Anthropometric and muscle strength evaluation in prepubescent and pubescent swimmer boys and girls*

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ABSTRACT

Anthropometric and muscle strength evaluation in prepubescent and pubescent swimmers and muscle strength and body composition are important for a better sporting performance. The objective of this study was to describe and to compare anthropometrical and muscle strength aspects of prepubescent and pubescent swimmer boys and girls. Forty-eight healthy competitive swimmers participated in this study. Among them, 11 boys were prepubescent (PP) and 16 were pubescent (PU) and 8 girls were PP and 13 PU. The anthropometrical data studied were body weight, stature, skinfolds and circumferences. A computerized dynamometer (Cybex Norm) was used to isokinetic (60 and $90^o.s^{-1}$) and isometric strength measurements (45 and 60^o) of knee extension (KE) and isokinetic (60 and $90^o.s^{-1}$) and isometric (60 and 90^o) strength of elbow flexion (EF). There were no differences between PP boys and girls in muscle strength. In PU group, the boys were stronger than girls in all KE and EF tests. This difference was shown in almost all tests when adjusted by body weight (except in KE isometric tests, where values were similar between boys and girls). PU boys and girls were stronger than PP in all tests and this difference was shown in almost all tests, when adjusted by body weight (except in KE isometric tests, where PU and PP girls were not different). These results show the anthropometrical and muscle strength pattern in swimmer children and adolescents.

Key words: Child. Swimming. Puberty.

INTRODUCTION

Body composition and muscular strength may both reflect the health state and predict performance in some sportive modalities.

There are studies on anthropometrical data conducted with swimmer children, but comparisons are limited, once in some studies, there is no classification according to the maturational stage[1-3]. As the maturational stage has direct influence on the child's natural growth through the increase on the circulating hormones, especially in boys, this control become important when children and adolescents are studied[4].

In other studies, however, the lack of data such as body weight, stature and BMI[2] made the evaluation of the anthropometrical data and muscular strength in groups of young swimmers difficult.

In swimming, the performance is influenced by the capacity of generating propelling power and minimizing the resistance to advance in the liquid environment. This occurs with the improvement of the technique, the biomechanical standard and the physical conditioning of the swimmer, including body composition and strength[5].

Two factors have been pointed as responsible for the propelling difference as result of the flutter kick: the flexibility of the ankle joint (plantar flexion)[6] and the strength of the muscles involved in the flutter kick[7]. The main muscular groups that act in the flutter kick downward are those involved in the knee extension, in other words, the rectus femoralis, vastus medialis, vastus intermedius and vastus lateralis, as well ad the sartorius muscle[8].

It is possible that swimmer children present higher muscular strength due to the swimming training and as result of the specific muscular strength training. The works on strength training for swimmers were not well accepted by athletes and coaches. They believed that these exercises would cause increase on the muscular mass, hypertrophy and decreased flexibility, thus reducing the swimmer's agility. Today, however, it is known that the muscular strength is an important factor in the search for a better sportive performance.

Through the knowledge of the muscular strength of swimmer children, one can evaluate the necessity of optimizing their performance through training. There are many studies on the strength trainability in children and adolescents, what demonstrates the importance of this component[9-12].

Strass (1988)[13] detected improvements from 0.04 to 0.08 m/s on the average velocity of adult swimmers in the distance of 50 meters after strength training with weights, demonstrating the strength importance in this sportive modality.

Hawley *et al.* (1992)[7] in a study with 12 adult male swimmers and 10 adult female swimmers, observed that laboratory anaerobic power measurements (Wingate test) have significant relations with the performance of swimmers in events of short (25 meters) and long (400 meters) duration.

The applicability of the strength computerized measurement in the sportive performance, health and rehabilitation area may present advantages such as to test different types of strength (isometric an isokinetic). Despite the high cost, this equipment has been widely used in laboratories in different groups such as non-athletes[14] and volleyball players[15], but not in swimmers.

