Journal of Medical Sciences

ISSN 1682-4474

science alert

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Research Paper

J. Med. Sci., 6 (4): 641-645
July-August, 2006

A Comparative Study on the Effects of Four Tapering Techniques on Hematological Responses in Semi-Professional Athletes

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This study aimed to compare four different tapering techniques to find out their effectiveness on hematological responses including biochemical, hematological and VO_2 max indices. Sixty semi-professional athletes (age 20-35 years old) and with VO_2 max 30-45 mL/kg/min were recruited in this study. The test was carried out in three steps. At first step, all subjects passed a four-week mild exercise and in the second step the subjects were carry out a two-week vigorous exercise and the heart rates were recorded. In the third step, the subjects were randomly divided into four groups. Taper 1 group's was asked to carry out exercises; two sessions per week and the intensity of the exercise was set at 85, 75, 65 and 55% of their vigorous exercise's intensity. Taper 2 group's task included two sessions training per week while the intensity reduced to 50% of their vigorous exercise's intensity. Subjects in Taper 3 were asked to carry out two sessions exercise per week with gradually reduction in intensity. Subjects in Taper 4 group did no exercise. Blood samples were taken from the subjects at weeks two, six and after the tapering. In terms of the laboratory tests, ANOVA tests showed no significant differences among the Taper groups. However, a significant difference was found in the average VO_2 max among the four Taper groups ($p = 0.04$). Based on the findings of this study, it can be concluded that Taper 3 could significantly change the hematological factors in semi-professional athletes.

Key words: Taper, VO_2 max, maximum heart rate, treadmill, intermittent exercise, laboratory tests

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JMS (ISSN 1682-4474) is an International, peer-reviewed scientific journal that publishes original article in experimental & clinical medicine and related disciplines such as molecular biology, biochemistry, genetics, biophysics, bio-and medical technology. JMS is issued six times per year on paper and in electronic format.

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INTRODUCTION

Proper body training program for athletes is very important in sport. This is more important particularly near the competitions to achieve more success (Mujika, 1998). Measurements of maximum heart rate and VO_2 max before and during the exercises are two initial common tests carried out in sports centers (Roberts and Scotto, 2000). To preserve more energy for competitions and keeping the acquired skills, it is usually recommended that athletes should reduce the intensity of trainings just days before the competition starts. This technique is called tapering (Shearman and Hamlin, 2002). The important factors in taper are reducing the intensity, volume and the frequency of the training sessions or a combination of them (Shearman and Hamlin, 2002). Research has already shown that not only no reduction occurs in the VO_2 max or the aerobic levels of the subjects during taper, but also it highly likely improve the subjects' muscle power, psychological and functional outcome and helps in remodeling muscle energies to achieve a better result in competitions (Shepley and Macdougall, 1992; Banister and Carter, 1999). In addition, previous studies have shown the effectiveness of taper on hematological, hormonal and enzymatic indices (Mujika and Chatard, 1999; Mujika and Padella, 1998; Houmard and Johns, 1994; Shepley and Macdougall, 1994), which in turn, is known as an athlete's improvement index. Mujika and Chatard (1996) expressed that a ratio of testosterone/cortisol may be a good index for detection and diagnosis of athletes' capacity. However, no such correlation was found in the sexual hormones and thyroxin. Latter on, Mujika and Padella (1998) investigated the effects of Taper on hematological factors. During four weeks tapering, they reported an increased serum's blood, Red Blood Cells (RBC) and hematocrit. Houmard and Johns (1994) reported an increased hematocrit and hemoglobin following the tapering. Researchers also reported that Creatin Phospho Kinaze (CPK) enzyme (an important factor in producing energy) and Creb's Cycle enzymes (e.g., LDH) as well as hematological factors are important in estimating the functional ability of the subjects. Although tapering has frequently been reported in literature (Shepley and Macdougall, 1994), the techniques of tapering is still a controversial issue and under investigations. It has even been reported that improper tapering could reduce the capability of athletes (Mujika and Padella, 1998, Houmard and Johns, 1994). Some researchers stressed on gradual reduction in intensity of trainings (Neary and Martin, 1992), while others recommended a reduction in volume, frequency or intensity of the exercises (Hooper and Mackinon, 1998; Hickson and Bentzen, 2002; Costill and Fink, 1995; Dressendorfer and Petersen, 2002). As brief, despite the extensive studies available there is no universal accepted Taper technique recommended to be used by most athletes.

