BILATERAL AND ANTERIOR-POSTERIOR MUSCULAR IMBALANCES IN SWIMMERS

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The purpose of this study was to determine the relative magnitude of bilateral and anterior-posterior differences in swimmers. Peak hand force was measured during aquatic exercise (horizontal arm abduction and adduction in a standing position) and swimming (freestyle and backstroke). The peak force values were significantly higher ($p<.01$) for exercise adduction than abduction and for the swim stroke with the arm in the adducted position (freestyle) rather than the abducted position (backstroke). The magnitude of the anterior-posterior difference was large for both exercise (1.5σ) and swimming (.8σ). Bilateral differences were trivial (.1σ, ns) in comparison. A training regimen that strengthens the arm abductors may not only decrease the incidence of injuries in all four strokes, but also increase hand force and, therefore, improve performance in backstroke.

Key Words: biomechanics, injury, technique, measurement, strength, evaluation.

INTRODUCTION
Bilateral imbalances are common in swimmers and can inhibit performance (6). Anterior-posterior differences are not only common, but also related to injuries such as shoulder impingement (2, 7). Muscular balance in the shoulder and scapula is necessary to avoid injuries (8). The ratio of land-based abduction to adduction strength was used to quantify anterior-posterior differences and was correlated to clinical signs of injuries in swimmers (1). The purpose of this study was to determine the relative magnitude of water-based bilateral and anterior-posterior differences in swimmers, relate these imbalances to complementary clinical screening procedures, and suggest related changes to training regimens.

METHOD
The subjects were 19 competitive swimmers (12 males and 7 females) between the ages of 14 and 17. The descriptive statistics for the males were: age (M = 15.4 yrs, SD = 1.4), height (M = 176 cm, SD = 7.9), and mass (M = 66.4 kg, SD = 9.9). The female data were: age (M = 15.4 yrs, SD = 1.4), height (M = 164 cm, SD = 7.5), and mass (M = 53.2 kg, SD = 5.4). Informed consent was obtained.
Peak hand force was measured performing aquatic exercise (horizontal shoulder abduction and adduction in a standing position) and swimming (freestyle and backstroke) with Aquanex (previously described and validated in 5). For the aquatic exercise, subjects were instructed to perform five repetitions with maximum intensity. For the swim trials, the subjects were asked to sprint 20 m to a wall. Hand force data were collected over the last 10 m. Two trials of each test were performed with about 1 min rest. The single highest peak force value for each trial was used as the criterion.

RESULTS
Sample exercise and swimming trials are shown in Figures 1 and 2.

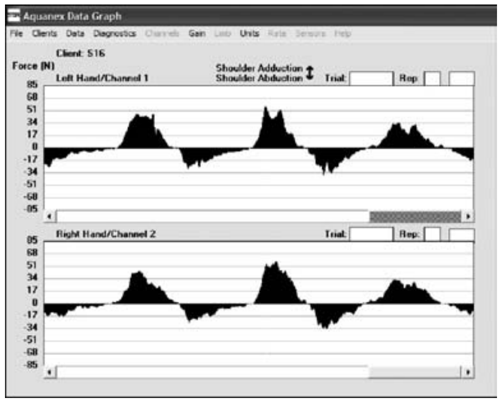

Figure 1. Aquanex image of horizontal shoulder abduction/adduction exercise.

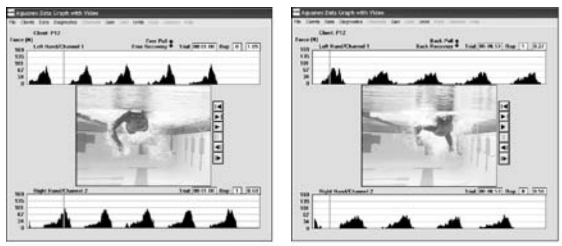

Figure 2. Aquanex+Video images of freestyle and backstroke swimming.

For aquatic exercise, the peak hand force values were significantly higher ($p<.01$) for adduction than abduction. For swimming, the peak hand force values were significantly higher ($p<.01$) for the stroke with the arm in the adducted position (freestyle) than in the abducted position (backstroke). Bilateral differences were not significant. The data are listed in Table 1 and graphed in Figure 3.

Table 1. Peak hand force values (N), reliability coefficients (Alpha), and effect sizes (ES) for aquatic exercise and swimming.