During puberty, the muscular strength is affected by maturation. The study of Pratt (1989)[16] showed higher correlation of strength and maturational stage compared with chronological age. The increment on the production of anaerobic hormones that occur during puberty affects the muscular hypertrophy. Boys present higher increase on the production of these hormones when compared with girls, what may explain the lesser increase on the muscular strength of girls in the same maturational stage, both for athletes and non-athletes[1,14].

We do not know about systematic studies on the strength evaluation in swimmer children and adolescents with computerized isokinetic dynamometers. The objective of this study was to describe and to compare anthropometrical and muscular strength data in prepubescent and pubescent swimmers from both genders.

METHODOLOGY

This descriptive, *ex post facto* and transversal study evaluated the anthropometrical and muscular strength data of prepubescent

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and pubescent swimmer children from both genders, according to the maturational stage.

The sample was composed of prepubescent and pubescent swimmer boys and girls during a competitive sportive training in a sports club.

Forty-eight volunteers (27 boys and 21 girls) participated in this study. All were Caucasian, participated in a swimming competitive sportive training and healthy, according to anamnesis supervised by a pediatrician[17].

The following exclusion criteria were used: muscular disease, chronic disease or obesity and the non-cooperation with the procedures adopted.

The prepubescent boys (PP) trained three weekly hours and for 24.5 months on average; the pubescent boys (PU) trained 12.9 weekly hours and for 39.7 months on average. The PP girls trained five weekly hours and for 36 months on average and the PU girls trained 12.8 weekly hours and for 36 months on average. All participated in the school physical education classes twice a week.

An invitation card was sent to coaches in order to elucidate the objectives of the study and this card informed the phone number of the swimmers interested in participating in this study. The parents were contacted for elucidation and scheduling of tests. Only those who agreed with all procedures adopted in the study and after their parents signed the written consent term could participate in this study. The project was approved by the Ethics Committee in Researches of the Rio Grande do Sul Federal University.

Each evaluation was performed by the same member of the stuff for a better standardization and control of the tests. Each athlete attended to the Exercise Research Laboratory (LAPEX) once followed by parents for the following procedures: 1) selection and explanations; 2) maturation and body composition evaluation; 3) strength evaluation.

That participants performed a self-assessment with regard to maturity as PP and PU, according to maturational classification[18]. This self-assessment has shown to be valid, with strong correlation with direct observation[19].

Body weight and stature were measured in electronic scale and stadiometer label Filizola, respectively, with later calculation of the BMI. The fat percentile was calculated[20], which considers gender, race and maturational stage. For the adiposity assessment, the right side skinfolds were measured using a Lange compass and following the Lohman *et al.* (1981) standards[21]. The arm and thigh circumferences (medial) were measured with a Lufkin tape measure.

The isokinetic (concentric) and isometric strengths were assessed in computerized dynamometer (Cybex Norm) always calibrated before the beginning of tests. The movements performed were knee extension (KE) and elbow flexion (EF) using the torque peak as strength measure. These movements, as well as the velocities used were selected due to the previous protocol used with prepubescent, pubescent and postpubescent non-athletes and volleyball player boys and girls. Thus, it will allow further comparison between these groups. The type of strength (isokinetic) used is the same one as the strength used in swimming, although the velocity in swimming is far higher. Moreover, the same type of equipment, test, velocity and rest were already used with children and adolescents in literature[1,12].

For all individuals tested, a familiarization with the three movements for each velocity was performed both in KE and in EF and, after 30 seconds of rest, the testing started.

In order to measure KE, the individual sat down comfortably in the equipment's chair holding side support. The individual's back was against the chair's back, which was adjusted up to the point the popliteal fossa was leant against the anterior part of the seat and the central point of the knee joint was aligned with the dynamometer's rotation axle. The hands were holding the chair's side support. For a better thigh fixation, a velcro belt was fastened above the knee joint just like a seat belt in order to adjust trunk to the chair's back.

For the EF measurement, the individuals remained in dorsal decubitus with inflected knees and feet leant against a specific support of the equipment. The trunk was fixed with a seat belt and the left hand holding support at the side of the equipment. The center of the elbow joint was aligned with the dynamometer's rotation axle. The shoulder was fixed with the velcro belt diagonally from the right shoulder up to the left elbow. This belt was fixed to the equipment in order to minimize the movement and to avoid compensation with shoulder musculature.

