The Effects of Annual Swimming Season on Oxidative Stress and Swimming Performance in Children

Çocuklarda Yıllık Yüzme Sezonunun Oksidatif Stres ve Yüzme Performansı Üzerine Etkileri

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ABSTRACT Objective: Aim of the study is to investigate the effects of annual swimming season, training (TP), detraining (DTP) and retraining periods (RTP) on blood oxidative stress and physical performance levels and the relationships between these parameters in children. **Material and Methods:** 10 trained, mean 11.1±0.6 years old male swimmers were joined the study. Critical speed (CS) as endurance performance criteria were calculated from maximum 50 m and 400 m freestyle swimming performances (MFSP) times. Serum total antioxidant status (TAS), total oxidant status (TOS) and oxidative stress index (OSI; TOS/TAS ratio) and biochemical markers of over training (OT) as urea, uric acid and aspartate aminotransferase (AST) were measured after TP, DTP and RTP subsequently every two months. TP measurement was performed 4 days after national swimming championship. Statistics significance was accepted as $p<0.05$. **Results:** MFSP times, CS and height were increased significantly after every period. TAS was higher at DTP than TP ($p< 0,05$) unlike TOS and OSI ($p<0.01$). TOS was increased where uric acid decreased at RTP ($p< 0.05$) compared to DTP, but no change in the other biochemical markers. No significant relationship was found between CS, MFSP times and body height with TOS and OSI with in any period. **Conclusion:** TP and RTP increased oxidative stress while DTP recovered. The developments in swimming performances and height were not affected from oxidative stress in any period. The given 4 days of recovery after competition realized following TP was not enough for oxidative stress toleration. Therefore, pursuance of whole season health status and performance levels of children is recommended.

Key Words: Oxidative stres; training; retraining; child; swimming; sports performance; athletic performance; physical endurance

ÖZET Amaç: Bu çalışmanın amacı; antrenman periodu (AP), deantrenman periyodu (DAP) ve reantrenman (RAP) periyodlarının kan oksidatif stres ve performans seviyeleri üzerine etkilerini ve bu iki parametre arasındaki ilişkileri araştırmaktır. **Gereç ve Yöntemler:** Çalışmaya yaş ortalamaları 11,1±0,6 yıl olan, aktif antrenman yapan erkek 10 yüzücü katılmıştır. Dayanıklılık performans kriteri olarak kritik hız (KH); maksimum 50m ve 400m serbest yüzme performanslarından (MSYP) hesaplanmıştır. Total antioksidan statüsü (TAS), total oksidan statüsü (TOS), oksidatif stres indeksi (OSI; TOS/TAS) ve üre, ürik asit, aspartat aminotransferaz (AST) gibi sürantrenmanın göstergeleri olan biyokimyasal göstergeler AP, DAP ve RAP sonrası her iki ayda bir belirtilen sıraya göre ölçülmüştür. AP sonu kanları, sezon sonu gerçekleştirilen Türkiye Yüzme Şampiyonasından 4 gün sonrasında alınmıştır. Anlamlılık düzeyi $p<0,05$ olarak kabul edilmiştir. **Bulgular:** MFSP zamanları, KH ve boy her periyod sonunda anlamlı olarak artmıştır. DAP'daki TAS düzeyi AP'ye göre artarken ($p=0,013$), TOS ve OSI azalmıştır ($p<0,01$). RAP'da ise TOS seviyesi tekrar artarken, ürik asit düzeyi düşmüştür ($p<0,05$). Diğer biyokimyasal göstergeler hiçbir periyotta anlamlı bir değişiklik görülmemiştir. TOS ve OSI ile KH arasında, MSYP zamanları ve boy arasında anlamlı bir ilişki bulunmadığe tespit edilmiştir. **Sonuç:** Çocuklarda AP ve RAP oksidatif stres düzeyini arttırırken, DAP bu stresi nötralize etmiştir. Fakat yüzme performansı ve boydaki gelişmeler oksidatif stresten etkilenmemiştir. AP sonunda gerçekleştirilen müsabaka sonrası verilen 4 günlük dinlenmenin ortaya çıkan oksidatif stresi tolere edemediği görülmüştür. Çocukların sağlık ve performans durumlarının takibi için tüm bir sezonun gözlenmesi önerilir.

