

The effect of training frequency on selected physical and hemodynamic parameters in the training and retraining of sedentary adult males

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Abstract

In the endeavour to apply exercise as a therapeutic or prophylactic modality, the health professional is challenged by the science of exercise prescription. In order to prescribe the correct “dosage” for a specific problem, the exercise principles (frequency, intensity, duration and time) should be borne in mind. Another frequently asked question to the Biokineticist/ Exercise Physiologist is what the effect of detraining and retraining will be when an interruption occurs in the rehabilitation or conditioning regimen. Hence the aim of this study was to determine the effect of training frequency on some physical and hemodynamic parameters in the training and retraining of adult males. Sixty (60) healthy but sedentary Caucasian males aged 28 – 49 years were recruited to participate in this study. They were randomly selected into 3 groups of 20 each. Groups A and B served as the training groups while group C formed the control group which remained sedentary, and followed their normal lifestyle. The experimental groups (A & B) initially trained for 12 weeks at a training frequency of 3 times a week. This was followed by a detraining and retraining regimen of 12 weeks each. During the retraining period, Groups A and B retrained at a frequency of 2 and 4 times per week respectively. Some physical and hemodynamic parameters were assessed before (baseline) as well as after each phase. The physical working capacity (PWC) results of this study indicated that the experimental groups lost about 50% of the gained benefits after 12 weeks of detraining. With retraining, a frequency of 2 times a week was able to maintain the level of PWC (Group A) while Group B, retraining at a frequency of 4 times a week, improved and exceeded the capacity reached after the initial training phase. The systolic and diastolic blood pressure at rest indicated salutogenic changes following the training and retraining regimens, with deterioration during detraining. However, not all changes were statistically significant. The parameters representing the effectiveness of cardio-vascular functioning during exercise, viz. systolic blood pressure as well as double product at peak (DP peak) workload, reflected statistically significant improvement with a training frequency of 3 times a week. After 12 weeks of detraining, deterioration occurred in all mentioned parameters, but not to the pre-training level. With retraining, a training frequency of 2 times a week showed improvement (but not significant) in DP peak but not in SBP peak, while retraining at a frequency of 4 times a week resulted in statistically significant improvements.

Keywords: Training, detraining, retraining, frequency, physical working capacity, systolic/diastolic blood pressure.

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Introduction

The burden of chronic diseases is presently reaching epidemic proportions throughout the world (UN-General Assembly, 2011; Booth, Gordon, Carlson & Hamilton, 2000), and it is projected that it will escalate in the future. In this respect Bouchard, Blair and Haskell (2007) indicated that by 2020 chronic diseases will account for almost 75% of all deaths worldwide. A possible reason for the slow progress in combating this health threat may be the very essence of chronic disease, as it is defined as “slow in its progress and long in its continuance” (Booth *et al.*, 2000). In this respect an individual may cross a threshold, called the “clinical horizon”, manifesting multifactorial chronic disease, many years after the original causes have taken effect (Booth *et al.*, 2000). In the light of this, many researchers presently advocate some intervention to start at a very young age in order to combat chronic disease (Pienaar & Strydom, 2012; American Academy of Pediatrics, 2006). In this battle against the global epidemic of chronic disease – also referred to as non-communicable disease – physical activity intervention plays a pivotal role. The importance hereof is adamantly expressed by some researchers stating that “with the possible exception of diet modification, we know of no single intervention with greater promise than physical exercise to reduce the risk of virtually all chronic diseases simultaneously” (Booth *et al.*, 2000).

This has led to the fact that the salutogenic effect of physical activity on the human body has been extensively researched (Ehrman, Gordon, Visich & Keteyian, 2009; Pedersen & Saltin, 2006). In order to establish the desired outcomes of a physical training intervention, various programme determinants – the so-called FITT-principles (frequency, intensity, time (duration) and type of activities) should be in balance (Oberg, 2007). Attempts have been made to evaluate the possible primary contribution of each principle and some evidence exists that frequency should be prioritized when health goals, related to the prevention of chronic diseases, are the focus. Intensity is more likely to impact on weight loss and athletic conditioning, while duration is particularly relevant to people with diabetes and blood sugar irregularity (Oberg, 2007). Various researchers also indicated that these programme constructs can be related to various injuries associated with physical exercise. In this respect, Wenger and Hellerstein (1978) as well as Kokkinos and Myers (2010) indicated that an increase in intensity can be related to an enhanced risk of cardiovascular complications, while an increase in the duration and frequency of the programme prescription may be associated with an increase in orthopaedic injuries (Wenger & Hellerstein, 1978). Haskell (1994) further indicated that an increase in the volume of physical activity (frequency and duration) with a moderate intensity, may be more beneficial for the promotion of general health than the increase in intensity. In this respect the initial fitness of the participants may also play a role (Kokkinos & Myers, 2010; Strydom, 2005).