This study aimed to compare four different tapering techniques and their effects on VO_2 max, biochemical and hematological indices such as CBC, RBC, hemoglobin, hematocrit, MCV, MCH, MCHC, RDW, Platelet, WBC, LDH and CPK.

MATERIALS AND METHODS

Subjects: This study was performed in Razmjoo Moghaddam physiotherapy clinic in 2004. Sixty semi-professional athletes, all track and field volunteers (age 20-35 years old) were recruited in this eight-week randomized clinical trial. The subjects had at least 3 years running experience, three days per week training sessions and having one competition per week. The subjects were no smoker and with no history of systemic disorders and were not on any medications. As an index of the subjects' training level, the VO_2 max of the subjects was calculated while running on an electrical treadmill (sport art, Taiwan) until they got exhausted. Only subjects with VO_2 max between 30 and 45 mL/kg/min were selected for this study.

Methods: An Ohio method was used to calculate their VO_2 max (Mujika and Padella, 1998). Based on the maximum heart rate that the subjects achieved in their aerobic test on the treadmill, a progressive training plan was set for the next four weeks for the subjects. The training program included running on treadmill. In these four weeks, the athletes carried out three session trainings per week, each lasted 30 min. Each session was divided three parts of 10 min exercise that its intensity was gradually increased. The range of speed was between 7-10 km/h and the inclination ranged 2-4%. In this stage, the maximum heart rate calculated using the following formula:

$$\text{Predicted heart rate} = \text{Maximum initial heart rate} \times (60/100) + 20$$

The calculated number was assumed as the predicted heart rate at the first step. For the second and third steps, 10 and 20 points were added to it, respectively. A blood sample was taken from the subjects at the second week and the Cell Blood Count (CBC) and the aerobic enzymes including LDH and CPK were studied.

When the 4-week training sessions of the first step finished, the second step of exercises was immediately started, which was included two weeks vigorous exercises. The intensity of the vigorous exercise was calculated using the following formula:

The predicted heart rate = 220-30×(80/100)

The final number was the predicted heart rate at the end of the third step. To find the predicted heart rate at the end of the first and second steps, 20 and 10 points were reduced from this number. The speed of running was also constant and between 9-12 km/h with a 4-7% inclination. The time of exercise increased to 45 min in this step. Another blood sample was taken from the subjects at the end of week six. After finishing these two steps, the third and main step was started, which was tapering. In this step, the subjects were randomly divided into four groups, each with 15 subjects. A special Taper plan was set for each group for two weeks. Subjects in taper 1 were asked to carry out two sessions exercise per week while the intensity was gradually reduced, so that at the first session 85%, the second session 75%, the third session 65% and at the fourth session they had 55% intensity of the vigorous exercise intensity. The second group (Taper 2) was asked to have two sessions exercise per week and the intensity of exercise decreased to 50% of the vigorous exercise intensity. In Taper 3, the athletes had two sessions training per week with gradually decreased intensity. In another words, they had intermittent rest and light exercise program. Subjects in Taper 4 group took rest during two weeks and had no exercise program. A blood sample was again taken from the subjects in each group. It should be noted that the blood samples were immediately taken to a standard laboratory in the city. A Doiatron cell counter unit was used for CBC; the LDH and CPK enzymes were measured using a photometer unit (Biometrio, France) with the use of kinetic technique. The laboratory tests results were recorded in a special form. A t-test was used to analyze the laboratory tests and VO_2 max in two situations. An ANOVA was used to analyze the repeated measured data recorded from four Tapers. The SPSS program, version 11 was used to analyze the results.