Anahtar Kelimeler: Oksidatif stres; antrenman; reantrenman; çocuk; yüzme; sportif performans; sporcu performansı; fiziksel dayanıklılık

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During aerobic exercise as swimming, oxygen consumption increases in skeleton muscle and increase of the oxygen consumption can also increase the production of reactive oxygen species (ROS) called as free radicals.[1-3] Free radicals which formed in cell are eliminated by an antioxidant defense system. Human body has both enzymatic and non-enzymatic antioxidant (As antioxidant vitamins, glutathion and albumin, uric acid) defense system to scavenge harmful effects of ROS.[4-6] If exercise bouts are too heavy or not followed by rest periods (As in overtraining), oxidative stress may occur and it may damage biomembranes and muscle structure, then it can lead to inflammation and muscle fatigue.[6] And oxidative stress may also decrease physical performance.[7] If following fatigue, recovery is inadequate time, and then overtraining may also occur which would result in decreased physiological performance, a disturbance of hormonal processes, which produce a depressed immune function, and an increased incidence of many diseases.[6] Even high intensity of exercise may also cause detrimental effects on children's growing process due to high oxidative stress.[1,8,9] Physical exercise-related oxidative damage is depending on some of factors such as exercise type, intensity and duration. Swimming is generally performed in aerobic intensity as physical activity. However, swimming trainings with high intensity and volume are applied in most countries including Turkey. In addition, national intensive competitions are also held at the end of swimming season. It was showed that lipid oxidation rate was significantly higher in healthy prepubertal children than adults during submaximum exercise.[10] Furthermore, children may be more susceptible to oxidative stress induced by chronic exercise.[11,12] However, the effects of long-term swimming training (TP) and detraining (DTP) and retraining period (RTP) on oxidative stress and physical performance levels as well as health status in children is not known. The information of a long-term study instead of a cross-sectional or short-term study are necessary to observe oxidative stress and performance levels, developments and the health status of children to able to prepare more effective training programs. Therefore, hypotheses of the present study were established as; 1) Whole swimming training season affects negatively on oxidative stress, endurance and sprint performance levels. 2) Two months of detraining period recovers these detrimental effects in child swimmers.

MATERIAL AND METHODS

SUBJECTS

16 trained, healthy and 10-12 (11.1±0.6) years old male swimmers who are Ege University swimming club active swimmers were joined the study at the beginning of study. Six swimmers were not able to participate in all measurements. Thus, number of participants was decreased to 10 at the end of study. Three measurement sessions were planned. Initial measurement session (TP) was performed four days after Turkish National Swimming Championship (Which contains 4 sessions in 2-days) which was held at the end of swimming season. Then, at the ends of detraining period and retraining period following measurements were conducted every two months subsequently. The aim, benefits, test applications, possible risks were explained to participated children and parents verbally and a written consent was received from the parents. Ege University Medical Faculty Ethics Committee approved the study. Study was conducted according to this committee decisions. This research was conducted and realized according to WMA Declaration of Helsinki-Ethical Principles for Medical Research Involving Human Subjects.

EXCLUDING CRITERIA AND WARNINGS

All swimmers filled up an anamneses form relevant to health and blood biochemical analyses of the swimmers were evaluated. Swimmers did not perform any swimming activity and apply diet variations, take any drug, vitamin supply or any antioxidant medicine which can affect on oxidative defense system during detraing period. Swimmers were warned not to change their nutrition and not to perform regular exercise in the last five days prior to the tests. In case of formation of any sickness and not obeying to these warnings, the swim-

mers were excluded from the study according to excluding criterias.

TRAINING DETAILS

In TP, training frequency was six days per week; total volume was between 25 and 30K. In RTP, swimmers trained one session a day and six days per week. In the first week, they were swum 18K in total; in the second week total volume was increased to 21K; in the third week the volume was reached to 24 to 27K; in the fourth week third week load volume was continued. Continuous and interval loading methods were used in training sessions.