In the practical experiences of professionals involved in exercise programme prescription the situation often occurs that patients have to stop their training programme for various reasons (travelling, illness, injury, business etc). Many questions are then posed to the professional regarding the effect of detraining as well as retraining. Various questions are also posed as to the effect of programme frequency in the retraining phase.

Very little research exists in this regard, probably due to the fact that this type of research is considerably time consuming in order to properly cover the training, detraining and retraining phases. In the case of rehabilitation, patients are also not willing to detrain once they have experienced the salutogenic effects following a period of initial training. Another barrier in this type of study design is that a high dropout figure may be experienced due to the duration of the research (Opperman, 1998). Therefore, some controversies still exist, with Sharkey (1997) claiming that retraining may take less time to reach the previous physical condition, while Pederson and Jorgenson (1978) claimed that no positive carry-over effect exists between consecutive conditioning periods.

Hence the aim of this study was to determine the effect of training frequency in the training and retraining phases, as well as to determine the volume of detraining after the initial period of training.

Methodology

Study design

The design of this research was a pre-test-post-test randomized-groups protocol of experimental and control groups (Thomas, Nelson & Silverman, 2011).

Participants

Sixty (60) healthy but sedentary Caucasian males between ages 28 and 49 years were recruited to participate in this study. None of them took any medication prior to or during the study and they were all employed in an academic environment. Participants were randomly divided into 3 groups of 20 each. Groups A and B were experimental groups which participated in a training and retraining regimen based on various frequencies, while group C acted as a control group and continued with their normal lifestyle. Due to the extended period (36 weeks) of this study, a considerable dropout figure in all groups was experienced, primarily caused by moving out of town, lack of motivation and illness. Therefore, at the end of this study, data of only 13 participants of group A, 16 of group B and 9 of group C could be used.

Training, Detraining and Retraining

For the first 12 weeks the experimental groups (A & B) trained at a frequency of 3 times per week, starting at an intensity of 60% of each individual's age-related maximal heart rate (MHR), determined by the formula of Karvonen (ACSM, 2010). In order to ensure progression, the intensity was increased every 2 weeks by 5%, causing the participants to reach 85% of their MHR (ACSM, 2010) by the end of the 12 weeks of training. After a warming-up of 5 minutes, aerobic training was performed on Monark bicycle ergometers (Model 864) for 30 minutes continuously. This was followed by flexibility and muscle strengthening exercises, using resistance equipment. The flexibility training primarily focused on low-back, shoulder and legs, while the muscle strengthening was directed at the upper body and abdominal muscles. The total duration of each session was 50-60 minutes.

After the first 12 weeks, a period of detraining (12 weeks) followed during which participants did not engage in any form of training except their normal daily duties. In the retraining phase (12 weeks) the same exercise training principles applied as in the training phase, except that group A retrained at a frequency of 2 times per week, while group B retrained at a frequency of 4 times per week. Assessments were conducted at the following intervals, Test 1- baseline data; Test 2 – After 12 weeks of training; Test 3 – After 12 weeks of detraining and Test 4- After 12 weeks of retraining.

Physical Working Capacity (PWC) (watt)

In order to determine the physical fitness profile of the participants, the physical working capacity test (PWC) was done by using a multistage bicycle ergometer protocol, performed on a Monark bicycle ergometer (Model 864)(ACSM, 2010). After adjusting the height of the saddle the initial workload was started at 75 watt. Every 5 minutes the load was increased by 25 watt up to the stage where the individual had reached his predetermined target heart rate of 85%, using the formula of Karvonen (ACSM, 2010). The workload where this level was reached was noted as the peak physical working capacity (PWC peak) in watt. The physical capacity (relative value) was then determined by the following: $PWC (Rel.) = \text{Peak watt} \div \text{Body mass (kg)}$ (Opperman. 1998).

Body Mass (kg)

The body mass was determined to the nearest 0.1kg using a Detecto scale. Participants were only allowed to wear an exercise short.