RESULTS

An ANOVA test showed no significant difference in laboratory tests among different tapers. However, a significant difference was found in VO_2 max among different tapers ($p = 0.04$). Laboratory tests showed a significant difference at week 2, 6 and after the taper including heart rate and hemoglobin ($p<0.05$) (Table 1-4), while other laboratory tests such as RBC, WBC,

Table 1: Comparison of laboratory tests and VO_2 max results among the second, sixth and eighth weeks post exercises with taper 1. Data are expressed as Mean±SD

	Taper 1					
	Mean±SD			p-value between three measurement		
Variables	2nd week	6th week	8th week	2nd and 6th	2nd and 8th	6th and 8th
Hemoglobin	15.41±0.7	15.1±1.4	14.94±1.1	NS	NS	NS
MCH	27.9±2.5	28.1±4.7	28.1±3.9	NS	NS	NS
Hematocrit	46.5±2.4	46.2±3.1	46.6±2.8	NS	NS	NS
MCV	88.7±5.08	85.1±9.8	87.7±9.7	0.001	NS	NS
Platelet	243.4±24.8	247.9±45	221.6±36.9	NS	0.018	0.018
WBC	6586.7±1233.9	6453.3±1322.8	7433.3±2974.1	NS	NS	NS
VO_2MAX	41.33±3.4	48.7±3.6	48.5±3.5	<0.001	<0.001	<0.001

NS = Not Significant

Table 2: Comparison of laboratory tests and VO_2 max results among the second, sixth and eighth weeks post exercises with Taper 2. Data are expressed as Mean±SD

	Taper 2					
	Mean±SD			p-value between three measurement		
Variables	2nd week	6th week	8th week	2nd and 6th	2nd and 8th	6th and 8th
Hemoglobin	15.18±0.95	25.3±1.1	15.4±1.2	NS	NS	NS
MCH	29.7±2.6	29.1±3.5	31.1±2.1	NS	0.025	0.007
Hematocrit	46.8±2.7	46.7±3.7	47.2±2.9	NS	NS	NS
MCV	91.53±7.6	87.9±8.7	90.5±6.2	NS	NS	NS
Platelet	233±36.2	231.9±40.2	208.2±42.8	NS	NS	NS
WBC	6033±1129.3	5800±834.1	6660±1181.9	NS	NS	0.003
VO_2MAX	42.07±3.7	49.9±3.8	54.2±3.5	<0.001	<0.001	<0.001

NS = Not Significant

Table 3: Comparison of laboratory tests and VO_2 max results among the second, sixth and eighth weeks post exercises with Taper 3. Data are expressed as Mean±SD

	Taper 3					
	Mean±SD			p-value between three measurement		
Variables	2nd week	6th week	8th week	2nd and 6th	2nd and 8th	6th and 8th
Haemoglobin	15.41±0.7	15.6±0.9	16.1±0.9	NS	0.001	NS
MCH	27.9±2.5	28.8±2.5	30.3±1.6	NS	NS	NS
Hematocrit	46.5±2.4	47.2±2.6	49.5±2.6	NS	0.001	0.01
MCV	88.7±5.08	87.5±6.6	92.1±3.3	NS	0.02	0.001
Platelet	243.4±24.8	234.3±49.7	206.9±54.1	NS	0.02	NS
WBC	6586.7±1233.9	5806.7±785.1	7000±1104.5	0.02	NS	0.002
VO_2MAX	41.33±3.4	46.7±3.1	46.9±3.6	<0.001	<0.001	<0.001

NS = Not Significant

Table 4: Comparison of laboratory tests and VO_2 max results among the second, sixth and eighth weeks post exercises with Taper 4. Data are expressed as Mean±SD

	Taper 4					
	Mean±SD			p-value between three measurement		
Variables	2nd week	6th week	8th week	2nd and 6th	2nd and 8th	6th and 8th
Haemoglobin	14.97±0.94	15.3±1.1	15.5±1	NS	NS	NS
MCH	29.5±3.1	29.4±2.1	30±3.3	NS	NS	NS
Hematocrit	46.7±3.04	47.25±3.1	48.5±3.3	NS	0.03	NS
MCV	88.3±7.5	88.1±5.3	89.3±9.4	NS	NS	NS
Platelet	231.4±29.5	218.6±41.8	221.4±47.4	NS	NS	NS
WBC	6586.7±1187.9	6400±1428.8	6553.3±1121.8	NS	NS	NS
VO_2MAX	41.9±4.05	48.1±4.3	47.4±4.4	<0.001	<0.001	<0.001

