University Of Thessaly
Department Of Physical Education
Graduate Thesis

THE EFFECTS OF A RESPIRATORY WARM-UP ON THE 20M-SHUTLE RUN TEST PERFORMANCE

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Contents

Abstract

The purpose of the present study was to examine whether ‘warming-up’ the inspiratory muscles could have an effect in the classic 20m shuttle run (Leger et al, 1984) performance. Nineteen Greek sport science students (20.6 ± 0.8 years old, 78.2 ± 6.5 kg body weight and 1.77 ± 5.6 meter height) volunteered. In three different occations, they were radomly subjected to the following assessments: 1) Maximum inspiratory mouth pressure using a hand-held mouth pressure meter, followed a maximal oxygen intake ($\dot{V}O_2$ max) test, 2) a 15-minute treadmill warm-up at 50% of the individuals $\dot{V}O_2$ max followed by a maximal 20-meter shuttle run test, and 3) a 15-minute treadmill warm-up at 50% of the individuals $\dot{V}O_2$ max, followed by a 2X30 inspiratory efforts against a resistance equivalent to 50% peak inspiratory mouth pressure (pMIP), using an inspiratory muscle trainer (POWERbreathe®), followed by a maximal 20-meter shuttle run test. In the latter occasion, performance in the shuttle run test increased by 3.7(± 5.2) % ($P<0.003$) indicating a positive effect of the preparatory 2X30 inspiratory warm-up prior to the running test. This finding is in line with recent data by Volianitis et al. (1999) who suggested that specific respiratory warm-up is more effective than whole body protocols.

METHODS

Subjects

A total of 25 male students from the Department of Sport Science and Physical Education, Thessaly University, Greece, participated after giving informed written consent to the study that was approved by the local Ethics Committee. No injuries or any respiratory tract infection – a condition known to have potential effects on respiratory muscle strength (Mier-Jedrzejowicz et al., 1988) – were reported.

Procedure

Before data collection, all subjects visited the lab on two occasions to be familiarised with an inspiratory muscle trainer, with a devise for assessing maximum inspiratory pressures (MIP), and treadmill-work. Subsequently, they performed an incremental test to volitional exhaustion on a treadmill, for a direct measurement of the subjects' maximal oxygen uptake ($\dot{V}O_2$ max).

Subjects were then tested three times – at random – using the 20-m shuttle run test, but with a different type of warm-up each time. Firstly, they performed the 20-m shuttle run test as previously described (Leger and Lambert, 1982) without any specific warm-up prior to testing. Secondly, and prior to testing, subjects went through a whole-body warm-up. It consisted of a 20-minute run on the treadmill at a velocity corresponding to 50% of the subjects' $\dot{V}O_2$ max. Lastly, all subjects used a specific respiratory warm-up followed by the same whole body warm-up previously described (i.e., 20-minute treadmill work at 50% of $\dot{V}O_2$ max). Maximum mouth pressures were assessed before and after each of the three treatment conditions, as well as before and after the two 'warm-up' conditions. In this way we attempted to assess the effectiveness of each protocol/condition on the strength of the inspiratory muscles, and to identify any warm-up effect on the same muscles.

All three-exercise sessions conducted within ten days, in order to control for any change in fitness level of our subjects. Also we needed to establish the reproducibility of the test. At least 48 hours intervened between sessions to allow for recovery. The hour and the place the tests took place all the three times were the same. This way we secured the objectivity of the assessments.

Incremental Test to Exhaustion

Maximal oxygen uptake ($\dot{V}O_2$ max) was measured directly during an incremental protocol to volitional exhaustion on a POWERJOG treadmill. The protocol consisted of five minutes of steady-state run, followed by progressive 3-minute increments to exhaustion. An automated gas analyser (Sensormedics V max - SERIES 29) was used to record respiratory parameters every 20 seconds during testing while subjects inspired room air through a low-resistance two way Rudolph valve. The gas analysers were calibrated with standard gasses previously checked by microtechniques. The pneumatach was calibrated for volume flows up to 10 litres per minute using a 1-litre syringe at different flow rates. These procedures were followed before each experimental session.