Blood Pressure (mmHg)

The systolic and diastolic blood pressure was determined at rest as well as during the last minute of each workload. A mercury sphygmomanometer was used following the procedure described by the ACSM (2010). In order to evaluate the effect of training on the systolic blood pressure (SBP) during peak workload, a ratio was calculated by using the following equation:

$SBP \text{ (peak ratio)} = SBP \div \text{Peak workload (Watt)} \text{ (Opperman, 1998).}$

Had only the blood pressure at the peak workload been noted as outcome, the results would have been misleading, since the peak workload may differ between the various groups as well as among participants within the same group and it is well established that the SBP shows a linear relationship with external workload (ACSM, 2010); therefore the motivation to express this hemodynamic response, resulting from the training, as a systolic blood pressure (peak ratio) (Opperman, 1998). In the case of the DBP, external work does not affect it as in the case of the SBP (ACSM, 2010), therefore the equation for the DBP (peak ratio) was as follows:

$DBP \text{ (peak ratio)} = DBP \text{ at peak workload (Opperman, 1998).}$

Double Product (DP)

In order to assess the myocardial efficiency resulting from the training regimen, the double product at rest was calculated by using the following equation (ACSM, 2010), Double product = Systolic blood pressure x heart rate. For determining the double product at peak level, a ratio was calculated as follows: $DP \text{ (peak ratio)} = DP \div \text{Peak workload (Watt)} \text{ (Opperman, 1998).}$

This approach gives a more accurate estimation of the myocardial adaptation during exertion resulting from a training regime.

Statistical Analysis

Statistical analysis of this study was done by the Centre for Statistics at the University of the Free State by using the SPSS 6.1 UNIX version software programme. For the evaluation of intragroup differences, paired t-tests were used, while for the intergroup differences, the one way variance analysis (ANOVA) for multiple dependant variables was used. The Scheffé test was used to determine statistically significant differences ($p \leq 0.05$) between the groups.

Results

The results of this study are presented in Tables 1 and 2, while the extent of changes that took place during the different phases of the study is presented in

Table 1b: The effect of training frequency on selected physical parameters in the training and retraining of healthy, sedentary adult males

		Physical Working Capacity – Relative [Peakload (Watt. kg ⁻¹)															
Groups	A (n = 13)	1.8	0.58	1.2	2.16	0.53	1.4	2.0	0.48	1.4	2.0	0.49	1.4	*	*	*	*
	Δ %			3.1	20 %		3.2	11.1 %		2.8	11.1 %		3.1	0.01	0.03	0.01	0.01
	B (n = 16)	1.9	0.32	1.3	2.24	0.30	1.7	2.1	0.30	1.6	2.4	0.34	1.7	*	*	*	*
	Δ %			2.5	17.9 %		2.8	10.5 %		2.8	26.3 %		3.1	0.01	0.03	0.01	0.01
	C (n = 9)	1.7	0.32	1.3	1.8	0.35	1.3	1.8	0.31	1.3	1.8	0.25	1.5	0.47	0.14	0.92	0.65
	Δ %			2.3	5.9 %		2.3	5.9 %		2.2	5.9 %		2.2				0.49
Intergroup Differences	A vs B	NB			NB			NB			NB						
	A vs C	NB			NB			NB			NB						
	B vs C	NB			*			NB			*						

Table 1c: The effect of training frequency on selected physical parameters in the training and retraining of healthy, sedentary adult males

		Body Mass (kg)															
Groups	A (n = 13)	84.7	9.7	71.0	85.9	9.0	71.3	87.5	9.8	72.0	87.0	9.5	72.0	*	*	*	
	Δ %			104.5	-1.4 %		105.	-3.3		105.	-2.7		103.	0.19	0.01	0.01	0.02
	B (n = 16)	85	11.0	62.0	84.6	11.	61.0	85.1	11.2	62.0	84.2	10.5	60.0	0.61	0.8	0.27	0.31
	Δ %			102.5	0.5 %	4	107.	-0.1		107.	0.9 %		102.				0.51
	C (n = 9)	81.8	11.1	65.0	82.8	11.	66.5	83.9	11.5	67.5	83.5	11.7	67.5	*	*		
	Δ %			96.0	-1.2 %	5	99.5	-1.6		100.	-2.1		101.	0.09	0.04	0.02	0.18
Intergroup Differences		NB			NB			NB			NB						
		NB			NB			NB			NB						
		NB			NB			NB			NB						

A = Experimental group A [Trained @ 3 times/ week – Retrained @ 2/week]; B = Experimental group B [Trained @ 3 times/ week – Retrained @ 4/week]; C = Control group: No Training or Retraining; * = $p \leq 0.05$; Δ % = Percentage difference from baseline value.

