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**PHYSIOLOGICAL DIFFERENCES BETWEEN PREPUBERTAL**  
**AND PUBERTAL SWIMMERS IN TESTING THE AEROBIC**  
**CAPACITY**

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***Abstract***

The aerobic effort capacity is of great importance to achieve success in the sport of swimming, because the level of aerobic training will influence the outcome of a race, regardless of distance and stroke. Our research aimed to find similarities and differences between the physiological responses of prepubertal and pubertal swimmers to a standard aerobic test (T-2000 test). Swimmers went through the T-2000 test in order to adequately assess their aerobic capacity. The values of physiological variables were gathered with heart rate monitors and a blood lactate analyser. The data were afterwards processed using statistical and mathematical methods. We compared the heart rate during and after the T-2000 test and the differences between groups were 1.1% during the swim and 3.1% in the first and fifth minute after they finished the test. Blood lactate values were recorded before the test and after it, in the first and fifth minute. They indicated a 5.9% higher value before the test for pubertal swimmers and a smaller value for pubertal swimmers after the test: 7.5% in the first minute and 9.4% in the fifth minute. In our opinion, these results indicate a widely similar physiological response in the aerobic capacity testing of prepubertal and pubertal swimmers. The heart rate values showed a slightly better adaptation level for older swimmers, but blood lactate values highlighted better dynamics of its production and metabolism.

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**Keywords:** Aerobic capacity, heart rate, blood lactate, young swimmers.



## 1. Introduction

A swimming coach is always faced with the difficult task of building performance out of potential, just as a sculptor does with a block of marble. In order to accomplish this task, intuition, flair and creativity are not sufficient, unless they are backed up by scientific knowledge and meaningful coaching experiences.

Sports science is growing very fast and this only raises more and more questions for athletes, coaches and scientists to try to answer. Everyone needs those extra hundredths of a second that will get them the gold medal, but what about the long journey from age-group swimming to the gold medal struggle?

We believe that countries with very few resources available to obtain those gold medals should focus their attention on age-group swimming. A coherent plan of action is thus required and it should contain the following: age-group coaches need better education, financial resources must be spread out to as many talented swimmers as possible and the sport science community has to assist with recommendations.

With this in mind, this research is a part of our effort to determine better and more efficient ways of training age-group swimmers in the struggle to maximise their potential.

We selected two groups of ten swimmers each, that trained regularly in a controlled program which followed similar training zones as those used in training senior swimmers. The first group was made out of prepubertal swimmers, and the second, of pubertal swimmers.

Both groups went through the T-2000 test in order to adequately assess their aerobic capacity, during which their heart rate was monitored with the Hosand Aqua GT system. Before and after the test (in the first and fifth minute after the test ended), blood samples were taken to determine the blood lactate level. We used the Lactate Pro Plus from Nova Biomedical in order to achieve this.

## 2. Problem Statement

Building a solid age-group foundation is a crucial condition for achieving junior and senior performance.

Swimming technique is a priority, and coaches should spend considerable amounts of time in order to let their athletes acquire the skills, but this does not mean that the energy systems can be overlooked. The growth process facilitates the development of aerobic capacity before the body matures: “This aerobic and endurance training should begin before maturation and general application and will stay with the swimmer through post maturation involvement in swimming” (Sweetenham & Atkinson, 2003, p. 13).

Addressing the matter, Brooks (2011) states in a very plastic, yet meaningful manner: “Kids are aerobic sponges. Their aerobic capacities seem infinitely elastic; their bodies are predisposed to huge increases if exposed to endurance training”, adding that “endurance training also harmonises with motor learning principles” (p. 23).

Sweetenham and Atkinson (2003) define aerobic training as “doing the greatest amount of work in the shortest possible time, with the least amount of rest, without the heart rate exceeding 40 beats below maximum” (p. 13), while Olbrecht (2013) claims that “the better the aerobic system is developed, the more oxygen can be used and the faster one can swim during prolonged exercises. The aerobic capacity is therefore the major factor determining performance in long distance events” (p. 1350).

Physiologists Wilmore, Costill and Kenney (2008) consider that “all athletes can benefit from maximising their endurance” (p. 222) and it is widely known that the swimmers’ level of aerobic training

will influence the outcome, whether you are racing a 50-meter sprint or a long distance event such as the 1500 meters.