	Abduction/Backstroke			Adduction/Freestyle			
	Alpha	M	SD	Alpha	M	SD	ES (σ)
Exercise/Left Hand	.87	34.4	16.5	.97	75.7	34.1	1.63
Exercise/Right Hand	.97	35.7	19.9	.98	79.4	38.6	1.49
Swimming/Left Hand	.88	120.5	33.4	.94	148.1	50.4	.66
Swimming/Right Hand	.95	116.0	33.9	.95	154.2	49.6	.91

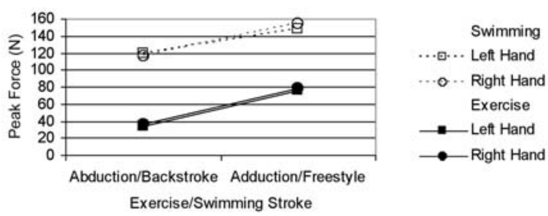

Figure 3. Peak hand force values for aquatic exercise and swimming.

DISCUSSION

The magnitudes of the anterior-posterior differences were large for both aquatic exercise (1.5σ) and swimming (.8σ). The anterior-posterior peak force ratios for aquatic exercise were similar to the values reported for land-based exercise (1, 4). The magnitude of these imbalances is less than ideal and can be related to performance restrictions and predisposition for shoulder injury.

Muscular imbalances and injuries have been attributed to stroke mechanics, inadequacies in dryland exercise, and overuse (2, 3, 8, 9). Although these are substantial issues, a coach can address each one in a typical training environment. For example, a coach can first conduct a technique analysis to qualitatively assess the mechanical basis for muscular differences. The freestyle recovery of the swimmer in Figure 4 shows a bilateral difference in the angle between the upper arm and the horizontal. The restricted right shoulder position reflects a strength decrement in shoulder abduction.

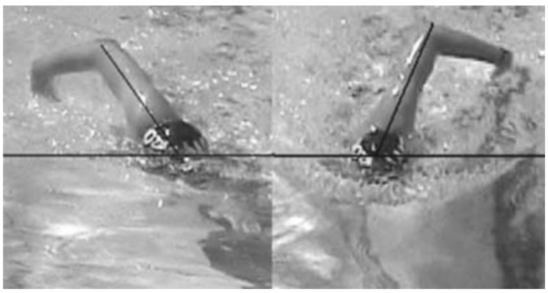

Figure 4. Stroke evaluation of freestyle recovery showing a smaller angle with the horizontal for the weaker right shoulder.

Such qualitative clinical evaluations can also identify related structural conditions. Testing that mimics the stroke mechanics can show muscular imbalance/stabilization dysfunction. The Swim Stroke Pull Test (Figure 5) is a dryland replication of the freestyle arm motion. The swimmer's hand directs force against the resistance of the examiner's hand to imitate the propulsive phase of the stroke. Strength decrement in shoulder adduction can be determined by qualitative analysis of the swimmer's force, body segment adjustments during the test, and video review. The scapular position for the affected right upper extremity shows dysfunctional elevation/protraction (Figure 6).

Figure 5. Swim Stroke Pull Test. Swimmer is initially positioned with upper extremity at full shoulder abduction and then applies pressure to the examiners hand to complete shoulder adduction.

Figure 6. Comparative demonstration of upper extremities completing the Swim Stroke Pull Test. Left upper extremity shows adduction position with no irregularities. Right upper extremity shows irregular position of the scapula and indicates weakness of the adductor function.

Once a structural problem is detected, a coach can implement changes in the training regimen. Specific strength training that targets the associated abductors can be added to the program. An adjustment of total training distance and the proportion of frontal stroke (butterfly, breaststroke, and freestyle) to dorsal stroke (backstroke) distance may also be appropriate.

CONCLUSIONS

Muscular imbalances of considerable magnitude are common in swimmers. A thorough strategy for dealing with muscular imbalances includes a minimum of three components: evaluation, remedial strength training, and adjustment of training distance and stroke. First, it is important to evaluate anterior-posterior muscular differences either quantitatively or qualitatively. Second, additional aquatic and/or land-based strength training may be necessary. Third, it may be appropriate to reduce the total training distance for the frontal strokes and/or increase the proportion of backstroke. A training regimen that strengthens the arm abductors may not only improve muscular balance and decrease the incidence of injuries in all four strokes, but also increase hand force and, therefore, performance in backstroke.