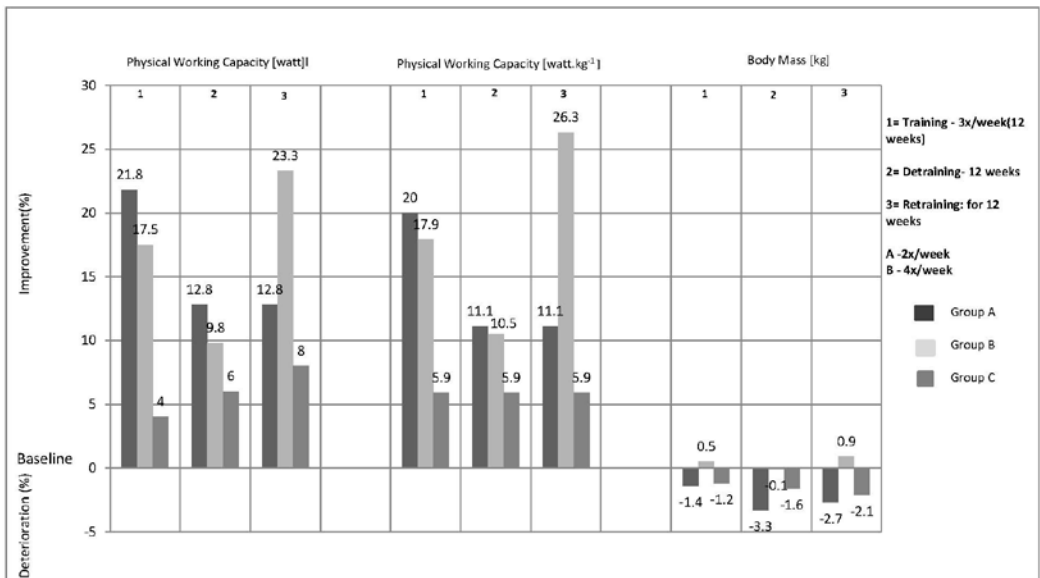


Figure 1: The effect of training, detraining and retraining on some physical parameters of sedentary adult males

The body mass of the various groups, however, followed different tendencies. Group A showed an increase in body mass after the training phase. During detraining, group A increased further (85.9 > 87.5 kg), followed by a slight decrease after the retraining phase (87.0 kg). Group B showed a slight decrease (85 > 84.6 kg) after training with an increase following detraining (85.1 kg) and a decrease following retraining (84.2 kg). The performance of the control group (C) showed a small but consistent increase following training, detraining and retraining. When interpreting the extent (%) of change in body mass as well as

all hemodynamic parameters (Figure 2) resulting from the various phases it must be borne in mind that a “% improvement” actually reflects a decrease in the real value of the parameter (Table 2). Therefore, a decrease in the actual value of the parameters (body mass, SBP, SBP/w-ratio, DP, DBP/w-ratio, DP rest and DP peak ratio) is indicated on Figure1 (Body Mass) and Figure 2 as an improvement in the various parameters.

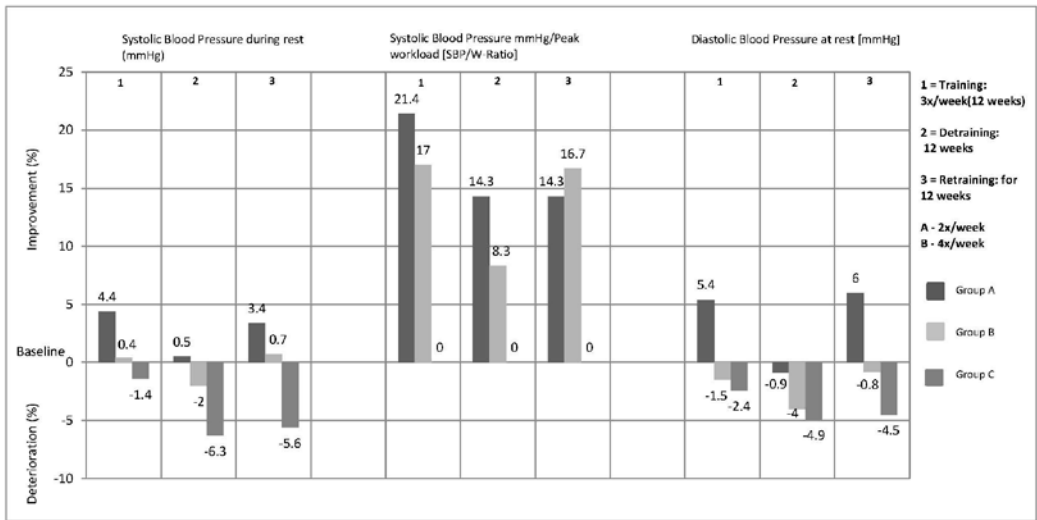


Figure 2a: The effect of training, detraining and retraining on some hemodynamic parameters of sedentary adult males