The explanation of how the tests were performed was given to participants before their performance, thus the participants were familiarized with three repetitions with no load in order to learn the movements.

Firstly, the isokinetic strength at velocities of 60 and $90^o.s^{-1}$ was evaluated in three consecutive repetitions for each velocity with interval of 90 seconds between them. The highest torque peak was considered as result.

One hundred and twenty seconds later, the isometric strength was evaluated at angles of 45 and 60° of the KE (total extension = 0^o), and at 60 and 90^o of the EF (total flexion = 180^o), always keeping this order and the right side, with an interval of 120 seconds between them. The test consisted of three maximum voluntary contractions in each angle each one with a contraction time of 5 seconds, with 90 seconds of interval between them, once the contraction time to assure one will reach maximum strength is of three to five seconds with two to five contractions[22]. The interval was of 120 seconds between the two angles. The highest torque peak of the three attempts was considered as result. The rest interval protocol used was based on the work of Ramsay *et al.* (1990)[12] and Hebestreit *et al.* (1993)[23].

The same appraiser performed the verbal encouragement during all evaluations. At the end of the tests, the appraisers oriented the stretching of the musculature tested.

The results are expressed as average and standard deviation per group, according to gender and maturity. The analysis of variance (ANOVA) was used for comparisons between genders and maturational stages. The strength was adjusted by the body weight. The significance level adopted was of $p < 0.05$. The software SPSS version 8.0 was used for the analyses.

RESULTS

Table 1 shows the physical characteristics of age, body weight, stature, body mass index, body fatness percentile, triceps skinfolds, sub scapular, suprailliac, abdomen and thigh, arm and thigh circumferences of each group.

No voluntary was excluded. With regard to the physical characteristics, no difference statistically significant between prepubescent boys and girls was observed. In the pubescent group, boys were heavier and taller than girls and these latter presented a higher fat percentile and higher triceps, suprailliac, abdomen and thigh skinfolds than boys.

The prepubescent boys presented higher fat percentile and higher triceps and thigh skinfolds than pubescent boys. However, pubescent boys presented higher arm circumference values than prepubescent boys.

Figures 1 and 2 present the results of the KE isokinetic and isometric strength, respectively for gender and maturation. In the isokinetic tests, no difference of muscular strength was observed between PP boys and girls. In group PU, boys were stronger than girls, and this result remained when the torque peak values were adjusted to the body weight ($60^o.s^{-1} = 2.88 \pm 0.51$ vs. 2.16 ± 0.35 and $90^o.s^{-1} = 2.4 \pm 0.32$ vs. 2.16 ± 0.30, respectively). PU boys and girls were stronger than PP boys and girls. This result remained when the torque peak values were adjusted to the body weight (boys: PU 60º.s-1 = 2.54 ± 0.38 vs. PP 1.62 ± 0.23; and PU 90º.s-1 = 2.40 ± 0.32 vs. PP 1.68 ± 0.20; girls: PU 60º.s-1 = 2.16 ± 0.35 vs. PP 1.54 ± 0.61 and 90º.s-1 = 2.16 ± 0.30 vs. PP 1.54 ± 0.44).

TABLE 1
Physical characteristics of the sample (average ± standard deviation)