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THE CONTRIBUTION OF THE AXILLARY ARCH TO THE OVERHEAD KINESIOLOGY OF THE SHOULDER

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According cadaveric, neurosurgical and medico diagnostic evidence the Axillary Arch of Langer (AA) creates symptoms similar to those of entrapment or obstruction type syndromes. In addition to the existing anatomical evidence and based on similar functional reasoning one can assume that in swimming the AA influences the shoulder girdle kinesiology also. In order to complete our knowledge of the AA we evaluated strength, endurance, motor control, precision and proprioception in two groups of physical education students (all good and average swimmers) one with AA and a control group without AA (both N=22). The results indicate a significant ($p<0.05$) influence of the presence of an AA on strength, throw or pull/push endurance and motor control increase in women associated with a minor increase of parasthaetics. For all these parameters no significant difference occurred in men. The pull/push simulation and proprioceptive joint position sense data however indicate a decrease both in men and women ($p<0.05$).These finding do not fully confirm the anatomical predictions from the cadaveric evidence nor support the diagnoses of excision of the AA.

Key Words: shoulder, axillary arch, strength, endurance, motor control, proprioception.

INTRODUCTION
The Muscular Arch of the axilla (AA) can be described as a small muscle coming from the M. latissimus dorsi crossing the axillary cavity towards the upper arm. This supernumerary muscle can either be a well developed thumb-shaped fleshy belly or a tiny fibro-muscular band or string. It inserts on the tendon and fascia of the M. pectoralis major or between this muscle and the sulcus intertubercularis, often with fibres sent to the aponeurosis of the Mm. biceps and/or coracobrachialis and to the tunica vaginalis intertubercularis. The arch is innervated variably by branches of the plexus cervicalis or brachialis. According to the literature the AA has been the subject of numerous descriptions on cadaveric material and in a lesser extend on in-vivo populations, giving this anomaly a rather popular status and an up-grade from anomaly to muscular variant (3).
The name of Langer (5) is generally attached to the most frequent form, the Axillary Arch (of Langer). Most authors find AA's in 8 to 10% of the subjects, but the extremes go up to 27% (11). The arch can be evaluated and/or palpated (figure 1).

Figure 1. The Muscular Axillary Arch of Langer in-vivo and Post-Mortem.

Because of the incidence of the AA and because of its assumed clinical relevance (assumed compression syndrome), an in vivo screening of function and position sense in athletes is over due. This is supported by the fact that e.g. Thoracic Outlet Syndromes (TOS) have been diagnosed in aquatic athletes also (4, 8, 12). The purpose of this study is to evaluate the proprioception, strength, precision and motor control influences of the presence of an AA in healthy (overhead) athletes. The obtained information should provide a better understanding of shoulder problems in swimmers and waterpolo-players.

METHODS
Three hundred and twenty seven (327) PE students (19 to 25y.), all good to average swimmers, were screened for the presence of one or two muscular AA indepently by two manual therapy experts. Twenty five persons had at least one AA of which 22 subjects participated in all tests. An equal number of subjects were at random selected as a control group (without AA).
A series of shoulder/arm tests were selected e.g.: *Elevated arm stress tests:* because of the anatomical evidence (3) testing with the arms in abduction seemed imperative. Maximal isometric hand/arm strength was measured with a factory calibrated Bettendorff Hand-Held Dynamometer (HHD) in 4 positions: a) alongside the body; b) in horizontal abduction; c) in maximal (vertical) abduction and d) arms in horizontal abduction with the elbow-flexed (90°) with forearm/hand vertical upwards (2 trials, 15 sec rest).
Maximum isometric strength tests: In addition to HHD, maximum isometric strength of the arm-shoulder muscular chain, both in abduction, adduction and throw or push/pull position, were measured with a BTE® primus work simulator (Baltimore Therapeutic Equipment co.) (figure 2) (3 trials; 30 sec rest). Consistency of effort is quantified by a coefficient of variation score.

Figure 2. I. Abduction/adduction testing of the shoulder with extended arm; II. Max. isometric strength of vertical ante-retroflexion; III. Simulated throw or push/pull in max. isometric and the endurance test conditions (BTE® primus work simulator).

Dynamic Endurance test: The Dynamic Endurance test is measured with the BTE® primus work simulator also. Two endurance tests were measured, both at 60 RPM within 1 min. over the full range of motion against an individually normalized resistance. The force was set at half of the averaged level that was used for the maximal isometric test of the weaker of the two extremities. (i) Adduction Endurance test (+/- 135°) with an extended arm, and (ii) (simulated) Throw or push/pull Endurance test (+/- 90°) of the flexed forearm with a rotation of the abducted upper arm.