Authors Riewald and Rodeo (2015) underline that “the processes of growth, maturation and development have a major effect on the ability of young athletes to leverage the physiological attributes that are commonly seen as a normal part of adult performance” (p. 360).

Regarding physiological differences between maturational groups, Bar-Or (1996) claims that maximal aerobic power or total blood hemoglobin is similar, and prepubertal girls and boys respond to resistance training in percentages of improvement similar to adolescents and adults. He also adds that undergoing training regimens similar to those practiced by adults produces trained states in prepubescents.

If aerobic capacity is described by so many authors as a key factor, it is natural that coaches should monitor its evolution with rigorous and adequate testing, and Maglischo (2003) comments that “blood testing is certainly the best method for this purpose”, while “other methods (like using heart rate monitors) have strengths and weaknesses, but they provide quantitative and qualitative data that can assist coaches in making better judgements about the effectiveness of their training” (p. 542).

### **3. Research Questions**

For this research study, we formulated the following hypothesis:

Prepubertal and pubertal swimmers react in a similar way to aerobic capacity testing.

### **4. Purpose of the Study**

The main objective of this research paper is to gain conclusive data on how the physiological variables of prepubertal and pubertal swimmers behave during and after an aerobic capacity test, in order to determine if training-based adaptations are similar.

### **5. Research Methods**

For this research, we used the ascertaining pedagogical experiment with two variables (the prepubertal group and the pubertal group), the controlled observation, the testing method (T-2000 Test), the Borg Scale, the graphical method and the statistical-mathematical method.

#### **5.1. Subjects**

The research was conducted at Aqua Team Sports Club and involved two groups of young swimmers (boys and girls) with ages between 10 and 14, irrespective of their level of performance.

The first group had 10 prepubertal swimmers, and the second group had 10 pubertal swimmers.

Both groups were equally divided in 5 boys and 5 girls.

We chose these two categories in order to observe their physiological responses during aerobic capacity testing throughout the growing and maturation processes, as their training regimen is similar in terms of periodisation and specific training stimuli. Of course, training parameters, as volume and intensity, are adjusted to fit their physical possibilities.

## **5.2. The T-2000 test**

The T-2000 test is described by Maglischo (2003) as a great way to test changes in aerobic capacity of the swimmer.

The swimmer has the task to swim a distance of 2000 meters with equal 100-m splits in the fastest time possible. The final time after 2000 m is recorded.

The times for every 100 meters should correspond to the anaerobic threshold, the swimmer being compelled to maintain this speed throughout the test. In the event that there is a difference bigger than 4 seconds between the fastest and the slowest 100 meters, the result of the test is disregarded. The final time after 2000 meters is recorded.

## **5.3. The equipment used**

The Hosand GT Aqua system uses telemetry technology to monitor the heart rate of groups up to 32 swimmers. The best feature of the system is that data are provided to the coach in real time, this meaning that he/she can adapt the training stimuli as the session progresses. A heart rate monitor (HRM) is placed on the swimmer's chest and the readings are sent by a small portable transmitter to the central unit (PC, laptop).

The data received are processed by special software: MCSOFT. In addition to the recording of the heart rate in real time, this software enables the division of data into zones of effort and getting statistical reports regarding the effort monitored.

We used the Lactate Meter Plus from Nova Biomedical to measure the concentration of blood lactate in the body. The device is characterised by a high-speed of analysis and a maximum deviation of 0.2 mmol.

The subject must first clean and dry his/her finger tip. After piercing the skin of the subject with a very thin, least painful lance, the first drop of blood that comes out is wiped off and the second drop is poured on the lactate strip. The unit automatically points the blood lactate concentration within the next 13 seconds.

## **5.4. Statistical and mathematical method**

For this research, we chose to use the following statistical-mathematical indices: the mean – a parameter of central tendency; the standard deviation – a statistical parameter of dispersion.

## **6. Findings**

Each swimmer was tested separately on an empty pool lane after receiving detailed instructions about the testing protocol.

Before they started the test, their basal value of blood lactate was measured and mean values for both groups were similar, with 1.52 mmol for prepubertal swimmers and 1.61 mmol for pubertal swimmers.