Maximum Inspiratory Pressures (MIP)

MIP is commonly used to measure inspiratory muscle strength. It reflects the force-generating capacity of the combined inspiratory muscles during a brief, quasi-static contraction (Mueller manoeuvre) (Larson et al., 1993 – Volianitis et al., 1999). MIP was recorded using a portable hand held mouth pressure meter (Precision Medical, UK). This device has been shown to measure inspiratory efforts accurately and reliably (Original Ref. - Stefanos' 1st paper). A minimum of five and a maximum of nine technically satisfactory measurements were conducted and the highest of three measurements, with 5% variability of within 5 cm H_2O difference, was defined as maximum (Volianitis et al., 1999).

The initial length of the inspiratory muscles was controlled by initiating each effort from residual volume (RV). This procedure was adopted because, based on our experience, RV is a more reproducible subdivision of the vital capacity than functional residual capacity (FRC). Subjects were instructed to take their time and to slowly empty their lungs to RV, thereby avoiding problems associated with variability in lung volumes. All manoeuvres were performed in the upright standing position and verbal encouragement was given to help the subjects perform maximally.

Whole-body Warm-up

This was consisted of a 20-min run on the same POWERJOG treadmill at an intensity equivalent to 50% of the subjects' VO_2max. Gas exchange analyses were conducted during parts of the warm-up period to ensure that subjects were working at the desirable level. Post warm-up measurements were made within two minutes of completion.

Respiratory Warm-up

Two sets of 30 breaths were performed using POWERbreath® inspiratory muscle trainer (IMT Technologies Ltd., Birmingham, UK) at 40% of the MIP measured before the start of the protocol. In practical terms, this was equivalent to a specifically chosen number of turns on the POWERbreath® which would enable subjects to complete 30 breaths without any fatigue or conscious undue exertion. Furthermore, 40% of maximum capacity has been suggested to approximate the upper loading limit before fatigue of the diaphragm occurs (Ranatunga et al., 1987; Volianitis et al., 1999).

POWERbreath® is a pressure - threshold device which requires continuous application of inspiratory pressure throughout inspiration in order for the inspiratory regulating valve to remain open. As with MIP, subjects were instructed to initiate every breath from RV. They continued the inspiratory effort up to the lung volume where the inspiratory capacity for the given resistance limited further excursion of the thorax. Powerful execution of the manoeuvres was encouraged to ensure maximal voluntary output for the given loading conditions. Because of the increased tidal volume, a decreased but spontaneous breathing frequency was adopted by the subjects in order to avoid hyperventilation.

Rating Breathlessness

A modified Borg Scale (Borg, 1982) was used to assess breathlessness during the 20-m shuttle run test (Table 2). In this way it is possible to assess whether breathlessness is delayed due to our interventions. The subjects were asked to rate their breathlessness, at the end of every stage of the run by pointing a number with their finger. The experimenter was confirming the choice by loudly repeating the same number. Two copies of the modified Borg Scale were placed in either ends of the 20-m runway.

RESULTS

MIP

For the comparison between every MIP assessment, that was conducted before and after the warm-up protocols as well as at the end of every SRT, T-Test for paired samples was used to compare differences between the MIP values before and after the three warm-up protocols. No significant changes were fount neither for the increase after the respiratory warm-up nor for the decrease after the maximum effort of the SRT test.

SRT

ANOVA with repeated measures was used to compare the three SRT assessments. Significance was fount between second and third SRT. In the third SRT performance increased by 3,7(± 5,2)% ($P<0,002$) indicating a positive effect of the preparatory 2x30 inspiratory warm-up prior to the running test. This finding is in line with resent data by Volianitis et al. (1999) who suggested that specific respiratory warm-up is more effective than whole body protocols.

Breathlessness Rating

There were no significant changes in the parameters measured other than SRT performance. Breathlessness Rating data obtained after the general and respiratory warm-up are summarised in table 1. A new comparison was done for the breathlessness in the percentages of 20, 40, 60, 80 & 100% of effort between second and third SRT (Table 4) Using the T-Test no significant changes were found.