NS = Not Significant

MHC, CPK and LDH showed no significant differences ($p>0.05$). A t-test showed a significant difference in hematocrit between week 2 and after the Taper 3 and also between hematocrit in week 6 and its level after the Taper 3. Its level at week 2 showed a significant difference with that after Taper 4. In terms of hemoglobin, a significant difference was found between its value at week 2 and after Taper 3. MCH at weeks 2 and 6 showed significant differences with its value after the Taper 2. MCV at week two showed a significant difference with MVC at week 6. MCV at week 6 showed a significant difference with that following Taper 1. A significant difference was also existed between MCV at weeks 2 and 6 with its value after the Taper 3.

Platelet level at week 2 showed a significant difference with its values after Taper 3 and 1. The WBC at week 6 showed differences with that after Taper 2. Its value at week 2 showed a significant difference with that at week 6 and its value at week 6 with that after Taper 3. VO_2 max showed significant differences when compared with VO_2 max at other tapers.

DISCUSSION

The results of this study revealed that Taper 3 could significantly change the tested factors relative to other tapers. In other words, Taper 3 caused the most changes in hematological and VO_2 max factors in semiprofessional athletes. Hematological factors have been related to the level of athletes' capabilities. Mujika and Chatard (1996) reported that during four weeks study on athletes and tapering, the level of iron in their blood serum, RBC, hemoglobin and hematocrits of the athletes increased. This was also confirmed in our study. In the present study, it occurred dramatically in Taper 3, which might be due to the nature of training in this tapering. In this intermittent technique (exercise-rest repetition), ATP and Phosphocreatine (PC) are the sources of energy. Therefore, in aerobic systems, since the oxygen used more, hematological factors' production also increases. Much research has been carried out during recent years regarding the effects of exercise on cellular levels. Mujika (1998) and Neary and Martin (1992) studied these effects and pointed out that myoglubin increases during exercise. It is obvious that myoglubin has a colorful substance that can be combined with oxygen (oxygenation), therefore plays a major role as the source of oxygen. It functions to carry the oxygen (O_2) from the cell membrane to the mitochondries. Research has proved that both the number and the size of mitochondries increase following exercises. Neary and Martin (1992) reported a 12% increase in the number of mitochondries in the vastus lateralis muscle following eight weeks stretching and distance running exercise (five days per week).

Tapering techniques, however, has not been unique and standard in the world and is carried out in different ways. Some research suggests a gradual reduction in exercise intensity. Some others recommend reduction in both intensity and frequency of exercises. Others, however, have suggested exercises with high intensity. The results of research in this area express that exercises with gradual reduction in intensity shows the most hematological effects, which are very similar to what was carried out in this study in Taper 3 (intermittent exercise-rest repetition). It showed positive effects on increasing hematological factors, CPK and LDH enzymes. Based on Neary and Martin (1992), exercises result in changes in some key enzymes important in ATP system. Phosphotase enzyme is involved in ATP destruction; however, ATP combination is carried out by CPK and myokinase enzymes. CPK also functions as a mediator in ATP production from Phosphocreatine (PC). In a study on human, 30% increase in ATPase, 20% in myokinase and 36% in CPK was found following eight weeks exercise.

The current study showed a significant difference among four tapers in terms of VO_2 max ($p<0.001$). This is similar to what Sheply and MacDougall (1992). VO_2 max is the maximum consumed oxygen during exercise and is the best index of cardiopulmonary endurance preparation level in athletes. It is measured based on the consumed oxygen volume per body weight per minute (Mujika and Padella, 1998). Each activity needs known volume oxygen, which increases as the speed or the intensity of the activity increases. The maximum oxygen consumption of every body is unique to him/her. The capability of people to apply a task is correlated to the required oxygen for that task. This capability, however, is limited with the maximum volume of oxygen consumption. Obviously, during an activity the more oxygen consumed, the less required time for carrying out the tasks (Mujika, 1998; Shepley and Macdougall, 1992; Banister and Carter, 1999).

In this study, although Taper 3 showed the most hematological effects on semi-professional athletes during two weeks, increasing this time to more than 2 weeks, in agreement with other researchers, might show more changes on hematological factors and this needs more investigations.

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