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Effects of Warm-up Exercises on Spirometric Measurements in Athletes and Sedentary Individuals

Aynur Otag[1] and Ilhan Otag[2]

[1]Department of Physiotherapy and Rehabilitation, Health Sciences Faculty, Cumhuriyet Üniversity, Sivas, Turkey
[2]Vocational School of Health, Cumhuriyet Üniversity, Sivas, Turkey

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ABSTRACT Regular physical activity is important for health. The present study aimed to examine the effects of warm-up exercises involving stretching on Spiro metric measurements in 30 athletes and 30 sedentary individuals. This study was designed as a randomized, crossover study. Initially, Spiro metric measurements were conducted before and after treadmill exercise in accordance with the Bruce protocol. After 15 days, Spirometric measurements were conducted before and after a warm-up program and the same exercise test. With warm-up exercises, the forced expiratory volume in 1 second increased in the athlete group. Additionally, the peak expiratory flow, forced inspiratory flow (25-75%), and $Vmax_{25}$ increased with warm-up exercises. However, warm-up exercises did not influence Spiro metric measurements in the sedentary group. Among athletes, ventilation volume values increased generally with warm-up exercises. For this reason, we can say that warm-up exercises increase muscle strength, resulting in optimization of aerobic function.

INTRODUCTION

Warm-up exercises typically include low-intensity aerobic exercises, stretching exercises, and special exercises (Fradkin et al. 2010; Neiva et al. 2014). Warm-up exercises increase the amount of blood flow to the muscles and tendons. The flexibility and temperature of muscles increase with warm-up; therefore, movement becomes easier (Gray et al. 2002; Bishop and Maxwell 2009; Fradkin et al. 2010; Neiva et al. 2014). In healthy individuals, the limiting factors for aerobic capacity include the cardiovascular system and skeletal muscles. In endurance athletes and those with pulmonary diseases, the respiratory system limits exercise capacity (Burtscher et al. 2011). Pulmonary function tests can provide information on the pulmonary system (Darby and Pohlman 1999; Albayrak et al. 2002; Basso et al. 2010; Layton et al. 2011; Atabek 2015; Burnett et al. 2016). Spirometry measurements are one of the most widely used methods (Layton et al. 2013; Özgül et al. 2015). These measurements are forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), peak expiratory flow (PEF), which is frequently used to distinguish between airway obstruction and restrictive diseases (FEV1/FVC), peak value of forced inspiratory flow (PIF), forced expiration period with the condition of lasting less than 6 seconds (FET), and volume withdrawal speeds of forced vital capacities of twenty-five percent, fifty percent, and seventy-five percent ($Vmax_{25}$, $Vmax_{50}$, and $Vmax_{75}$, respectively) (Miller et al. 2005; Evans et al. 2015). The exercise performance may be restricted by the functionality of the respiratory muscles. In this regard, there are many studies about the effects of specific warm-up exercises for respiratory muscles on Spiro metric measurements (Lin et al. 2007; Wilson et al. 2014; Taylor et al. 2015). However, there are no studies in the literature about the effects of general warm-up exercises on Spiro metric measurements. This present study aimed to determine the effects of warm-up exercises on Spiro metric measurements in athletes and sedentary individuals.

Address for correspondence:
Aynur Otag, PhD
Department of Physiotherapy and Rehabilitation,
Health Sciences Faculty, Cumhuriyet Üniversity,
Sivas, Turkey
E-mail: otagaynur@gmail.com

METHODOLOGY

This study was designed as a randomized, crossover study. The Research and Ethics Committee of the University of Cumhuriyet granted approval of the study after verifying that it fulfills the criteria laid out by the Helsinki Declaration. The subjects visited the laboratory twice. During their first visit, exercise test was performed with the Bruce protocol on a treadmill (Safrit 1990). In the exercise test, the speed of the treadmill was adjusted to 2.7 km/h and tilt was adjusted to 10 degrees in the first stage. A total of 7 stages were applied, with each lasting 3 minutes. At each stage, the speed and tilt were increased, according to the exercise protocol. When the subjects became tired, the test was terminated. The exercise lasted for approximately 21 minutes. Spirometric measurements were conducted before and after exercise. European Respiratory Society standards were used for the spirometric measurement methods (Miller et al. 2005). After 15 days, during their second visit, warm-up exercise was applied, the Bruce protocol was repeated, and spirometric measurements were performed before and after exercise (Table 1).