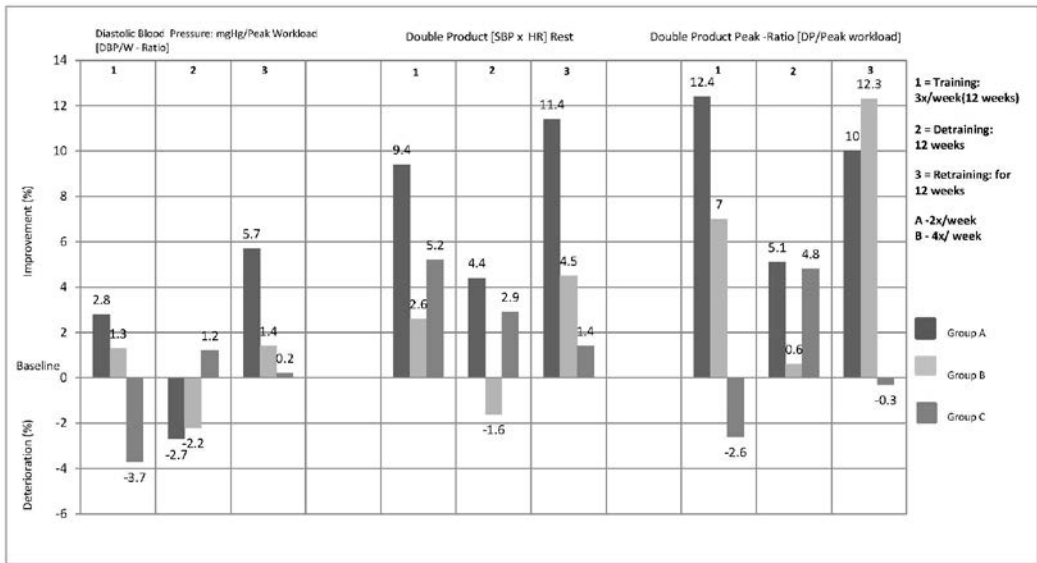


Figure 2b: The effect of training, detraining and retraining on some hemodynamic parameters in sedentary adult males

The systolic and diastolic blood pressure at rest in all groups showed little variation after training, detraining and retraining (Table 2, Figure 2). When looking at the

resting blood pressure values (systolic and diastolic) of the 3 groups during the baseline assessment (T₁), it becomes clear that all are within the normal range (ACSM, 2010). From Figure 2 it seems that training had positively affected the systolic blood pressure, while detraining resulted in deterioration of Group B, while Group A still remained 0.5% better after training. However, the different training frequencies do not seem to considerably affect the extent of change. This is also true for the diastolic blood pressure peak ratio. For the systolic blood pressure peak ratio a greater extent of change occurred, but it followed the same trend of improvement after training and deterioration after detraining. After retraining it seems that Group B (4 times/ week) showed a significant improvement (16.7%) while Group A (2 times/ week) remained at the detraining level of 1.2 (14.3 %) improvement, based on the baseline values.

The double product at rest as well as the double product peak ratio (during work) reflects the salutogenic effect of training on the myocardial effectivity. However, at rest the changes were not statistically significant, while the responses during peak workload indicated significant improvement, except those of group B that showed a 7% improvement (but not significant) after the training phase (T₂).

Table 2a: The effect of training frequency on selected hemodynamic parameters in the training and retraining of healthy, sedentary adult males

