2.281	0.023**
	Sub.	53.7	48.2-60.2		
Back strength (kg)	Con.	158.5	146.177.2	-2.975	0.023**
	Sub.	190	178-208.5		
Leg strength (kg)	Con.	147.5	140.5-154.5	-2.685	0.007**
	Sub.	171.5	160.-180.7		
ReMaxP (watt)	Con.	458.0	455-478.2	-0.058	0.954
	Sub.	467.0	453.2-488.5		
ReMeanP (watt)	Con.	214.0	204.7-235.7	-2.31	0.021**
	Sub.	233.5	226.7-250		
Re500m (min)	Con.	1.51	1.4-12.01	-3.23	0.001**
	Sub.	1.33	1.25-1.40		
Re1000m (min)	Con.	3.5	3.36-3.55	-1.64	0.099
	Sub.	3.41	3.30-3.46		
Re1500m (min)	Con.	5.4	5.31-5.54	-1.53	0.125
	Sub.	5.35	5.27-5.46		
Re2000m (min)	Con.	7.48	7.39-7.9	-2.40	0.16
	Sub.	7.34	7.28-7.41		

Discussion:

Statistically significant differences were found in favour of the post-test in resting heart rate, right-left handgrip strengths, back strength, leg strength, ReMaxP, ReMeanP, Re500m, Re1000m, Re1500m, and Re2000m variables in the subject group (Table-6, $p < 0.05$). In the control group pre-test and post-test data, significant differences were found in favour of the post-test in resting heart rate, right-left handgrip strengths, back strength, leg strength, ReMaxP, ReMeanP, Re1000m, Re1500m, and Re2000m variables. (Table-7, $p < 0.05$). When the two groups were compared, statistically significant differences were found in favor of the subject group in right-left handgrip strengths, back strength, leg strength, ReMeanP, Re500m (Table-8, $p < 0.05$).

Yardimci *et al*. (2017) examined the rowing ergometer performances of the athletes before and after 44 units of training in a study conducted with elite single rowing and double rowing athletes. Similar to the present study, significant improvements were found in the 2000m rowing ergometer performances for both groups. Bourduna *et al*. (2009), a study with 10 rowers, found the rowing ergometer 2000m transition time of athletes as 428.5± 7.2sec and the rowing ergometer mean power as 288.6±17.2 watts. Çelikel *et al.* (2017) examined the 2000m rowing ergometer performances of 10 male athletes in 3D biomechanical terms and found better results than the present study. According to these three studies, the lower mean power and higher 2000m performance time in our study are related to the competition levels and the sports ages (1-2 years) of the participants. Results of Simoes et al. (2006) on 10 male rowers on rowing ergometer performance of 2000m are also close to the results of the present study but better, is thought to be due to the age, height and bodyweight of the athletes being a determining factor in the 2000 meter rowing ergometer performance.

Majumdar *et al.* (2017) examined the effects of 199 elite rowers' physical and strength parameters on 2000m rowing ergometer performances, and the obtained handgrip strength, back strength and 2000m rowing ergometer times were similar to the present study. Considering these results, it can be said that the participants displayed a performance close to the elite rowers.

Driller *et al.* (2009) applied high-intensity interval training (HIIT) and routine rowing training for 4 weeks to compare the effects of traditional and HIIT methods on elite rowers. As a result, both groups showed improvement in rowing ergometer transition times and maximal power output, while the group doing HIIT training achieved better results. This aspect is in parallel with the present study. However, in the present study, HIIT in the subject group was included in a combined training method with

strength training. However, compared to the control group using the traditional rowing training method, the 2000m rowing ergometer times of the subject group were found to be better, although not significant. This is thought to be due to the lower performance of the subject group compared to the control group in the pre-test data.

In another study examining the effect of four-week HIIT and endurance training on the peak VO_2 performance of rowers, it was stated that HIIT and endurance training improved their 2000m rowing ergometer performance (Carr, 2011). Akca & Aras (2015) stated that HIIT and supramaximal interval training applied to 20 male rowers studying at university for 4 weeks improved their performances. The positive effects of HIIT training and achieving the same improvement as endurance training in these studies support the results of this research.

Gentil *et al.* (2017) investigated the effects of single-joint and multi-joint strength training on body composition, cardiorespiratory endurance, and strength gains. In their 8-week of study, there were greater increases in the strength tests of the group that applied multi-joint exercises compared to the group that applied single-joint exercises. This supports the present study's assumption that multi-joint strength training, which is included in the combined training applied to the subject group, is more advantageous than single-joint strength training.

In conclusion, it could be said that the strength and endurance developments of the athletes who apply a combined training program are better, and the performance and training levels of rowers can be increased. In future studies, this application can be improved by using the blood lactate test, aerobic threshold, anaerobic threshold, and maxVO_2 measurements. More efficient results can be obtained with sleeping patterns, diet tracking, and a longer training plan.

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