	Boys		Girls	
	Prepubescent (11)	**Pubescent (16)**	**Prepubescent (8)**	**Pubescent (13)**
Age (years)	9.0 ± 0.7	13.6 ± 1.2#	9.6 ± 1.0	12.7 ± 1.7#
Body mass (kg)	38.1 ± 8.9	56.0 ± 7.1*#	37.8 ± 8.6	46.6 ± 5.6#
Stature (cm)	1.44 ± 0.08	1.68 ± 0.08*#	1.48 ± 0.07	1.58 ± 0.07#
BMI (kg/m²)	18.3 ± 2.5	19.6 ± 1.6	17.2 ± 3.1	18.6 ± 2.1
%Fat	21.0 ± 8.4#	13.6 ± 8.4	20.7 ± 6.8	18.7 ± 4.8*
Triceps (mm)	14.3 ± 5.5#	8.4 ± 2.8	15.3 ± 6.8	11.3 ± 3.3*
Sub scapular (mm)	8.9 ± 5.6	7.4 ± 2.4	9.7 ± 6.4	9.7 ± 4.8
Suprailliac (mm)	10.0 ± 5.9	8.4 ± 3.3	12.2 ± 8.2	12.2 ± 5.0*
Abdomen (mm)	13.8 ± 7.6	10.7 ± 4.0	15.6 ± 9.3	14.9 ± 5.2*
Arm circumference (cm)	22.8 ± 2.6	25.9 ± 2.5#	22.7 ± 3.2	24.2 ± 2.1
Thigh circumference (cm)	42.1 ± 4.5	45.9 ± 9.3	42.2 ± 5.2	45.8 ± 3.6

* > opposite gender within same maturational stage; # > other maturational stage within same gander; (p < 0.05).

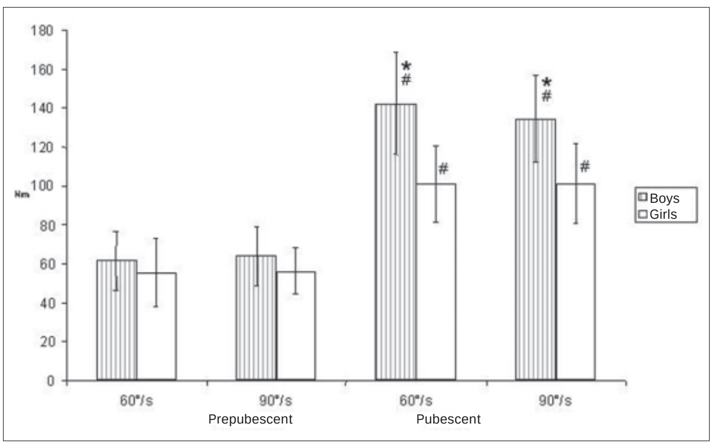

__Fig. 1__ – Isokinetic muscular strength of knee extension (KE) in Nm (average ± SD)

* > opposite gender within same maturational stage; # > PP within same gander (P < 0.05).

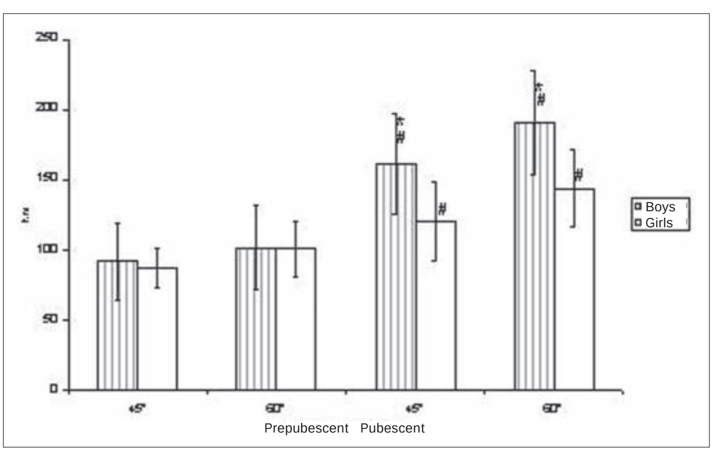

__Fig. 2__ – Isometric muscular strength of knee extension (KE) in Nm (average ± SD)

* > opposite gender within same maturational stage; # > PP within same gender; (P < 0.05).

In the KE isometric tests, no difference on muscular strength was observed between PP boys and girls. In group PU, boys were stronger than girls; however, the values were similar when adjusted to the body weight (45º = 2.54 ± 0.38 vs. 2.56 ± 0.41 and 60º = 3.41 ± 0.57 vs. 3.06 ± 0.31, respectively). PU boys and girls were stronger than PP boys and girls. When adjusted to body weight, this difference remained in the male group, but not in the female group (in other words, PP and PU girls presented similar strength values when the torque peak values were adjusted to body weight (45º = 2.35 ± 0.46 vs. 2.56 ± 0.41 and 60º = 2.73 ± 0.63 vs. 3.06 ± 0.31).