		Systolic blood pressure during rest (mm Hg)												Intragroup differences						
Test 1 Before training		Test 2 After 12 weeks of training: 3x/week			Test 3 After 12 weeks of detraining			Test 4 After 12 weeks of retraining (A= 2x/week, B= 4x/ week)												
		$\bar{x}$	SD	Min Max	$\bar{x}$	SD	Min Max	$\bar{x}$	SD	Min Max	$\bar{x}$	SD	Min Max	1-2	1-3	1-4	2-3	2-4	3-4	
Groups	A (n=13)	130.8	10.9	110 145	125.1	5.0	120 136	130.1	9.8	118 146	126.3	9.8	104 140	0.13	0.78	0.20	0.17	0.69	0.34	
	$\Delta\%$			4.4%			0.5%			3.4%										
	B (n=16)	127.5	10.8	110 150	127.0	9.9	118 148	130.1	11.6	120 158	126.6	11.3	110 158	0.8	0.23	0.65	0.23	0.89	0.12	
	$\Delta\%$			0.4%			-2.0%			0.7%										
	C (n=9)	127.8	8.7	118 140	129.6	10.9	118 150	135.8	15.5	118 170	134.9	11.5	120 160	0.73	0.30	0.18	0.16	0.07	0.80	
	$\Delta\%$			-1.4%			-6.3%			-5.6%										
Intergroup Differences		A vs B			NB			NB			NB									
		A vs C			NB			NB			NB									
		B vs C			NB			NB			NB									

Table 2b: The effect of training frequency on selected hemodynamic parameters in the training and retraining of healthy, sedentary adult males

		Systolic blood pressure/Peak work load (SBP/W-ratio)																	
		$\bar{x}$	SD	Min Max	$\bar{x}$	SD	Min Max	$\bar{x}$	SD	Min Max	$\bar{x}$	SD	Min Max	1-2	1-3	1-4	2-3	2-4	3-4
Groups	A (n=13)	1.4	0.3	0.8 1.7	1.1	0.2	0.8 1.4	1.2	0.3	0.9 1.8	1.2	0.8	1.2 1.6	0.8	*	*	*	*	
	$\Delta\%$				21.4%			14.3%			14.3%			1.6	0.01	0.05	0.01	0.02	0.10
	B (n=16)	1.2	0.2	0.9 1.6	1.0	0.2	0.8 1.5	1.1	0.2	0.8 1.6	1.0	0.2	1.0 1.6	0.7	*	*	*	*	
	$\Delta\%$				17%			8.3%			16.7%			1.3	0.01	0.20	0.00	0.03	0.11
	C (n=9)	1.4	0.3	1.0 2.0	1.4	0.4	1.1 2.3	1.4	0.2	1.1 1.8	1.4	0.2	1.1 1.8	1.1	0.97	0.35	0.54	0.48	0.70
	$\Delta\%$				0%			0%			0%			1.8					0.23
Intergroup Differences		A vs B			NB			NB			NB								
		A vs C			NB			NB			NB								
		B vs C			NB			NB			*								

Table 2c: The effect of training frequency on selected hemodynamic parameters in the training and retraining of healthy, sedentary adult males

		Diastolic blood pressure during rest (mm Hg)																	
		$\bar{x}$	SD	Min Max	$\bar{x}$	SD	Min Max	$\bar{x}$	SD	Min Max	$\bar{x}$	SD	Min Max	1-2	1-3	1-4	2-3	2-4	3-4
Groups	A (n=13)	86.4	5.8	78 96	81.7	3.9	78 92	87.2	5.5	80 96	81.2	6.5	70 90	*	*	*	*	*	
	$\Delta\%$				5.4%			-0.9%			6.0%			0.00	0.52	0.01	0.00	0.79	0.00
	B (n=16)	82.8	7.9	70 100	84.1	4.9	78 92	86.1	7.5	70 100	83.5	6.1	72 98	0.30	0.12	0.62	0.25	0.65	0.12
	$\Delta\%$				-1.5%			-4.0%			-0.8%			0.30	0.12	0.62	0.25	0.65	0.12
	C (n=9)	83.1	4.3	80 90	85.1	4.3	80 90	87.2	8.3	80 100	85.8	7.8	80 100	0.35	0.23	0.40	0.41	0.75	0.42
	$\Delta\%$				-2.4%			-4.9%			-4.5%			100					
Intergroup Differences		NB			NB			NB			NB								
		NB			NB			NB			NB								
		NB			NB			NB			NB								

Table 2d: The effect of training frequency on selected hemodynamic parameters in the training and retraining of healthy, sedentary adult males