In the following tables, we show the results of the T-2000 test for both groups.

We used the Borg Scale (Centers for Disease Control and Prevention, 2015) for perceived exertion at the level of psychological stress to which swimmers were exposed through this test. We recorded an equal mean of 16.1 for both groups.

Looking at Table 01, we can see the prepubertal group results in the T-2000 test. Table 02 contains the results of pubertal swimmers.

**Table 01.** Summary table with the evolution of measured physiological variables for prepubertal swimmers

Item no.	Full name (Initials)	Age	Sex	Results								
				Time	Borg	Basal	During T-2000 testing		First minute after		Fifth minute after	
							Average Heart Rate	Max Heart Rate	Lactate	Heart Rate	Lactate	Heart Rate
1	B. R.	10	M	32:01.2	20	1.6	169	183	3	136	2	113
2	S.D.	10	M	29:13.2	15	1.3	179	193	3.9	158	2.7	139
3	A. A.	11	M	29:34.7	15	1.8	183	198	5.4	137	3.9	124
4	I. A.	11	M	27:58.4	18	1.8	185	201	4.5	172	3.5	146
5	S. T.	11	M	27:59.6	17	1.9	184	197	5.5	150	4	121
6	R.C.	11	F	30:46.7	13	2.1	181	193	2.7	172	2.1	122
7	A. A.	11	F	30:02.0	17	1.4	190	200	2.4	185	2.1	142
8	B. A.	11	F	29:20.6	17	1.1	180	191	3.1	157	2.6	124
9	D. B.	11	F	30:20.4	15	1.1	172	184	2.9	156	2.2	119
10	C.C.	11	F	30:24.1	14	1.1	174	197	5.1	156	3.9	115
				Arithmetic mean	16.1	<b>1.5</b>	<b>180</b>	<b>194</b>	<b>3.85</b>	<b>158</b>	<b>2.9</b>	<b>127</b>
				Standard deviation	1.97	<b>0.3</b>	<b>6.1</b>	<b>5.91</b>	<b>1.12</b>	<b>14.55</b>	<b>0.79</b>	<b>11.0</b>

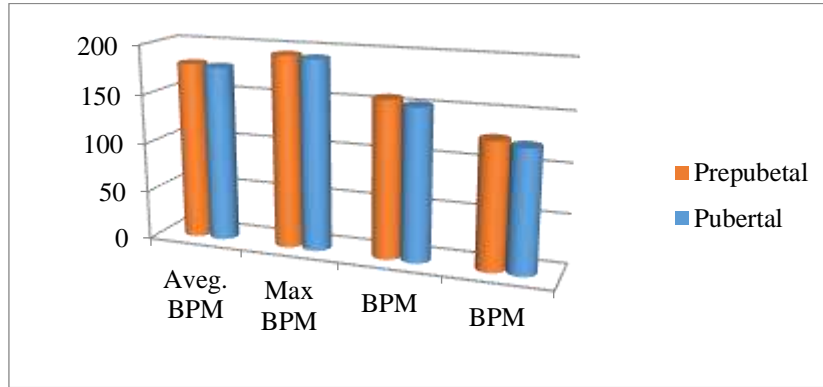
**Table 02.** Summary table with the evolution of measured physiological variables for pubertal swimmers

Item no.	Full name (Initials)	Age	Sex	Results								
				Time	Borg	Basal	During T-2000 testing		First minute after		Fifth minute after	
							Average Heart Rate	Max Heart Rate	Lactate	Heart Rate	Lactate	Heart Rate
1	C. S.	12	M	30:17.2	13	1.7	169	186	3.9	144	3.1	116
2	G. A.	12	F	27:59.7	20	1.7	189	198	2.4	149	2.1	128
3	M. I.	12	F	28:20.9	20	1.3	174	187	1.9	160	1.6	121
4	C.A.	12	F	29:15.0	12	2.2	187	201	3.7	161	2.8	143
5	P.D.	13	M	28:01.2	20	2	170	184	3.2	133	2.4	108
6	R.M.	13	M	30:30.1	20	2	180	198	4.5	150	3.8	115
7	O.A.	13	F	31:20.5	14	1.1	182	199	4	165	2.2	128
8	P.A.	14	M	27:07.2	14	1.2	174	188	4.2	154	2.6	124
9	V.M.	14	F	29:44.3	13	1.4	192	205	2.7	170	2	133
10	S.R.	15	M	28:38.1	15	1.5	162	177	5.3	146	3.9	112
				Arithmetic mean	16.1	<b>1.6</b>	<b>178</b>	<b>192</b>	<b>3.58</b>	<b>153</b>	<b>2.65</b>	<b>123</b>
				Standard deviation	3.27	<b>0.3</b>	<b>9.22</b>	<b>8.57</b>	<b>0.98</b>	<b>10.49</b>	<b>0.72</b>	<b>10.06</b>