Data and Diagrams

Preliminary Measurements						Main measurements		
Name	weight	height	age	VO2max	MIP	1stSRT	MIPprior to testing	MIPafter testing
Mandilas N.	92	1.89	21	45.2	143	83	140	125
Xristodoulou V.	83	1.77	20	49.8	153	74	142	147
Flouris A.	76	1.83	20	52.9	145	91	148	145
Kliris M.	84	1.81	21	50.1	186	114	176	181
Parasiris G.	74	1.71	20	54.5	205	110	147	185
Tofas T.	72	1.77	22	61.7	158	122	134	130
Metsios G.	71	1.79	21	55.7	193	102	185	193
Zourbanos N.	71	1.78	21	55.9	189	105	171	180
Papagiotis S.	86	1.82	21	51	181	92	178	170
Drisbiotis K.	73	1.71	20	50.6	146	93	113	153
Papakemos V.	74	1.76	20	48.4	135	86	135	123
Pavlou P.	85	1.89	22	48.1	202	118	199	203
Kavouras G.	78	1.73	20	47.5	177	97	186	178
Liopiris E.	79	1.74	20	50.6	176	100	159	154
Tsamardos N.	86	1.78	20	49.5	151	67	145	147
Frantzoglou G.	75	1.72	20	52.8	139	88	149	151
Simos N.	77	1.76	21	44.4	143	61	132	152
Beltsidis M.	68	1.7	19	50.7	174	81	183	178
Vartalas L.	83	1.82	22	43.5	210	65	191	200
Anagnostou E.	75	1.76	23	46.1	135	64	130	133
Average	78.26	1.77	20.58	50.45	167.05	90.65	157.15	161.4
SD	6.51	5,564E-02	0.84	3.0380952	21.19047619	13.98571	20.34761905	20.51428571

Table 1: Data Collection

Main measurements					
Name	**2ndSRT**	**MIPprior to whole-body warm-up**	**MIPafter whole-body warm-up**	**MIPafter testing**	**3rdSRT**
Mandilas N.	74	135	123	121	79
Xristodoulou V.	74	151	153	149	67
Flouris A.	101	153	146	146	102
Kliris M.	91	170	169	188	96
Parasiris G.	103	168	186	195	96
Tofas T.	126	144	157	130	131
Metsios G.	103	180	190	193	108
Zourbanos N.	107	170	175	185	113
Papagiotis S.	93	178	175	166	100
Drisbiotis K.	106	164	166	159	111
Papakemos V.	88	130	135	126	90
Pavlou P.	102	190	204	215	108
Kavouras G.	100	154	167	159	102
Liopiris E.	88	159	169	167	102
Tsamardos N.	70	150	152	160	75
Frantzoglou G.	78	156	150	163	82
Simos N.	64	162	162	149	69
Beltsidis M.	76	180	184	187	78
Vartalas L.	68	175	203	205	72
Anagnostou E.	66	129	131	135	69
Average	88.9	159.9	164.85	164.9	92.5
SD	13.61905	13.14285714	16.63333333	20.65714286	14.42857143

Table 1: Data Collection

Main measurements				
Name	**MIPprior to whole-body warm-up**	**MIPafter whole-body warm-up**	**MIPafter respiratory warm-up**	**MIPafter testing**
Mandilas N.	120	132	143	124
Xristodoulou V.	150	151	150	145
Flouris A.	143	151	136	137
Kliris M.	184	162	171	185
Parasiris G.	177	189	207	210
Tofas T.	163	155	161	154
Metsios G.	175	180	190	193
Zourbanos N.	175	179	185	190
Papagiotis S.	150	154	160	128
Drisbiotis K.	156	153	149	166
Papakemos V.	118	121	130	126
Pavlou P.	200	208	210	208
Kavouras G.	175	187	177	171
Liopiris E.	167	162	169	156
Tsamardos N.	160	169	163	164
Frantzoglou G.	160	165	154	192
Simos N.	146	146	143	136
Beltsidis M.	184	183	183	168
Vartalas L.	202	183	199	186
Anagnostou E.	130	133	138	140
Average	161.75	163.15	165.9	163.95
SD	17.57142857	16.63333333	18.84761905	21.86190476