PHYSICAL MEASUREMENT METHODS

Body compositions (body weight) were measured by using a body composition analyzer (Tanita SC-330 S, Tokyo, Japan). Height was measured in centimetres (cm) using a height scale (Seca 213, Hamburg, Germany). Body mass index (BMI) was calculated via height and body weight values according to following formula; BMI= Weight (Kg) / height^2 (m).

SWIMMING PERFORMANCE TESTS

Critical speed (CS) is used as criteria aerobic endurance capacity, which was calculated according to following formula via 50 m and 400 m maximal freestyle swimming performance (MFSP) times in seconds which were measured with one day break and full resting in the length of 50-meter indoor pool.[13] CS was defined as the theoretical maximal swimming speed that could be maintained without exhaustion for a long period of time.

Critical speed formula: 400m-50m/400m (sec) -50m (sec)= m/s.

Whole physical measurements and exercise tests were realized in the morning between 09:00/11:00 o' clock subsequent 12 hours of fasting. Subjects were warned about not to do intensive exercises at least 3 days prior to tests.

TAKING AND ANALYSIS OF BLOOD SAMPLES

Subject's overnight fasting venous blood samples were taken into tubes with EDTA for hemogram analysis and into tubes for serum. Blood hemogram analysis was determined by a hematology analyzer (BC-3000 Plus, Mindray, China) which included "Erythrocyte (RBC), Leukocyte (WBC), Hematocrit (HCT), Hemoglobin (HGB), and Mean Erythrocyte Volume (MCV). For serum samples were waited 30 min in room temperature and then centrifuged at 2000g for 10 min. The serum samples were kept at -70 °C until the biochemical assays were performed. Biochemical analyses were performed in a single batch and within a month. Determination of total oxidant status (TOS) and total antioxidant Status (TAS) were determined by auto analyzer (Beckman, CX7, USA) using commercial kits (REL Assay Diagnostics, Turkey) with cromogenic methods in and.[14-16] The intra and inter coefficient of variation (CV) was smaller 3.0%) for both TAS and TOS.

Oxidative Stress Index (OSI): Total oxidant status quantity to antioxidant status was accepted as (TOS/TAS ratio).

BIOCHEMICAL MARKERS

Serum; glucose, urea, creatinine, uric acid, albumin, alanine amino transferase (ALT) and aspartate amino transferase (AST) enzyme activities and iron and ferritin levels were analyzed by standard enzymatic methods with commercial kits (Dialab Gmbh, Austria) by auto analyzer (Beckman, CX7, Brea, CA, USA).

STATISTICAL ANALYSIS

Data were analyzed using SPSS for Windows (Release 22 Chicago, IL, USA). The Kolmogorov-Smirrnov test was applied to determine whether the data were normally distributed and it exhibited a normal distribution. Therefore, parametric analysis methods were used. Means and SDs were used for descriptives. Binary comparisons were done by paired t test. It was used "Pearson test" for correlation analysis. It was used ($p=0.05$) values for significance. G*Power 3.1 statistical power analysis program was used to test the effect size (d) and power (pw; as 1-β approaches 1) of statistical test used for differences in TAS.[17]

RESULTS

PHYSICAL AND PHYSIOLOGICAL PARAMETERS

Physical and physiological parameters data and comparisons were given in Table 1. Body weight increased between TP and DTP measurements but no significant change was detected in RTP when compared with DTP. Heights increased significantly in all measurements. BMI only decreased significantly between DTP and RTP. Maximal 50 m and 400 m free swimming performance times and CS increased significantly following each period ($p<0.01$).

HEMATOLOGICAL PARAMETERS

Hematological parameter data and comparisons were given in Table 2. WBC, MCV, HCT, HGB were decreased significantly between TP and DTP and also from TP to RTP measurements. MCV also

TABLE 1: Physical and physiological measurement data (Mean ± SD) and comparisons.