Shoulder proprioception test: Proprioception is the sensory modality of touch that encompasses the sensation of joint kinaesthesia and joint position sense (7). It involves measuring the accuracy of joint position replication. Since joint proprioception appears to play an important role in stabilizing the glenohumeral joint and the management of muscular activity (2) an active repositioning test was chosen. The "Index Finger Touch Test" (IFTT) is executed with the blindfolded subject standing at arm distance of a screen of which the midpoint corresponds with the eye level of the subject. The subject is guided with its Index finger top by the examiner to 3 vertical bars (H 30 cm, interdistance 15 cm) on the screen. After the 3 guided "finger touches" the subjects leaves the arm against the body for 5 sec and tries subsequently to reposition the index on the location touched before. This test is repeated twice left and right (Clarys et al. unpublished data, 2005).

Statistics

All data were handled with SPSS 12.0 including. Normality distribution t-test ($p<0.05$), one-sample and two-sample Kolmogorow-Smirnov test (numerical data); the Pearson Chi-Square, the Ficher's Exact test and the Linear-by-Linear association (score type data).

RESULTS AND DISCUSSION

In order to discriminate influences and effects between overhead athletes with and without an AA both groups were homogeneous and allowed for comparison of various strength and proprioceptive measurements. Figure 3 shows the HHD results for gender and both arms with and without an AA. Men and women score significantly different ($p<0.05$) as could be expected. It is interesting however to see that there is no significant difference between men with and without an AA while there is a difference ($p<0.05$) in women, e.g. the presence of an AA enhances the isometric strength in women but is almost equal for both groups in men. The strength increase in female due to an AA, may explain why paresthesia (twingling) was observed more consistently in women (with AA) than in man. This reaction suggests a nervous compression which in clinical circumstances could allow for a TOS indication (1, 13).

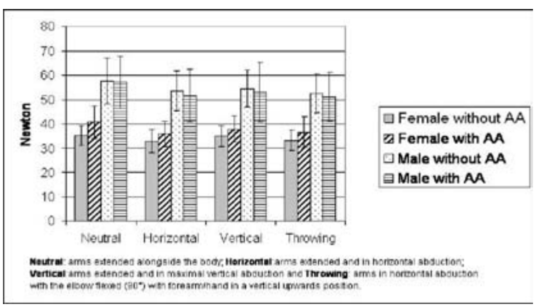

Figure 3. H.H.. Dynamometry of 4 shoulder positions.

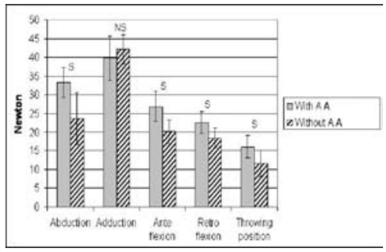

Figure 4. BTE isometric strength in women (p<0.05).

Both the BTE® maximum isometric strength and the dynamic endurance confirm the HHD test results: no differences in men but significant differences ($p<0.05$) in women both for the isometric maximum (figure 4) and the dynamic endurance testing (figure 5). In other words the presence of an AA increases the strength and the endurance of the overhead shoulder of the female athlete, while this effect was not significant in men. Referring to the TOS diagnose and its female to male ratio of 4:1 the question rises whether this is not overrated because of undiagnosed Axillary Arches in women? ... Or the AA explains part of the ratio? As the neuromuscular control increases, the AA, will have stabilizing effect. However it remains an interesting phenomenon that in women the AA probably influences isometric, dynamic and endurance strength while the presence of an AA assumes a more stabilising capacity in men. The combination of these findings conflict with the compression theories of the AA, has led to excision (3, 10). Our findings suggest the opposite since the strengthening and stabilising function of the AA increases the quality of the overhead motion and therefore creates better opportunity to enhance performance rather than to decrease it (4, 6, 9).

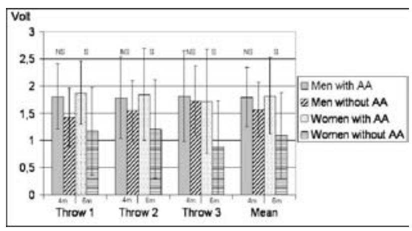

Figure 5. BTE throw/pull/push endurance in male and female (p<0.05).