Figures 3 and 4 present the results of the EF isokinetic and isometric strength respectively by gender and maturation. In these tests, no difference on muscular strength between PP boys and girls was observed. In group PU, boys were stronger than girls, and this result remained when the torque peak values were adjusted to body weight (60º.s-1 = 0.55 ± 0.01 vs. 0.41 ± 0.10 and 90º.s-1 = 0.55 ± 0.11 vs. 0.37 ± 0.01; 60º = 0.79 ± 0.16 vs. 0.60 ± 0.01; 90º = 0.72 ± 0.17 vs. 0.59 ± 0.11, respectively). PU boys and girls were stronger than the respective PP groups, and this result remained when the torque peak values were adjusted to body weight (PP boys 60º.s-1 = 0.28 ± 0.10 vs. girls 0.28 ± 0.01; PU boys 0.55 ± 0.01 vs. girls 0.41 ± 0.10; PP boys 90º.s-1 = 0.26 ± 0.01 vs. girls 0.27 ± 0.01; PU boys 0.55 ± 0.11 vs. girls 0.37 ± 0.01; PP boys 60º = 0.46 ± 0.13 vs. girls 0.51 ± 0.01; PU boys PU 0.79 ± 0.16 vs. girls 0.60 ± 0.01; PP boys 90º = 0.46 ± 0.16 vs. girls 0.46 ± 0.004; PU boys 0.72 ± 0.17 vs. girls 0.59 ± 0.11).

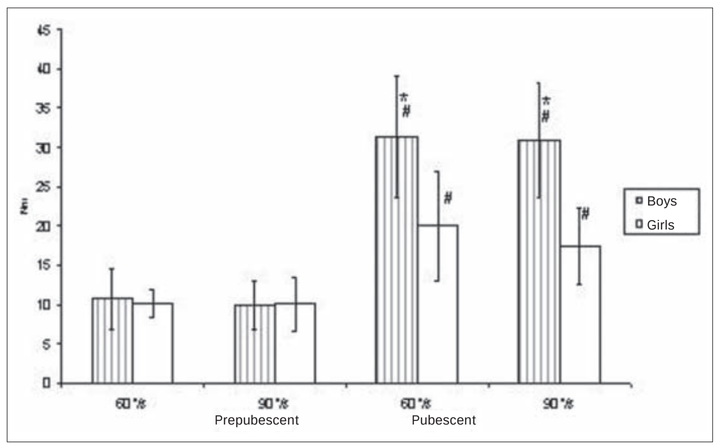

__Fig. 3__ – Isokinetic muscular strength of elbow flexion (EF) in Nm (average ± SD)

* > opposite gender within same maturational stage; # > PP within same gender; (P < 0.05).

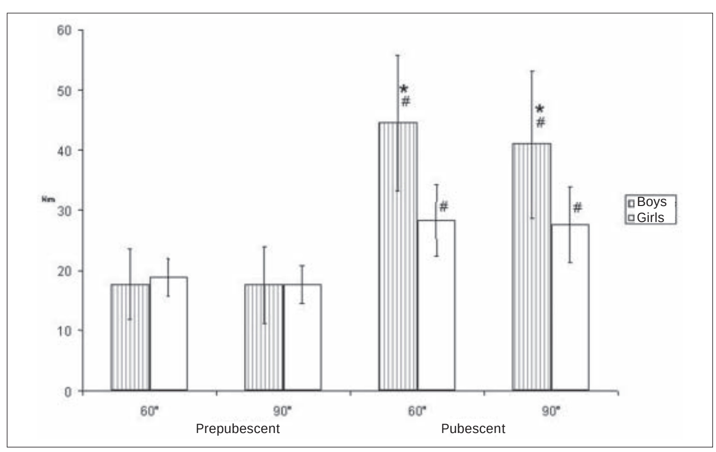

__Fig. 4__ – Isometric muscular strength of elbow flexion (EF) in Nm (average ± SD)

* > opposite gender within same maturational stage; # > PP within same gender; (P < 0.05).