	TP&DTP			DTP&RTP			TP&RTP		
	X	SD	t	X	SD	t	X	SD	t
Age (year)	11.10	0.56	-	11.10	0.56	-	11.10	0.56	-
	11.10	0.56		11.10	0.56		11.10	0.56	
Weight (kg)	47.60	8.23	-9.31**	50.86	8.83	2.05	47.60	8.23	10.29**
	50.86	8.83		50.30	8.56		50.30	8.56	
Height (cm)	1.52	0.96	-12.33**	1.56	0.10	-6.13**	1.52	0.96	13.62**
	1.56	0.10		1.58	0.10		1.58	0.10	
BMI (kg/m^2)	20.38	2.55	-2.17	20.76	2.68	4.25**	20.38	2.55	2.32
	20.76	2.68		19.97	2.48		19.97	2.48	
CS (m/s)	1.03	0.07	-3.21*	1.04	0.07	-5.46**	1.03	0.07	-6.53**
	1.04	0.07		1.07	0.08		1.07	0.08	
50mT(s)	37.30	3.19	7.33**	37.45	3.18	15.23**	37.70	3.19	14.09**
	37.45	3.18		36.67	3.26		36.67	3.26	
400mT(s)	376.30	26.97	5.50**	372.90	26.84	8.70**	376.30	26.97	10.19**
	372.90	26.84		364.20	28.16		364.20	28.16	

Upper (X) shows first measurement, Bottom (X) shows following measurement. BMI: Body Mass Index; CS: Critical Speed. Comparatively with previous value * $p<0.05$, ** $p<0.01$.

TABLE 2: Hematological measurement data (Mean ± SD) and comparisons.

	TP&DTP			DTP&RTP			TP&RTP		
	X	SD	t	X	SD	t	X	SD	t
WBC (103/mm^3)	7.42	1.74	3.35**	5.37	1.73	0.78	7.42	1.75	5.12**
(NR: 4-10)	5.45	2.01		5.12	1.25		5.12	1.25	
RBC (106/mm^3)	5.17	0.38	0.68	5.08	0.35	-4.09**	5.17	0.38	-2.43*
(NR: 4-5.5)	5.08	0.35		5.50	0.40		5.50	0.40	
HGB (g/dL)	13.81	0.98	5.62**	12.70	0.83	0.17	13.81	0.98	4.96**
(NR: 12.5-16)	12.70	0.83		12.67	0.97		12.67	0.97	
HCT (%)	40.78	2.72	5.99**	37.26	2.15	-1.73	40.78	2.72	2.65*
(NR: 37.3-49)	37.26	2.15		38.52	2.29		38.52	2.29	
MCV (fL)	79.03	4.22	4.04**	73.66	5.31	10.91**	79.03	4.22	6.67**
(NR: 77-94)	73.66	5.31		70.30	5.09		70.30	5.09	
FERRITIN (ng/mL)	24.37	8.83	-1.88	31.79	16.11	1.25	24.37	8.83	-1.55*
(NR: 20-140)	31.79	16.11		28.28	12.42		28.28	12.42	

Upper (X) shows first measurement, Bottom (X) shows following measurement. WBC: White Blood Cells; RBC: Red Blood Cells; HGB: Hemoglobin; HCT: Hematocrit; MCV: Mean Cell Volume; NR: Normal range; comparatively with previous value * $p<0.05$, ** $p<0.01$

TABLE 3: Antioxidant and oxidant measurement data (Mean ± SD) and comparisons.

	TP&DTP			DTP&RTP			TP&RTP		
	X	SD	p	X	SD	p	X	SD	p
TAS	0.92	0.11	-3.10*	0.98	0.17	-0.94	0.92	0.11	-5.44**
(mM Trolux Equiv./L)	0.98	0.17		1.03	0.10		1.03	0.10	
TOS	73.37	25.72	8.74**	2.85	0.63	-2.42*	73.37	25.72	8.75**
(μmol H_2O_2 Equiv./L)	2.85	0.63		3.34	0.76		3.33	0.76	
OSI	79.79	37.22	6.54**	2.93	0.69	-1.46	80.63	37.22	6.50**
	2.93	0.69		3.26	0.71		3.26	0.81	

Upper (X) shows first measurement, Bottom (X) shows following measurement. TAS: Total Antioxidant Status; TOS: Total Oxidant Status; OSI (TOS/TAS ratio): Oxidative Stress Index. Comparatively with previous value * p<0.05, ** p<0.01.

decreased between DTP and RTP. RBC levels increased significantly between both DTP and RTP and TP and RTP. Ferritin increased significantly from TP to RTP.