Table 1: Data Collection

Breathlessness Rating 1st SRT

Name	Stage1	Stage2	Stage3	Stage4	Stage5	Stage6	Stage7	Stage8	Stage9	Stage10	Stage11	Stage12
Mandilas N.	0.5	1	2	3	4	5	7	9	10			
ristodoulou V.	1	1	2	2	4	5	7	9				
Flouris A.	0	0.5	1	1	2	3	4	5	7	9		
iris M.	0.5	1	1	2	3	3	4	4	5	7	9	
arasiris G.	0.5	0.5	1	1	3	3	3	4	7	9	10	
Tofas T.	0	0.5	1	2	3	3	4	5	5	5	7	9
Metsios G.	0.5	1	1	2	3	3	4	5	7	9	10	
ourbanos N.	0.5	0.5	1	1	2	3	4	5	7	9	9	
Papagiotis S.	0.5	1	1	2	3	4	4	5	7	9		
risbiotis K.	0	0	0.5	0.5	1	2	2	3	4	9		
apakemos V.	0	0	1	1	1	2	3	4	5			
Pavlou P.	0.5	1	1	1	2	3	3	4	5	7	9	10
Kavouras G.	0	0	0.5	0.5	1	2	3	5	7	9		
opiris E.	0	0	0.5	0.5	1	2	2	3	4	4	7	
Tsamardos N.	0.5	1	1	2	3	5	7					
rantzoglou G.	0	0	0.5	1	1	1	2	3	4			
imos N.	0	2	2	4	4	5	7					
Beltsidis M.	0	0	0.5	0.5	0.5	1	3	3	5			
artalas L.	0	0.5	1	2	3	4	5					
nagnostou E.	0	1	3	4	5	7	7					
Average	0.25	0.625	1.125	1.65	2.475	3.3	4.25	4.75	5.93333	7.81818	8.71428	9.5
SD	0.261904	0.416666	0.4286	0.8095	1.0262	1.1333	1.38095	1.1765	1.30833	1.37879	0.85714	0.3333

Table 1: Data Collection

Breathlessness Rating 2nd SRT

Name	Stage1	Stage2	Stage3	Stage4	Stage5	Stage6	Stage7	Stage8	Stage9	Stage10	Stage11	Stage12	Stage13
andilas N.	0.5	1	1	2	3	4	5	7	7	9			
istodoulou V.	1	1	3	3	4	7	9	10					
Flouris A.	0	0.5	1	2	4	4	5	5	7	7	9		
iris M.	0.5	1	1	2	3	4	5	5	9	10			
arasiris G.	0.5	0.5	1	2	3	3	4	4	5	7	10		
Tofas T.	0.5	0.5	0.5	1	2	3	3	3	3	5	5	9	10
etsios G.	0.5	1	2	3	3	3	4	5	7	9	10		
urbanos N.	0.5	0.5	1	1	2	3	4	5	7	9	9		
Papagiotis S.	0.5	1	1	2	3	4	4	5	7	9			
isbiotis K.	0	0.5	1	2	2	4	5	7	7	9	10		
apakemos V.	0	0.5	1	2	2	2	3	4	7				
Pavlou P.	1	2	2	3	3	3	4	5	7	9	10		
avouras G.	0	0	0.5	0.5	1	2	2	3	4	5	7		
piris E.	0.5	0.5	0.5	1	2	3	4	4	7				
Tsamardos N.	0.5	1	2	3	4	4	7	7					
antzoglou G.	0	0	0.5	2	3	4	5	7	9				
mos N.	0.5	2	2	3	4	5	7						
Beltsidis M.	0	0.5	1	1	2	3	4	5					
artalas L.	0.5	2	3	3	5	7	7	9					
agnostou E.	0.5	1	2	2	3	5	7						
Average	0.4	0.85	1.35	2.025	2.9	3.85	4.9	5.5556	6.6429	8	8.75	9	10
SD	0.2285	0.4286	0.6238	0.5571	0.6952	0.919	1.2381	1.4386	1.0571	1.33333	1.22222	0	0