The study included 30 healthy male volunteers who were amateur football players for 5 years (athlete group) and 30 male volunteers who had no regular physical activity (sedentary group) (Table 2). Ethical approval was obtained from Cumhuriyet University Clinical Research Ethics Committee.

Table 2: The demographic data of the subjects

N=30	*Sedentary*	*Athlete*
Age	22.40± 2.66	23.06± 1.98
Height (cm)	176.20± 7.63	179.16± 4.69
Weight (kg)	66.33± 8.28	73.46± 8.96

All statistical analyses were performed using SPSS 22 Windows software. For comparisons between the athlete and sedentary groups, the t-test was used. For comparisons among the groups, the paired t-test was used in dependent subjects, p-value <0.05 was considered significant.

RESULTS

In the sedentary group, no significant changes were observed in the spirometric measurements after exercise with warm-up, while in the athlete group, significant changes were observed in the Spiro metric measurements, particularly in expiratory volume flow measurements, after exercise with warm-up. The FVC (p=0.001) and FET (p=0.031) values exhibited a significant decline, while the FEV1 value increased (p=0.002). The PEF (p=0.004), forced inspiratory flow (FEF) twenty-five – seventy-five percent (p=0.040), and $Vmax_{25}$ (p=0.018) values increased in the athlete group with warm-up (Table 3).

DISCUSSION

Warm-up exercises are used in almost every sports area to increase physical performance and prevent injuries prior to physical activity (O'Leary et al. 2014; Baklouti et al. 2015; McCrary et al. 2015). Many researchers emphasize that warm-up exercises increase muscle temperature and muscle contractions, increasing blood flow to a safe state that increases vasodilation (Guidetti et al. 2007; Fradkin et al. 2010; Neiva et al. 2014).

Warm-up exercises typically include aerobic exercises followed by stretching and specific exercises at low intensity (Fradkin et al. 2010). In the literature, there are many publications about the contribution of warm-up exercises to the prevention of injuries (Gray et al. 2002; Guidetti et al. 2007; Fradkin et al. 2010; Neiva et al. 2014; McCrary et al. 2015; Baklouti et al. 2015). Additionally, there are many publications in the literature in view of respiratory performance, regarding the application of warm-up exercises on specific respiratory muscles and the relation with performance (Lin et al. 2007; Cheng et al. 2013; Sales et al. 2016). However, there are no studies on the effects of general warm-up exercises on spirometric measurements. In this regard, the researchers' study appears to be important for demonstrating the effects of general warm-up exercises on spirometric measurements in sportsmen and sedentary individuals.

With regard to the relationship between warm-up exercises and the respiratory system, in 1980, De Bruyn-Prevost and Lefebvre showed

Table 1: The exercise protocol

1. Test	Spirometric measurements	Exercise test	Spirometric measurements		
2. Test	Spirometric measurements	Jog (10 minutes)	Active Stretching exercise	Exercise test	Spirometric measurements

