limited V_E. We can neither conclude that during swimming hypercapnia was caused because values of Pco_2 were similar to those during rest; however it has to be considered that these values were obtained with significantly increased V_E. Our results seem to be in accordance with the results of previous studies (2, 5). However, in this interpretation it should be considered that because of the protocol of collecting samples from the earlobe, approximately 30 seconds were needed and in that time according to measured V_E during maximal and supramaximal swimming on average about 60 l of the air was exchanged in the lungs. This could influence obtained results of Pco_2 and Po_2. It should also be considered that in the study where swimmers performed 200 m freestyle at maximum effort and haemoglobin saturation was measured using a finger pulse oximeter swimmers developed exercise induced arterial hypoxemia (3). Controlled respiratory parameters during exercise when swimming with swimming snorkel (V_E, Vco_2, Vo_2) increased with the swimming intensity from 80 % to 100 % intensity; however, during 110 % intensity, the swimmers were no longer able to sustain the previously defined swimming velocity at the moment the mentioned respiratory parameters reached almost similar values to the ones at 100 % intensity (table 1.). It is thus evident that limited pulmonary ventilation due to biomechanical characteristics of front crawl is probably the factor which mostly limits the observed parameters (V_E, Vco_2, Vo_2), and therefore the limits of values are probably not absolute but specific for each individual swimmer.

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KINETIC RESPONSE OF SALIVARY IGA TO SEVERAL EXERCISE PROTOCOLS PERFORMED BY WELL TRAINED SWIMMERS

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The relationship between training load and the mucosal immune responses has been a recent focus of research. Intense training and the psychological stress associated with competition seems to lower the salivary IgA (sIgA) levels in athletes. Salivary IgA antibodies provide protection against infections and play a significant anti viral role at the mucosal surface. Salivary IgA deficient persons are susceptible to recurrent infections, mostly of the upper respiratory and gastrointestinal tracts. The purpose of this study was to monitor the salivary IgA response to different aerobic and anaerobic land tasks and two aerobic swimming protocols, using several time points in order to study the time effects of the exercise loads in the mucosal immunity of the athletes.

Key Words: mucosal immunity, salivary IgA, training load, swimmers.

INTRODUCTION

The influence of training load on the immunity status has been the subject of extensive research in different environments of sporting participation (2, 3, 4, 5). Due to less invasive methodology, one of the most commonly immunity marker used in this kind of research is the salivary IgA (sIgA). Several studies reported immune suppression with low values of sIgA associated with intense training, contrasting with the reinforcement of sIgA levels associated with moderate exercise (3, 4, 5). Different loads induce specific physiological adaptations. It was hypothesized that the immune response behaves differently adjusting to specific training loads. The purpose of this study was to monitor the salivary IgA response as an immunological marker, using several time points after different tasks and at rest to follow the influence of the training load on this parameter. Two swimming aerobic protocols of identical intensity and volume but with different procedures, namely continuous and intermittent loads, one running test aiming to estimate the $\dot{V}O_2$max and the Wingate anaerobic test were selected.

METHODS

Twelve male swimmers of Portuguese national level (17 ± 0.9 years old, height 177 ± 7 cm, weight 66.5 ± 7.2 kg, 7.3 ± 0.9 years of training), participated in this study. The subjects were informed about the implications of the study and gave their consent. During 10 days they accomplished four different protocols : two swim aerobic tasks – a 20min continuous swim and an intermittent 5 x 400 m with 45 s rest swim and two land protocols - the Luc Léger running test aiming to estimate the VO_2 max, and the Wingate Anaerobic Test (WanT) used to determine the maximal anaerobic power. Swimming, Wingate and Luc-Léger exercices were preceded by a normalized warm-up. The schedule used on this study alternated land and water protocols, with at least 48 hours between testing sessions. All sessions took place at the same hour of the day (7.00 pm). During the study, athletes underwent a normal training schedule corresponding to a stabilizing workload period. Each testing session was preceded by at least 12 hours of rest.

1ª protocol	→	2ª protocol	→	3ª protocol	→	4ª protocol
5 x 400L	48 h	Wingate aanaerobic test	48h	T20	48h	Luc-Léger aerobic test

Figure 1. Study schedule.

Capillary blood samples were taken after exercise to evaluate the lactate (La) concentration. Heart Rate (HR) and perception of effort (Cr10) (2) were also controlled at each protocol. Saliva samples were colleted for determination of IgA concentration, flow rate and IgA secretion rate. The collecting time points were: immediately before de exercise; 15 min, 1.5 hours and 2.5 hours after; in the next morning at wakeup and 24 hours after the test. Obeying to the same timetable on the nearest weekend free from either training workouts or competitions, saliva samples were collected, aiming to get the sIgA response on a recovery day with the purpose to control for possible circadian effects. Saliva collection was done using salivette tubes (Sarstedt, Portugal). Salivary IgA levels were determined by nephlometry (BN2 Analyzer, Dade Behring, USA). To determine the IgA secretion rate (srIgA), the subjects were told to chew on the cotton swab for 2 min. The volume of saliva collected was measured and the secretion rate calculated according to the following equation: *IgA sr=([IgA]*Vsal)/ t*, were Vsal (µl) is the volume de saliva collected, and *t* is the time of collection (s) (1). To compare the behaviour of sIgA and srIgA between moments and protocols, the non-parametric Wilcoxon test was used, with a confidence level of 95%. This statistical option avoids the errors associated with the small dimension of the sample and prevents the absence of a normal distribution of some of the variables.