Table 1: Data Collection

Breathlessness Rating 3rd SRT													
Name	**Stage1**	**Stage2**	**Stage3**	**Stage4**	**Stage5**	**Stage6**	**Stage7**	**Stage8**	**Stage9**	**Stage10**	**Stage11**	**Stage12**	**Stage13**
Mandilas N.	0.5	1	1	2	2	3	4	5	7				
Xristodoulou V.	1	2	2	3	3	4	7	9					
Flouris A.	0	0.5	1	1	2	3	4	4	5	7	9		
Kliris M.	0.5	0.5	0.5	1	2	3	3	4	7	9			
Parasiris G.	0.5	0.5	1	2	3	4	5	5	7	9			
Tofas T.	0.5	0.5	1	2	2	3	4	4	5	5	7	9	10
Metsios G.	0.5	1	1	2	3	3	4	5	7	9	10		
Zourbanos N.	0.5	0.5	1	2	2	4	4	5	7	9	9	10	
Papagiotis S.	0.5	0.5	1	1	2	3	4	5	7	9	9		
Drisbiotis K.	0.5	1	1	2	2	3	4	4	5	7	9		
Papakemos V.	0	0.5	1	2	3	4	5	7	9	10			
Pavlou P.	1	2	2	3	3	3	4	4	5	7	9		
Kavouras G.	0	0	0.5	0.5	1	2	2	3	4	7	9		
Liopiris E.	0	0.5	0.5	0.5	0.5	1	2	3	4	5	7		
Tsamardos N.	0.5	1	1	2	3	4	7	7					
Frantzoglou G.	0	0.5	0.5	1	2	4	5	7	9				
Simos N.	0.5	3	4	4	5	5	7	9					
Beltsidis M.	0	0.5	0.5	1	4	5	7	9					
Vartalas L.	0.5	3	4	5	5	7	7	9					
Anagnostou E.	0.5	1	2	2	3	5	7	9					
Average	0.4	1	1.325	1.95	2.625	3.65	4.8	5.85	6.286	7.75	8.6667	9.5	10
SD	0.229	0.5714	0.70238	0.7285	0.8333	0.9047	1.3142	1.8285	1.295	1.3077	0.6667	0.33333	0

Table 1: Data Collection

	Breathlessness Rating 2nd SRT %					Breathlessness Rating 3nd SRT %				
Name	**20%**	**40%**	**60%**	**80%**	**100%**	**20%**	**40%**	**60%**	**80%**	**100%**
Mandilas N.	1	2	4	7	9	1	2	2	4	7
Xristodoulou V.	1	3	4	7	10	2	2	3	4	9
Flouris A.	0.5	2	5	7	9	0.5	1	4	5	9
Kliris M.	1	2	4	5	10	0.5	1	3	4	9
Parasiris G.	0.5	2	4	5	10	0.5	2	4	5	9
Tofas T.	0.5	2	3	5	10	1	2	4	5	10
Metsios G.	1	3	4	7	10	1	2	4	7	10
Zourbanos N.	0.5	1	4	7	9	0.5	2	4	9	10
Papagiotis S.	1	2	4	5	9	0.5	1	4	7	9
Drisbiotis K.	0.5	2	5	7	10	1	2	4	5	9
Papakemos V.	0.5	2	2	3	7	0.5	2	4	7	10
Pavlou P.	2	3	4	7	10	2	3	4	5	9
Kavouras G.	0	0.5	2	4	7	0	0.5	2	4	9
Liopiris E.	0.5	1	2	4	7	0.5	0.5	2	4	7
Tsamardos N.	1	2	4	4	7	1	1	3	4	7
Frantzoglou G.	0	2	3	5	9	0.5	1	2	5	9
Simos N.	0.5	2	3	5	7	3	4	5	5	9
Beltsidis M.	0.5	1	2	3	5	0.5	0.5	4	5	9
Vartalas L.	2	3	5	7	9	3	4	5	7	9
Anagnostou E.	0.5	2	2	5	7	1	2	3	5	9
Average	0.75	1.975	3.5	5.45	8.55	1.025	1.775	3.5	5.3	8.9
SD	0.38095	0.41904	0.85714	1.180952	1.22381	0.561905	0.733333	0.761905	1	0.54285

Breathlessness rate% T-Test between 2nd and 3rd SRT				
20%	**40%**	**60%**	**80%**	**100%**
0.077	0.288	1	0.707	0.32

Table 1: Data Analysis

HOW YOU WOULD ENROL YOUR BREATHLESSNESS?	
0	Not At All
0.5	Very-Very Slight (Barely sensible - insignificant)
1	Very Slight
2	Slight
3	Fair – Mild
4	Rather Severe
5	Severe
6	
7	Very Severe
8	
9	Very – Very Severe (Almost maximal)
10	Maximum (Maximum Dispnea)

Table 2: Modified Borg Scale.