DISCUSSION

The present study described and compared the anthropometrical and muscular strength data of swimmer boys and girls from 9 to 13 years of age. The KE and EF tests were performed in isokinetic dynamometer using protocol previously applied in a group of non-athlete[14] and volleyball player[15] children and adolescents.

In the present study, no differences on the physical characteristics between prepubescent swimmer boys and girls were observed, according to results of the study of Damsgaard *et al.* (2000)[2]. However, during puberty, boys and girls were taller and heavier than prepubescent boys and girls. Pubescent girls, on their turn, presented higher fat percentile and triceps, suprailliac, abdomen and thigh skinfolds values when compared with boys, demonstrating that among swimmers, the differentiation between genders prevails, with higher fat accumulation among girls.

Prepubescent boys presented higher fat percentile and triceps skinfolds values than pubescent boys. In the other skinfolds (sub scapular, suprailliac, abdomen and thigh), the group PU tended to present lower values when compared to group PP.

The swimming training may have resulted in a lower fat percentile, especially among pubescent boys and girls. These anthropometrical results (except for a higher arm circumference among pubescent boys in relation to prepubescent boys) are similar to those found among volleyball players[15]. Among non-athlete children[14], the fat percentile and skinfold values were similar between prepubescent and pubescent boys and girls and in some cases, these values were higher for pubescent girls in relation to prepubescent girls.

Only pubescent boys presented a higher arm and thigh circumference in relation to prepubescent boys, and this fact may be explained due to the higher increase on the muscular mass in this maturational stage[24].

A study[3] involving the same age range and protocol as the present study analyzed the anthropometrical data of swimmers, presenting higher BMI (19.6 to 20.5 for boys and 20.4 to 20.2 for girls) and triceps skinfold values (15.5 to 15.4 for boys and 15.8 to 16.4 mm for girls). This may have occurred due to the shorter weekly training period of swimmers of this study (three to five weekly hours for boys and girls).

Both swimmer boys and girls tended to be taller than non-athletes of the respective gender[25,26]. In our study, prepubescent and pubescent swimmer boys were about 6% and 8% taller than non-athletes, respectively and the prepubescent and pubescent swimmer girls were about 10% and 5% taller than non-athletes, respectively[14]. This difference in the stature of swimmers may reflect the growth and development of an early maturation[2].

A standard on results of all muscular strength tests both for lower and upper limbs was observed. When adjusted to body weight, the KE isometric test was the only one in which PU girls were not significantly stronger than PP girls. No difference between genders was observed in group PU either. This may have occurred because the strength differences between genders were attenuated, especially in the lower limbs[27], when adjusted to body weight.

When groups of non-athletes were compared[14], the swimmers were stronger both in the KE and in EF tests. The magnitude of these differences is weak between PP groups and more intense between PU groups. This may be explained due to the higher volume and longer time of the PU swimming training (12.9 weekly hours for boys and 12.8 weekly hours for girls) in relation to PP groups (3 weekly hours for boys and 5 weekly hours for girls).

The pubescent swimmers of the present study, both boys and girls, seemed to be stronger than swimmers of the study of Bencke *et al.* (2001)[1] in the EF isometric test at 90º. This result may be due to higher stature, body weight and weekly training time of pubescent swimmers of the present study.

In the present study, we searched to use a previous protocol[14,15] that would allow the comparison between groups with no correlation with performance events. It would be important the use of strength tests at angles, movements and velocities that could reflect the specific swimming gestures for the correlation with performance in this sportive modality. This was the limitation of the present study.

We believe that these results demonstrate the physical and anthropometrical characteristics as well as the isokinetic and isometric strengths in KE and EF tests in a sample of prepubescent and pubescent swimmer boys and girls. These data will be useful as reference for other groups of swimmers for comparisons with similar studies of other sportive modalities and further muscular strength trainability studies for this group of athletes. As suggestion for further studies, we emphasize the importance of a controlled prospective longitudinal model for a better comprehension of the anthropometrical and muscular strength behavior in this population.

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