ANTIOXIDANT AND OXIDANT PARAMETERS

Antioxidant and oxidant parameters data and comparisons were given in Table 3. TAS was increased significantly from TP to DTP ($p<0.05$); although this (p value) seems weak, it was found very strong (d=2.76, pw=1.0) according to statistical results calculated by G*power analysis.[17] However, no significant difference between DTP and RTP measurements, the difference was moderately strong (d=0.77, pw=0.592). TAS value of RTP was higher than TP value ($p<0.01$) (Table 3, Figure 1). TOS levels were decreased significantly between both TP and DTP and also TP and RTP. TOS significant increase was observed between DTP and RTP ($p<0.05$) (Figure 2). OSI levels were decreased significantly between TP and DTP measurements and also between TP and RTP. No significant difference was found between DTP and RTP measurements (Figure 3).

BIOCHEMICAL MARKERS

Biochemical markers and comparisons were given in Table 4. All biochemical markers were in their normal ranges. No significant difference was found for albumin and urea. Creatinine values decreased significantly in all periods. Uric acid decreased significantly between DTP and RTP. Significant glucose increases were found between TP and DTP and also between TP and RTP. ALT activity decreased significantly between both TP and DTP and TP and RTP, but no AST change was observed in any period.

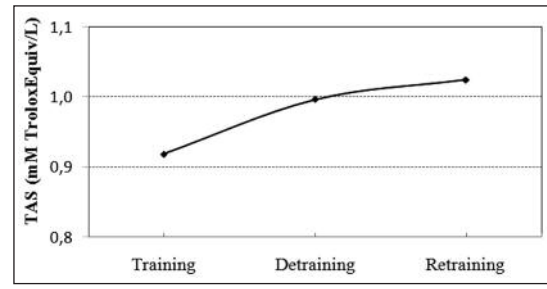

FIGURE 1: Total antioxidant status (TAS) during periods.

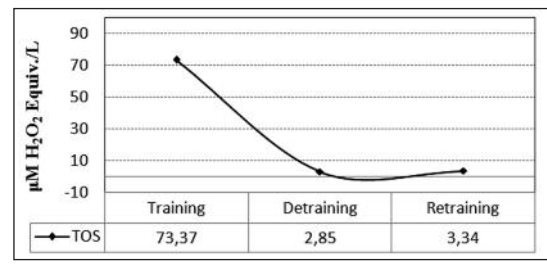

FIGURE 2: Total oxidant status (TOS) during periods.

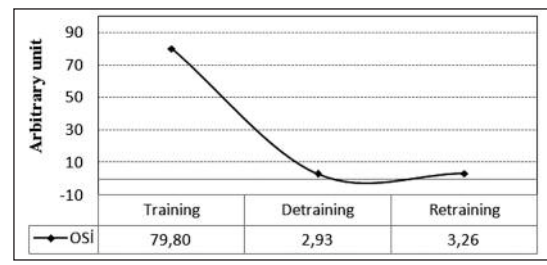

FIGURE 3: Oxidant stress index (TOS/TAS) ratio during periods.

CORRELATIONS

Significant relations between oxidative stress markers and other parameters were given in Table 5. It was found significant correlations between TAS with uric acid, CS and maximum 400 m sprint times and between CS and both maximum 50 m

TABLE 4: Biochemical indicators measurement data (Mean ± SD) and comparisons..