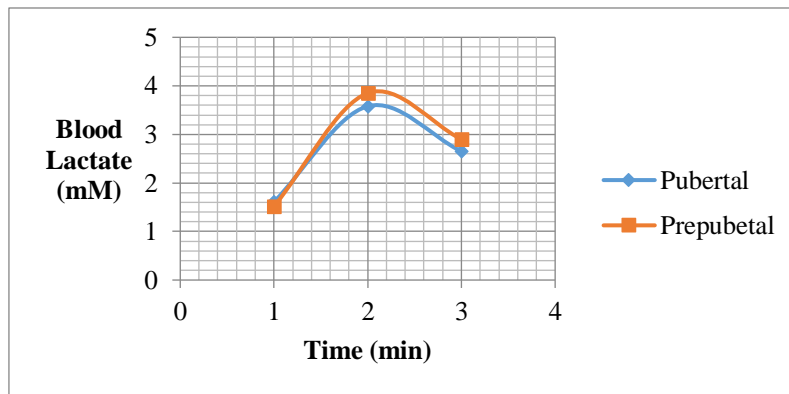
For the heart rate evolution during the T-2000 test, the mean value recorded was 180 BPM (beats per minute) for the prepubertal group and 178 BPM for the pubertal group, with a mean maximum heart rate of 194 BPM for the first group and 192 BPM for the second group. This results in a small difference of 1.1%, which implies a similar reaction.

The prepubertal group had a mean heart rate, in the first minute after the test ended, of 158 BPM, whilst the pubertal group had a mean of 153 BPM. In the fifth minute after the test ended, the mean heart rate of the pubertal group was still slightly smaller, with a value of 123 BPM, while the prepubertal group

had a mean value of 128 BPM. This indicates a difference of 3.1% in favour of the older, more mature swimmers; the difference that can be explained by the bigger stroke volume of the more developed hearts of pubertal swimmers.



**Figure 01.** Graphical representation of the results from T-2000 test (Heart Rate)



**Figure 02.** Graphical representation of the results from T-2000 test (Blood Lactate)

We graphically represented the results of both groups in Figure 01 (Heart Rate) and Figure 02 (Blood Lactate).

Blood lactate values were recorded with the Lactate Meter Plus before the test and after it, respectively in the first and fifth minute.

In the first minute, the mean value of blood lactate for the prepubertal group was 3.85 mmol and 3.58 mmol for the pubertal group. This 7.5% lower value indicates a small margin for pubertal swimmers in the efficiency of blood lactate metabolism.

This is even better highlighted in the fifth minute, when the mean value of blood lactate for pubertal swimmers was 2.65 mmol and 2.9 mmol for prepubertal swimmers, resulting in a 9.4% difference.

According to the calculated standard deviations, all means for the measured physiological variables of both groups show a normal distribution of data.

## 7. Conclusion

After analysing our findings, we have drawn the following conclusions:

- Aerobic capacity is an important factor in building fast and competitive swimmers.

- Endurance training should be a focus when working with age-groups swimmers, as it gives them a broader perspective in their event specialisation.
- Prepubertal swimmers and pubertal swimmers have almost identical values for their heart rate during aerobic testing (average heart rate and maximum heart rate).
- After the testing, pubertal swimmers have a slightly faster decrease in heart rate than prepubertal swimmers.
- Prepubertal swimmers had more blood lactate after the aerobic testing in both the first and the fifth minute, but their metabolic processing rate was almost identical.
- Prepubertal and pubertal swimmers react in a similar way to aerobic capacity testing – the research hypothesis is confirmed.

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