Diastolic blood pressure at Peak workload (DBP-Peak-mm.Hg)																	
Groups	A (n = 13)	87.2	8.3	70	84.8	7.8	74	89.6	5.9	80	82.2	7.7	70	0.08	0.34	*	*
	Δ %			100	2.8 %		100	-2.7 %		98	5.7 %		98			0.01	0.03
	B (n = 16)	84.5	7.5	74	83.4	8.0	68	86.4	7.4	70	83.3	6.9	70				*
	Δ %			100	1.3 %		98	-2.2 %		100	1.4 %		98	0.36	0.16	0.19	0.07
Intergroup Differences	C (n = 9)	89.1	7.1	80	92.4	6.3	80	88.0	8.2	50	88.9	8.6	80	*		*	*
	Δ %			100	-3.7 %		100	1.2 %		100	0.2 %		100	0.03	0.57	0.91	0.03
	A vs B	NB			NB			NB								0.04	0.68
	A vs C	NB			NB			NB									
	B vs C	NB			NB			NB									

Table 2e: The effect of training frequency on selected hemodynamic parameters in the training and retraining of healthy, sedentary adult males

Double Product at rest (DP- rest)																	
Groups	A (n = 13)	9637	2213	6480	8728	1400	6120	9211	1449	7320	8540	1338	6720	10920	0.07	0.39	0.11
	Δ %			14000	9.4 %		11640	4.4 %		12638	11.4 %		10920			0.16	0.69
	B (n = 16)	8360	2038	5610	8146	1796	5546	8492	2528	5490	7976	1866	5830	13430	0.45	0.65	0.24
	Δ %			13172	2.6 %		12180	-1.6 %		15168	4.5 %		13430			0.38	0.61
Intergroup Differences	C (n = 9)	10291	1955	7320	9760	2115	6726	9992	1758	7316	10143	1829	7680	12480	0.57	0.75	0.81
	Δ %			13440	5.2 %		12450	2.9 %		12920	1.4 %		12480			0.66	0.48
	A vs B	NB			NB			NB			NB						
	A vs C	NB			NB			NB			NB						
	B vs C	NB			NB			NB			*						

Table 2f: The effect of training frequency on selected hemodynamic parameters in the training and retraining of healthy, sedentary adult males

Double Product at Peak workload (DP- peak)																	
Groups	A (n = 13)	217.4	45.0	144	190.5	32.7	137	206.4	43.3	153	195.6	37.2	136	*	*	*	*
	Δ %			275	12.4 %		238	5.1 %		289	10.0 %		266	0.01	0.31	0.02	0.04
	B (n = 16)	189.2	28.6	142	175.9-7.0 %	37.8	139	188.1	34.3	138	165.9-12.3 %	33.3	125	*	*	*	*
	Δ %			245			272	0.6 %		260			234	0.09	0.89	0.01	0.04
Intergroup Differences	C (n = 9)	229.2	40.5	160	236.0	57.3	166	218.8	37.2	172	229.3	46.7	159				
	Δ %			317	-2.6 %		370	-4.8 %		282	-0.3 %		315	0.47	0.35	0.94	0.24
	A vs B	NB			NB			NB			NB					0.51	0.22
	A vs C	NB			NB			NB			NB						
	B vs C	*			*			NB			*						

A = Experimental group A [Trained @ 3 times/ week – Retrained @ 2/week]
B = Experimental group B [Trained @ 3 times/ week – Retrained @ 4/week]
C = Control group: No Training or Retraining
* p ≤ 0.05
Δ % = Percentage difference in baseline values. Note that in these parameters (Table 2) a negative value represents an improvement in Fig. 2.

Discussion

Interruption in training regimes (detraining) occurs on a regular basis among the training population. In the highly trained athletes this may happen following some injury, while in the adult population that trained for the sake of health and wellness, it may be the result of business, illness and so on (Opperman, 1998). A frequently asked question to coaches or exercise professionals posed by those who had interrupted their training regime is how fast the training benefits will be lost and whether retraining will produce faster benefits than the initial training. Answers to these questions are still not absolutely clear at this point in time, probably due to the variety of co-factors which may influence the situation such as initial level of physical fitness, genetic potential and extent of initial training regime (Sharkey, 1997).

Another issue that may add to this difference of opinion is that highly trained athletes may respond differently to detraining than their counterparts who are training for