	TP&DTP			DTP&RTP			TP&RTP		
	X	SD	t	X	SD	t	X	SD	t
Urea (mg/dL)	23.60	5.06	-1.33	25.70	5.91	-0.32	23.60	5.06	-1.58
(NR:10-50)	25.70	5.91		26.20	5.95		26.20	5.95	
Creatinine (mg/dL)	0.85	0.08	3.54**	0.76	0.08	6.57**	0.85	0.08	5.88*
(NR: 0.5-1.1)	0.76	0.08		0.65	0.08		0.65	0.08	
Albumin (g/dL)	4.44	0.22	0.54	4.39	0.21	-1.12	4.44	0.22	0.29
(NR: 3.8-5.4)	4.39	0.21		4.47	0.25		4.47	0.25	
Uric Acid (md/dL)	3.75	0.29	-1.74	4.44	1.31	3.32**	3.75	0.29	0.32
(NR:3.5-7.2)	4.44	1.31		3.68	0.80		3.68	0.80	
Glucose (mg/dL)	81.30	6.60	-6.53**	93.10	5.13	1.51	81.30	6.60	-6.62**
(NR: 70-100)	93.10	5.13		90.20	4.82		90.20	4.82	
AST (U/L)	13.33	3.04	0.75	22.75	2.10	-0.68	23.33	3.04	-0.22
(NR:0-35)	22.75	2.10		23.54	4.39		23.54	4.39	
ALT (U/L)	22.91	4.18	5.38**	16.10	3.90	0.41	22.91	4.18	4.28**
(NR: 0-45)	16.10	3.90		15.73	5.00		15.73	5.00	

Upper (X) shows first measurement, Bottom (X) shows following measurement. AST: Aspartate aminotransferase; ALT: Alanine Aminotransferase; NR: Normal range; comparatively with previous value * p<0.05, ** p<0.01.

TABLE 5: Correlations between oxidative stress indices and other parameters in various periods.

	in TP		in DTP		in RTP	
	r	p	r	p	r	p
TAS-400m time	-0.630	0.009			-0.808	0.0079
TAS-CS	0.654	0.0256	0.843	0.0061	0.853	0.0054
TAS-Uric Acid			0.945	0.0013	0.932	0.0076
CS-Maximum 50 m sprint time	- 0.650	0.046	-0.655	0.035	-0.680	0.025
CS-maximum 400 m sprint time	-0.990	0.0009	-0.992	0.0008	-0.998	-0.006

TAS: Total Antioxidant Status; CS: Critical Speed.

and 400 m sprint times. No significant relationship was found between CS with TOS and OSI, maximum 50m and 400m swimming times and Height levels.

DISCUSSION

The main findings of the present study are that both TP and RTP were increased oxidative stress in child swimmers whereas DTP recovered it. Therefore, the hypotheses about these subjects were accepted. However, no significant negative oxidative stress effect was found on MFSP and CS values which indicate endurance and sprint performance levels in any period and the hypothesis related with this issue was rejected.

EFFECTS OF TRAINING, DETRAINING, RETRAINING PERIODS ON OXIDATIVE STRESS

Serum TOS and OSI values were found significantly lower ($p<0.01$) at DTP than TP (Figure 2, 3), whereas TAS values were higher than TP (Figure 1). These findings indicate that TP increased oxidative stress and suppressed antioxidant defense system whereas 2-months of DTP recovered it. Although the increase of TAS in DTP and RTP was insignificant statistically, it was found strong according to the results calculated by G*power analysis. TOS increased moderately ($p<0.05$) while uric acid which is a major non-enzymatic antioxidant decreasing significantly in RTP.[18] This decrease confirms a moderate presence of oxidative stress in RTP. TOS and OSI values