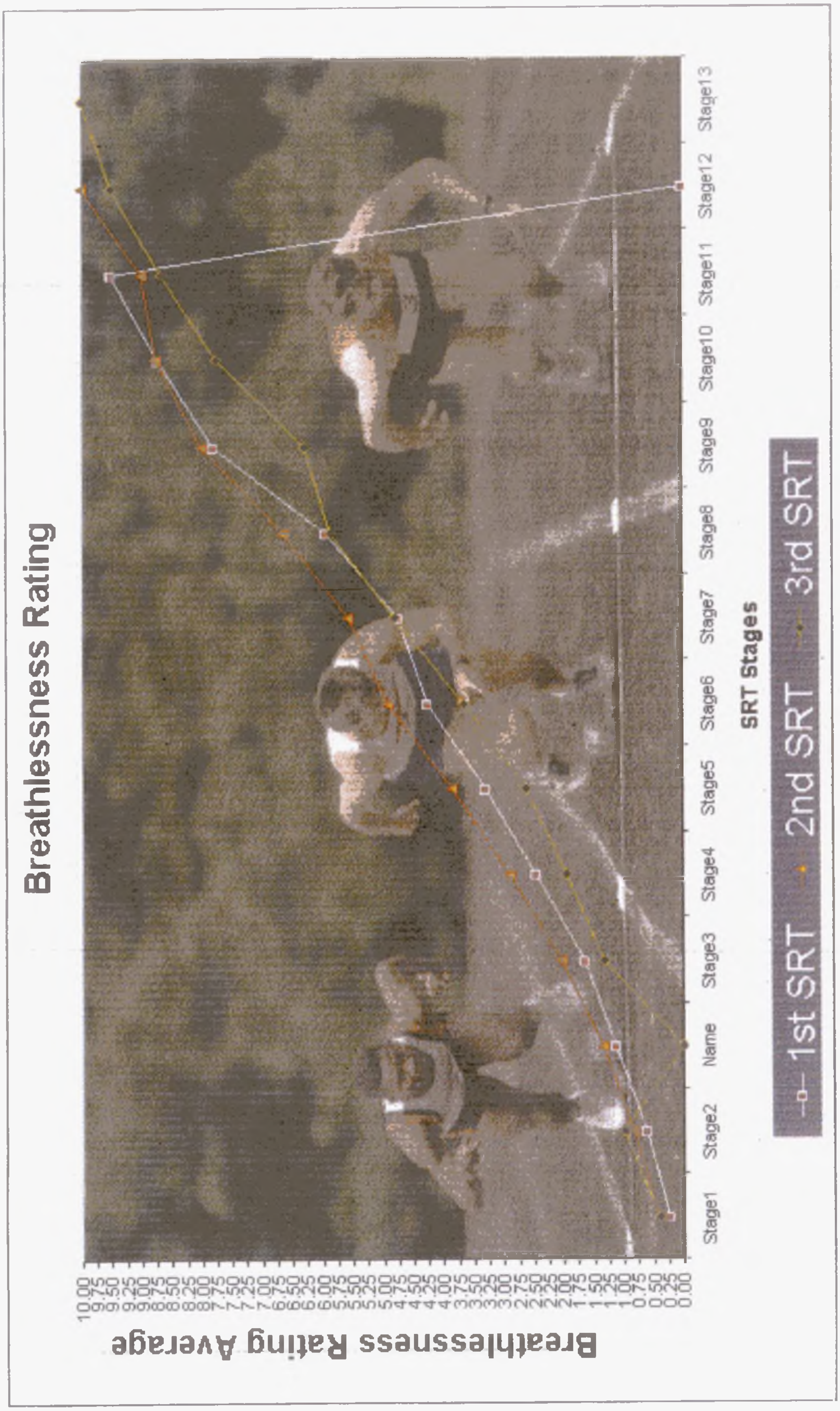

Table 3: Breathlessness analysis according to Borg scale

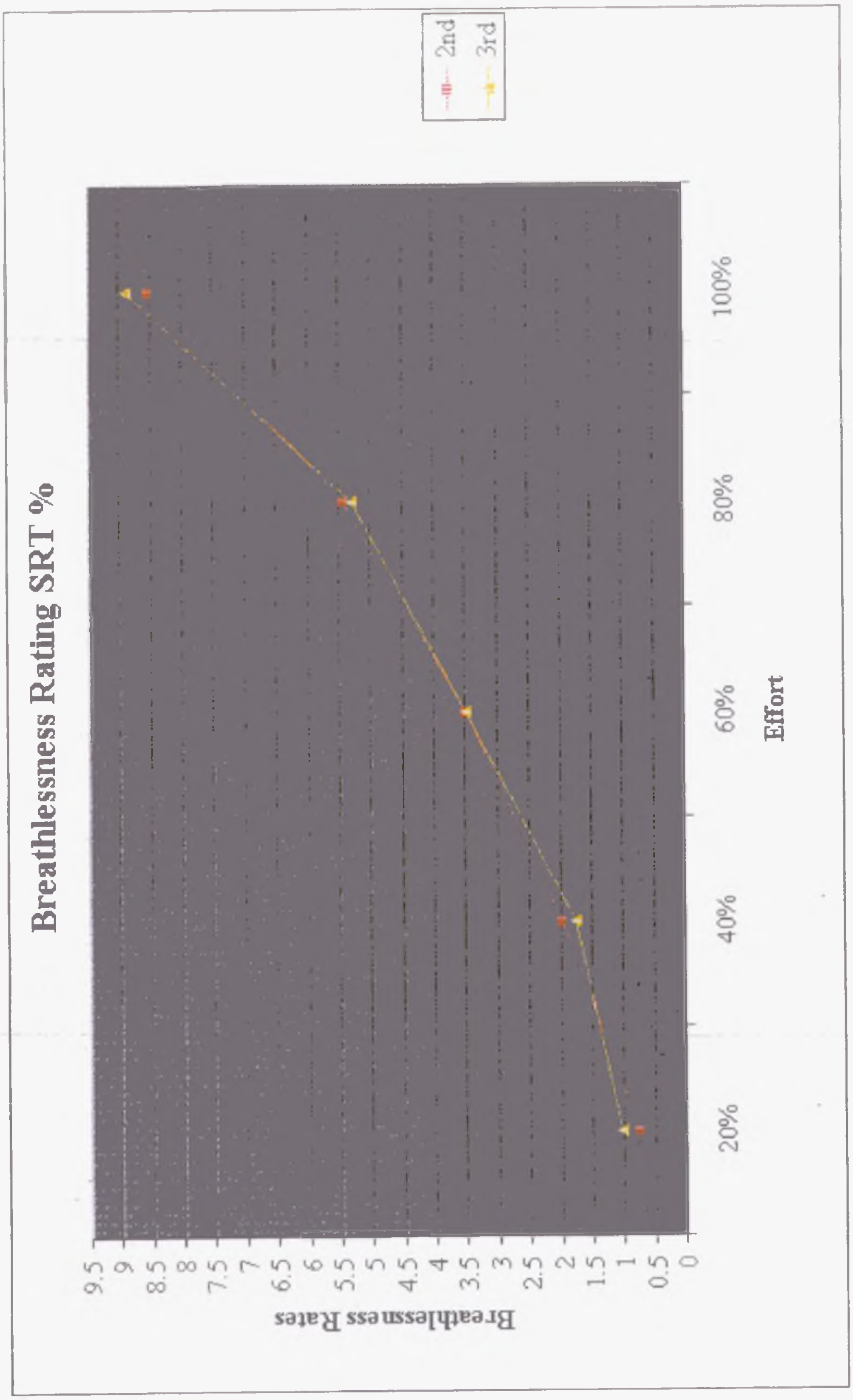

Table 4: Breathlessness comparison between 2nd and 3rd SRT test according to specific percentages of effort

DISCUSSION

The main finding of this study was that performance increased significantly following the Respiratory warm-up but not following the two whole body warm-up protocols. The phenomenon, which emerges with at least 30 breaths using POWERbreath®, raises the possibility that the respiratory system may have different warm-up requirements (threshold) than the locomotor system.