health and wellness benefits. In this respect it is indicated that highly trained athletes showed a rapid drop in aerobic endurance in the first three weeks of detraining, with less rapid decline in the following weeks. In the case of people with low to moderate levels of aerobic fitness little changes occurred in stamina during the first 3 weeks but quickly reversed back to their original pre-exercise levels after additional weeks of detraining (<http://www.tinajuanfitness.info/articles/113004.htm>). With regard to strength training, the effect of detraining also differs from that in endurance training. According to Taaffe and Marcus (2000), a rapid decline occurred in muscle strength with detraining over the first 2 weeks, and then basically remained constant for the next 6 weeks, with some further decrease then in the following weeks. They further stated that with detraining over a period of 12 weeks, 70% of the strength gained with the initial training phase of 24 weeks remained (Taaffe & Marcus, 2000). When the participants started retraining, they rapidly regained strength (Taaffe & Marcus, 2000). According to research (Lee, Moore, Everett, Stenger & Platts, 2010), the initial rapid loss of aerobic capacity occurs parallel with the loss of blood plasma volume. From Figure 1 it is clear that the participants did not lose all their gained physical working capacity which resulted from the 12 weeks of training. When both groups retrained, Group A, following a training frequency of 2 times per week, just maintained their PWC, while Group B, training 4 times a week, exceeded the PWC initially reached after the 12 weeks of training. This is in agreement with research that indicates that a frequency of two times per week will maintain the aerobic capacity – provided the exercise intensity is high (85-100% VO_2max) (Ready & Quinney, 1982). However, McArdle, Katch and Katch (1996) indicated that some evidence exists that if the exercise intensity is kept constant, no difference is found between training frequencies of 2 versus 4 times a week.

From Table 1 (Figure 1) it is clear that in this study cohort both exercising groups (A & B) retained about 50% of the physical working capacity increase resulting from the initial training phase. In both cases (the absolute (watt) and relative physical capacity ($\text{watt}\cdot\text{kg}^{-1}$) it seems that retraining at 2 times per week was effective in maintaining their status, while in contrast, a training frequency of 4 times a week showed a significant increase and even exceeded the status reached after the initial training at a frequency of 3 times a week. The responses of the control group indicated a small increase in PWC, for which the reason is unclear at this stage but may be related to the control group becoming familiar with the procedures.

It is well established that the systolic blood pressure follows a linear increase with the increase in external workload (ACSM, 2010). Regular training may result in various physiological adaptations, which can cause a decrease in systolic blood pressure response with increase in external workload, indicating that the cardiovascular system has become more efficient through training (Ehrman *et al.*, 2007). From Fig. 2 it seems that both the training groups (A & B) showed improvement in the SPB (peak ratio). This indicates that the participants were able to execute a higher peak workload (watt) with less response in the systolic blood pressure. The lower ratio in Table 2 thus reflects an improvement of the cardiovascular system during physical exertion

resulting from positive training adaptations. This is of special importance for healthy as well as cardiovascular patients, as it implies that a higher physical exertion (work) could be tolerated with less strain being put on the cardiovascular system.

This improvement in the cardiovascular system is also reflected in the double product (DP) at rest as well as the DP peak ratio. The results (Table 3 and Figure 3) therefore prove that both training groups (A & B) improve with training over a period of 12 weeks. This is more noticeable in the DP peak ratio. This suggests that the heart rate and systolic blood pressure product, which is a good reflection of the myocardial oxygen consumption (ACSM, 2010), decreased at the peak external workload due to the training adaptations. This again highlights a very important implication, especially to patients suffering cardiovascular disease such as ischemic heart disease. The implication of this decrease in DP (peak ratio) indicates that such patient can tolerate a higher external workload, either vocational or recreational, before ischemic signs such as angina pectoris may be provoked (ACSM, 2010). This could largely contribute not only to their physical wellness but also to all other wellness domains viz, vocational, psychological, social and so on (Strydom, 2005). With detraining of 12 weeks, not all positive gain was lost and with retraining both groups once again showed improvement, but group B training at 4 times per week experienced a greater improvement. In contrast with some of the other parameters in this study, a training frequency of 2 times per week also resulted in an increase in the cardiovascular efficiency (DP peak ratio), where in the case of the PWC, absolute and relative values as well as SBP (peak ratio) a training frequency of twice a week only maintains the status (Figs. 1 & 2).

Conclusion

The results of this study indicated that training for 12 weeks at a training frequency of 3 times per week, starting at 60% of the age-related maximal heart rate, with a progression of 5% every 2 weeks to reach an intensity of 80% by the end of the regimen, resulted in a significant improvement of the physical working and cardio-hemodynamic parameters. With detraining of 12 weeks about 50% of the gained results were lost, while with retraining at a frequency of 2 times a week the physical working capacity status was maintained, but no improvement had occurred as was the case in group B which trained at a frequency of 4 times a week. However, in the cardiovascular function (DP & DP/peak ratio) Group A, that trained at a frequency of 2 times per week, also reflected improvement – however, not statistically significant. This is in agreement with the study of Ramadan and Barac-Nieto (2001).

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