1º time point	2º time point	3º time point	4º time point	5º time point	6º time point
Before test	15 min after	1.5 h after	2.5 h after after	**Next** morning Wake up	24 h after

Figure 2. Time points of saliva sample collection.

RESULTS AND DISCUSSION

As expected, significant higher values of HR, [La] and perception of effort (Cr10) were found on the Luc Léger test when compared to all the other protocols. The same parameters were higher in the Wingate Anaerobic Test compared to the swimming tasks. Between these last two situations, there were no significant differences, however, the intermittent protocol showed slightly higher levels of these markers (Table1). The intensity used at the two swimming situations was respectively 71.0 % ± 2.3 for T20, and 74.2 % ± 3.1 for the5x400m, of the maximal velocity obtained on a maximal test of 15 m (v15).

Table 1. Mean and Standard Deviation (SD) for the perception of effort (Cr.10 Borg), Lactate (La) heart rate (HR), predicted $\dot{V}O_2max$ from the Luc Léger test, peak power of the Wingate Anaerobic test, intermittent aerobic task (Int Aer. Task), percentage of maximal swimming velocity used on swimming protocols, and T20".

	Luc Léger		Wingate		Int Aer. task		T 20	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cr10	8	1.3	6.6	1.1	4.4	1.8	3.5	0.7
La	13.6	4.0	10.0	2.0	3.6	1.5	2.9	0.6
HR	197	7	165	10	161	9	157	11
$\dot{V}O_2max$ ($ml.kg.m^{-1}$)	52.3	2.8						
Peak Power (W)			656	97				
% max. Velocity ($m.s^{-1}$)					75.0	2.3	74.2	3.1

The sIgA concentration values (table 2) show identical patterns at different experimental conditions. With the Wingate Anaerobic test and the two swimming aerobic protocols the sIgA concentration showed a significant increase ($p<0.05$) (6) after testing followed by a decrease 1.5h and 2.5h after the test. This decrease was significant ($p<0.05$) in the response to the intermittent aerobic swim protocol. In the land tasks this decrease was significant 2.5h after ($p<0.05$). Next morning fasting saliva showed significantly ($p<0.01$) higher values of sIgA. 24h after testing, sIgA levels had recovered to the initial values in all situations ($p<0.01$).
With the Luc Léger test, sIgA, showed an initial decrease after test which was significant ($p<0.05$) for the srIgA values, followed by an elevation 1.5h after and again a significant ($p<0.05$) decrease 2.5h after. The morning and the 24h after values followed the same pattern of the other situations (1, 7). At rest situation, an identical behavior for the sIgA values was found but with less diurnal variation. The only significant alteration of sIgA and srIgA values on the resting day was found in the morning with a slight elevation. These results agree with the idea of exercise influencing the sIgA behavior.

Table 2. Mean and Standard Deviation (SD) of salivary IgA concentration ($mg.dl^{-1}$) for all the time points (TP) selected of the different protocols and at rest situation.

	TP 1		TP 2		TP 3		TP 4		TP5		TP 6	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
T20 Swim	5.45	2.92	7.55	4.12	3.63	2.25	4.03	1.77	23.7	25.4	3.94	1.30
Aer Int Swim	6.41	4.84	8.37	6.03	4.73	3.58	5.85	4.65	27.5	24.2	8.13	6.72
L.Leger	8.15	5.76	5.60	3.31	7.19	4.39	3.53	1.59	18.1	10.7	7.59	4.04
WanT	5.40	4.11	8.60	6.19	3.90	2.44	2.35	0.81	32.2	46.1	5.30	5.16
Rest	7.10	7.37	7.23	5.80	5.27	4.45	10.1	8.6	12.2	14.2	6.2	3.1

When the salivary IgA response between protocols was compared, a statistical significant difference was found between time points 1 and 4, respectively before and 2.5h after in all the tasks. In the Luc Léger test, the sIgA concentration 1.5h after (3º time point) showed higher values when compared to the swimming protocols and the Wingate test. After the Wingate test, the sIgA concentration 2.5h after (4º time point) was significantly lower when compared to the same time point in the intermittent swimming protocol. For the 24h recovery time point, the continuous swim protocol (T20), showed significant lower values of sIgA when compared to the same time point for the intermittent swim and the Luc Léger tests.
In spite of significant differences in lactate levels, heart rate, and perception of effort (Cr10) between the land and water tasks, 24 hours after testing the sIgA concentration and secretion rate values were similar to the ones found before testing (1^{st} time point).
When the sIgA values were compared at rest situation (nearest rested weekend), with the different protocols tested, significant differences were only found for the 4^{th} time point with Wingate test. Both sIgA concentration and secretion rate were lower at this time point for the other three protocols but they failed to reach statistical significance. Rest values show minor variations related to the diurnal cycle when compared to the ones obtained after the tests.