The precise mechanism(s) responsible for the increase in performance following the Respiratory Warm-Up cannot be identified easily. A skeletal muscle warm-up has been reported to have an effect on maximum isometric force when the change in the muscle temperature is substantial (Bergh U et al. 1979 and Nava S et al. 1993). However, since in the present study it was not possible to measure the temperature of the diaphragm or the intercostals muscles, we can only suggest that a temperature related effect, if any, was unlikely. This suggestion is justified under the assumption that the temperature of the diaphragm and the other inspiratory muscles is essentially equal to the core temperature because of their location.

Thus, by a process of elimination, an altered motor control hypothesis is suggested. It is possible that the intermuscular co-ordination between inspiratory and expiratory muscles is improved in a manner similar to the one identified for other skeletal muscles (Komi P. V. 1992). Repeated performance of the specific recruitment pattern might decrease the degree of co-contraction known to exist between inspiratory an expiratory muscles at RV and consequently improve force generation and readiness for better performance

Although the protocols used in the general Warm-Up and Respiratory Warm-Up did not alter MIP, a possible explanation may be that during the Respiratory Warm-Up the recruitment of the chest wall muscles is substantial as loading compensation enhances the inspiratory activity of the external intercostal muscles. Furthermore, deliberate inspiratory efforts tend to make grater use of inspiratory intercostal muscles of the chest wall then do spontaneous metabolically stimulated inspirations (Whitelaw W.A. 1989). It has often been observed in strength-training studies that increases in strength depend on how similar the strength test is to the actual training exercise in terms of muscle fibre length and type of contraction (Roussos C.S. 1977). Indeed, the recruitment pattern of the Mueller manoeuvre is more similar to the pattern of the Respiratory Warm-Up than the pattern of the two whole body warm-up protocols. In combination with this assumption is the verbal statement of the subjects for a convenient breath at the first stages of the last SRT, although again, the T-Test comparison of breathlessness rating between second and third SRT revealed no significance.

Finally our data suggest that in the clinical and academic fields, studies that examine the function of the inspiratory muscles under different treatment conditions should account for a 'warm-up' effect on performance.

Conclusions

According to studying of the articles which are related to warm-up the following conclusions are are coming up:

1. The warm-up exercise of short duration (25min) and mild intensity was more beneficial than long duration (45 min) and intense exercise (kesavachandran C., Shashidhar S, 1977)
2. The mechanisms of the warm-up phenomenon may be different, time depended and related to previous training. (Tomai F, et al, 1996).
3. The combination of a warm-up, stretching and massage reduces some negative effects of eccentric exercise. (Rodenburg JB, et al.1994).
4. Body warming enhances not only the heat dissipating activity of the thermoregulatory center, but also the induction of peripheral sweat gland activity.(Torii M,et al, 1996).
5. The preliminary exercise allows better adjustment of thermohydric regulation by moderating the rise in body temperature and increasing water loss during physical work. (Mandengue SH, et al, 1996)
6. When blood and muscle lactate concentrations after the sprint ride were expressed relative to values before the sprint ride, the warm-up trial resulted in a lower accumulation of blood lactate and muscle lactate. Also, oxygen consumption during the first of the sprint ride was higher in the warm-up trial. (Rogers RA, et al, 1991).
7. A continuous warm-up of 15 min at 60% VO_2max can significantly decrease post-exercise bronchoconstriction in moderately trained athletes. (Mc Kenzie DC, et al, 1994).
8. The warming muscles can aid in injury prevention and improvement in athletic performance. (Noonan TJ,et al, 1993).

From the above conclusions it was established that:

1. The accomplish of warm-up is an essential presupposition for the performance of the main part of training.
2. The exercise in warm-up has to be of a short duration and mild tension, so we will come to the desirable result.
3. During warm-up there is an increase of oxygen uptake and body temperature. This way we have a better muscle bloodiness. All these are elements, which prepares the athletes organism for more difficult and demanding charge.

Additionally to this conclusion, according to the present study, a warm-up phenomenon, similar to the one present in locomotion, exists in the inspiratory muscles. This enhancement is more effectively elicited by specific inspiratory manoeuvres than by whole body warm-up protocols (Volianitis et al. 1999). The major proof of this phenomenon is the maximize of the performance in the 20 m. SRT after the specific inspiratory warm-up.

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