in RTP were found significantly lower than TP ($p<0.01$) and TAS values in RTP were found higher than TP ($p<0.01$). Therefore, these findings reveal that the oxidative stress in TP was in an extreme level as compared with RTP. This high oxidative stress amount may be mainly due to intensive national competition (4 sessions in 2-days) which was held the end of TP. TP measurement was performed 4 days after these competitions. ALT and WBC as inflammation markers in TP were higher significantly than DTP and RTP. Therefore, increased inflammation in TP may be the result of the oxidative stress due to maximum loading which were applied in national competitions.[19] Thus, inflammation is related to oxidative stress.[19] This inflammation due to exercise can also result in some of "discomforts of delayed-onset of muscle soreness" (DOMS).[16] Contrary to our expectations, ALT values were increased more than AST values in the present study though WBC and these transaminases were in normal borders. In addition, urea and albumin levels which are used as indicators of overtraining with AST activities were not different significantly in all three periods. Therefore, no over training situation was observed which biochemical parameters indicate at the end of any period. Thus, increases in WBC and ALT levels in TP can be the indicators of DOMS, which is not probably pathological.[16] These results support that the extreme oxidative stress in TP was the result of intensive competitions realized at the end of TP. Despite the increase of TAS in RTP, the oxidant substances as TOS can be still produced in RTP.[20] This may indicate inadequacies in the antioxidant defense system during this period. However, the increase of TAS may also due to a large reserve in the capacity to handle free radicals during exercise.[21] The study findings confirm that, aerobic based trainings have dual affect and aerobic swimming trainings can also increase antioxidant capacity.[6,11,22-24] Moreover, recovery breaks longer than 3-4 days are required to rest after 2-days of intensive competitions in children as revealed in this study.

EFFECTS OF TRAINING, DETRAINING, RETRAINING PERIOD AND HEALTH STATUS

Although creatinine levels which were used as an indicator of kidney functions were higher at TP than both DTP and RTP, they were found in normal range in every period. The increase in creatinine at TP compared with DTP and RTP may due to the small hemoconcentration which was occurred due to national competitions at the end of TP. Decrease in RBC, HCT and HGB values from TP to DTP may reveal presence of a small hemoconcentration at TP. However, other biochemical parameters were in their normal ranges in the present study. Physical development (In Height), MFSP and CS values of swimmers were increased significantly throughout whole training season. But unlike our hypothesis, no relationship was found between OSI and TOS with MFSP and CS after every period, whereas significant positive relationships were found between CS and TAS; and between TAS and maximal 400 m times in all three periods. The results show the affects of antioxidant capacity on endurance performance in children even at DTP similarly other studies.[25,26] It was reported that repeated exercises in an endurance training increase the induction of antioxidant gene expression during exercise. Increased antioxidant capacity accelerates metabolism of ROS occured during exercise and it can increase defense for mammalian skeletal muscles against damage by ROS.[6,27] It may be also the role of above the mentioned mechanism in increase of TAS in the present study. It was reported that sprint performance is not affected by increased antioxidant capacity.[28] It was exhibited that adaptations to endurance training regulated the redox (Oxidant-antioxidant balance) and force relationship in isolated mammalian soleus skeletal muscles, but not extensor digitorum longus in rats.[26] The results may help to explain that the relationship between TAS or TOS and maximal 50 m swimming performance is not found. These results exhibits that oxidative stress has no significant negative effect and antioxidant capacity level has positive effect on endurance performance in childhood. Significant negative relationships were found between CS and maximal 50m and 400m free swimming times after every period as expected. The findings confirm contribition of endurance performance to both 50 m and 400 m sprint performance. Body weights increased between "TP and

DTP", "TP and RTP" whereas decreased between DTP and RTP as BMI. The differences may be due to more energy intake at DTP and decreased basal metabolic rate (RMR).[29] Contrary the present study, there are also studies showed the decreasing in endurance performance after a 30-day of detraining in ultra-endurance men triathletes.[29] Relation was found between CS and Height of sportsmen at TP. This relation exhibits the affects of physiological developments on endurance performance in children and the differences among previous studies may also due to this development age. Consequently, absence of overtraining and existence of the children in development age may also have important role in increased antioxidant capacity due to training in the present study results.

LIMITATIONS

Our study discussion was limited with lack of literature relevant and similar as design and duration to the present study, the number of subject. Even though it masks the real effects of TP, the presence of a very important oxidative stress at TP was provided to us the opportunity to investigate whether extreme oxidative stress conditions affect sports performance and TAS levels as well as biochemical parameters related with health in the pool conditions, but not laboratory.

CONCLUSION

TP and RTP increased oxidative stress while DTP recovered. The developments in the swimming performances and the heights were not affected from oxidative stress in any period. The given 4 days of recovery after competition realized subsequent TP was not enough for toleration of oxidative stress. Therefore, pursuance of whole season training is recommended for observation of health status and performance levels of children.

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