Table 3. Mean and Standard Deviation of Salivary IgA secretion rate (µg.mn-1), for all time points (TP) selected for the different protocols and rest situation.

	TP 1		TP 2		TP 3		TP 4		TP 5		TP 6	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
T20	50.27	33.97	61.65	37.26	34.83	22.80	39.29	18.60	181	154	41.78	18.97
Aer Int												
Swim	51.44	49.56	59.85	53.31	35.26	29.20	41.21	33.62	153	88	60.13	41.33
L.Léger	57.6	40.81	39.77	29.52	62.16	43.15	28.53	16.58	129	75	57.91	40.34
WanT	35.46	24.73	55.78	44.89	39.18	36.32	29.42	21.21	226	238	43.3	46.3
Rest	55.93	63.11	55.71	44.41	48.78	50.91	70.27	55.9	102	116	49.88	23.64

The IgA secretion rate generally followed an identical pattern to the sIgA concentration reinforcing the importance of the variation of this immune parameter (1).
When percentual variation of sIgA values were analysed, in all the protocols studied, the negative impact of the load was located 2.5hours after the test, with values that were 50 to 85% of the initial ones. Only for the continuous swimming protocol, the sIgA recovery values were under the initial ones. This may be related with the longer time spent on the task which probably conduced to a greater utilization of glycogen. In spite of the similar duration of the intermittent aerobic swimming protocol. the managment of the load does not have an identical impact on the glycogen stores.
Identical results are found on studies aiming to understand the acute response of salivary IgA to exercise. The protocols selected for this study aim to reproduce some of usual training loads done by athletes namely swimmers at their preparation (2). Most studies with swimmers only use swim tasks but land work is also an important tool in swim training. With these specific loads our results show that 24 hours are sufficient for the recovery of the sIgA values.
The relevance of this study resides on the recognition of an immune alteration regarding salivary IgA in response to exercise, mostly 1.5 hour to 2.5 hours after the training session. Coaches and swimmers must be aware of this variation, as it seems that because of the kind of the exercise done (with some intensity), they may be more prone to infection during this period. Keep way from crowded places and wrap up when you leave, is good advice to avoid infections of the upper respiratory tract.

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INSULATION AND BODY TEMPERATURE CHANGES BY WEARING A THERMAL SWIMSUIT DURING LOW TO MODERATE INTENSITY WATER EXERCISE

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This study investigated thermal swimsuit (TSS) effects on body temperature and thermal insulation during low-intensity and moderate-intensity water exercise. Nine male subjects were immersed in water (23°C) and pedalled on an underwater ergometer for 30 min with a TSS or a normal swimsuit (NSS) at two exercise intensities. Oesophageal temperatures (T_{es}) were maintained higher in TSS than in NSS at both intensities. Moderate exercise decreased the tissue insulation (I_{tissue}) compared to low-intensity exercise. However, the increased metabolic heat production at moderate intensity and added suit insulation (I_{suit}) were sufficient to offset the decrement of I_{tissue} and T_{es}. The proportion of I_{suit} to total insulation and skin-fold thickness showed a negative correlation, indicating that subjects with lower body fat can benefit more from wearing TSS. Results suggest that TSS in cool water was especially useful for subjects with low body fat.

Key Words: thermal insulation, body temperature, thermal swimsuit, water exercise.

INTRODUCTION

Several investigators have shown that moderate exercise facilitates overall heat loss during cold water immersion (5, 10) because the increased blood circulation to muscle tissues raises the conductive heat transfer from the body core to the skin, thereby reducing tissue insulation (12). Furthermore, in this moderate exercise conditions, body movements through the water accelerate convective heat loss from the skin surface to the water. However, vigorous physical activity seems to maintain the core body temperature (5, 11) because the increased metabolic heat production is sometimes sufficient to offset the heat loss. The intensity of water exercise for improving physical fitness or learning swimming techniques is lower than that for competitive swimming training. Therefore, we must develop some means to maintain the core body temperature without increasing the exercise intensity. An additional layer of insulation on the skin surface is a convenient strategy to reduce convective heat loss without an increment of exercise intensity. Many investigators have reported that wetsuits' additional insulation layers mitigate the decrease of core body temperature and facilitate longer immersion periods (1, 3, 13). However, the wetsuits investigated in those reports were pro-