Table 3: Spirometric values of the subjects

		Sedentary (n=30)		*Athletes (n=30)*	
		Without warm-up	*Warm-up*	*Without warm-up*	*Warm-up*
FVC (L)	Pre-exercise	3.31± 0.91	3.40± 0.72	4.11± 0.9[‘“]	4.49± 0.91[‘“]
	Post-exercise	3.09± 0.92	3.22± 0.85	3.85± 0.86[*]	4.25± 0.87[*#‘“]
FEV1 (L)	Pre-exercise	2.2± 0.82	2.92± 0.79	3.23± 0.79[‘“]	3.77± 0.78
	Post-exercise	2.80± 0.81	2.94± 0.76	3.37± 0.77[‘“]	3.79± 0.71[#]
PEF (L/mins)	Pre-exercise	4.08± 1.71	4.20± 1.68	4.28± 1.57	5.43± 2.01[‘“]
	Post-exercise	4.17± 1.42	4.52± 1.47	4.67± 1.85	5.74± 2.25[#‘“]
PIF (L/mins)	Pre-exercise	3.35± 1.48	3.62± 1.43	4.05± 1.48	4.1± 1.11
	Post-exercise	3.40± 1.51	3.85± 1.52	3.84± 1.43	4.09± 1.25
FEV1/FVC	Pre-exercise	86.41± 13.93	86.52±14.97	81.23± 14.3	84.89±13.5
	Post-exercise	91.84± 9.24[*]	89.81±20.59	88.28± 11.81[*]	88.64±11.31[#]
FEF25/75(L/mins)	Pre-exercise	3.29± 1.35	3.53± 1.36	3.61± 1.25	4.22± 1.48
	Post-exercise	3.52± 1.14	3.75± 1.19	4± 1.52	4.43± 1.5[#]
Vmax25	Pre-exercise	3.86± 1.76	3.84± 1.55[*]	4± 1.52	4.97± 1.94[‘“]
	Post-exercise	3.99± 1.45	4.28± 1.52	4.54± 1.94	5.42± 2.35[‘“]
Vmax50	Pre-exercise	3.48± 1.48	3.59± 1.46	3.79± 1.38	4.45± 1.64[‘“]
	Post-exercise	3.72± 1.21	3.92± 1.25	4.26± 1.75	4.71± 1.62[‘“]
Vmax75	Pre-exercise	2.48± 0.98	2.71± 0.96	2.81± 0.89	3.08± 0.98
	Post-exercise	2.68± 0.88	2.92± 0.95	2.94± 1.16	3.16± 1.04
FET(mins)	Pre-exercise	1.51± 0.58	1.50± 0.68	1.73± 0.71	1.56± 0.54
	Post-exercise	1.35± 0.65[*]	1.29± 0.6[*]	1.37± 0.35	1.49± 0.45[#]

[*]$p<0.05$ compared with the previous exercise value
[#]$p<0.05$ compared between with and without warm-up
[‘“]$p<0.05$ compared between the athlete and sedentary

that 5 minutes of mild warm-up exercises increased the heart rate and oxygen consumption, and reduced lactic acid buildup. In 2015, Banerjee et al. showed that the FVC and FEV1 values reduced after a bicycle ergometer test in high-school students.

In the researchers' study, no change was observed during the warm-up protocol in the sedentary group, while the FVC values decreased significantly in the athlete group after exercise, and the values were higher with warm-up than without warm-up. This finding shows that warm-up increases the temperature and contraction rate of muscles; thus, it appears to be consistent with previous findings indicating that ventilation is supported (Gray et al. 2002; Neiva et al. 2014).

In a previous study, it was stated that the functionality of the respiratory muscles limited exercise performance; therefore, these muscles should be warmed up before their use. In studies performed in different areas, it was shown that the performance increases when respiratory muscles are warmed up with special tools (Lin et al. 2007; Cheng et al. 2013; Wilson et al. 2014; Arend et al. 2015; Taylor et al. 2015; Sales et al. 2016).

In the researchers' study, routine warm-up methods were used, and the FEV1, PEF, FEF twenty-five – seventy-five percent, $Vmax_{25}$, $Vmax_{50}$, and $Vmax_{75}$ values increased. These results indicate that expiratory flow volume increases in athletes, and forced expiratory volume, which is an important indicator of ventilation, improved with warm-up exercises. On the other hand, FET values reduced after warm-up exercises in both sedentary subjects and athletes, and the lower decrease in athletes supports the researchers' view that warm-up exercises have a therapeutic effect on ventilatory parameters. This view is consistent with the views of authors who mentioned that aerobic function is optimized with vasodilation and an increase in muscle blood flow that occur in veins as a result hyperthermia following warm-up exercises (Gray et al. 2002; Neiva et al. 2014).

CONCLUSION

There were differences in spirometry measurements between the athlete and sedentary groups, as well as between exercises performed with warm-up and those performed without warm-up. Warm-up exercises increase muscle strength, resulting in optimization of aerobic function. Additionally, the researchers' results may indicate that warm-up exercises accelerate the adaptation to changes in ventilation among athletes. The adaptation of the ventilatory control of the nervous system and the fact that skeletal muscles can contract better with warm-up and stretching exercises might explain this increase. In sedentary individuals, late adaptation to exercise might not change ventilation.

RECOMMENDATIONS

In the same work can be done in future studies of men and women. The effects of warm-up exercises on ventilation in women and men can be examined.

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