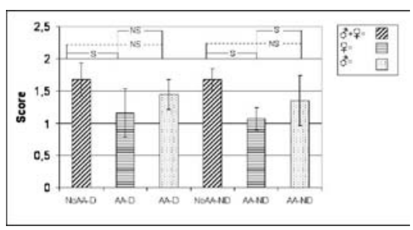

Figure 6. Average of the proprioceptive IFTT score of the Dominant (D) and Non Dominant (ND) arm with an Axillary Arch (AA) versus the control group (No AA) for men and women separated (s=p<0.05).

Again, the logical continuation of data acquisition is the proprioceptive testing of the articular and neuromusculo position sense. The Index Finger Touch Test (IFTT) results are averaged for both the dominant and non-dominant arm (figure 6). The AA influences the proprioceptive joint position sense both in men and women, but again more discriminative for the female, showing a lower joint position sense. These findings indicated that repositioning accuracy for ± 90° abduction/ante flexion movements again might be influenced by an AA for both in the dominant and the non- dominant arm. The sensation of movement is markedly enhanced by the contracted AA and again stresses the fact that its stabilising function is important.

CONCLUSIONS

The in-vivo detection of an Axillary Arch in a young, healthy and homogeneous population is in agreement with the incidence found on cadaveric material (non-homogeneous and aged samples). The AA seems to involve women significantly more than men. The AA increases their hand strength, their shoulder abduction and adduction strength, both static and dynamic; it increases their throw/pull/push endurance capacity but creates minor paresthetics too. The AA decreases their joint position sense.
In the "balance" the AA seems to have more positive effects than negative and does not destabilise the shoulder. These data suggest that the diagnoses of an AA no longer results in an excision of this supernumerary muscle and that the AA is an extra compression of TOS cannot be supported anymore.

ACKNOWLEDGEMENTS

The authors are grateful to Laurens Finsy and Karel Vandekerckhove for the logistic support in the collection of the data.

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APPLICATION OF A PROTOCOL FOR EXERCISE INTENSITY PERCEPTION IN SUBJECTS WITH MULTIPLE SCLEROSIS EXERCISING IN THE WATER.

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Acute physical fatigue (APF) is one of the most common problems related to Multiple Sclerosis (MS), as the perception of fatigue is a very subjective and individual matter which can be different among subjects. Usually water activities are adopted as a healthful treatment to improve MS affected subjects' quality of life, but sometimes not respecting intrasubject variability or exercise capability. The aim of this study was to examine if CR10 scale for rating of perceived exertion (RPE) could be useful to manage with exercise intensity and effort perception in 4 subjects suffering different grades of MS. The results showed that subjects could improve their exercise intensity perception (production of intensities of 3, 6, and 9 grades in CR10 scale) after a three week treatment. Due to the results, it can be argued that RPE can be a useful tool when prescribing exercise intensity with subjects suffering MS.

Key Words: Multiple Sclerosis, physical activity, RPE, fatigue and water exercises.

INTRODUCTION

Multiple Sclerosis (MS) is characterized by variables symptoms (8) that have to be treated in an interdisciplinary way. It is widely accepted to point out the necessity of using physical activity in the programs applied with subjects suffering Multiple Sclerosis (MS), as a very useful way to improve their quality of life (6, 10). One of the most common problems related to this pathology is the acute physical fatigue (APF) that is suffered by 75 to 95% of the patients (4). Its impact into the quality of life is very high, many times implicating daily common activities. So, APF becomes one of the greatest problems to be treated, as the perception of fatigue is a very subjective and individual matter which can be different among subjects.
Changes in the temperature can produce crisis of APF; in fact, exercise and related body temperature elevation are shown as factors that can increase fatigue (2, 3). Usually activity in the water is adopted as a healthful treatment to improve MS affected subjects' quality of life, because of some characteristics of this singular environment -flotation, hydrodynamic resistance, viscosity…- (5, 7), adding that immersion in the water can decrease body temperature. This could help to practice physical activity reducing the risk of hyperthermia.
The aim of this study was to examine if CR10 scale (1) for rating perceived exertion (RPE), could be useful to manage with exercise intensity and effort perception in subjects suffering

different grades of MS, when practicing out of the swimming pool but also when practicing in the water. So, it was hypothesized that subjects could regulate exercise intensity and this could be useful not to pass the individual threshold above which APF can be reached. This is very important as APF can also influence negatively MS and everyday physical activity.

METHODS

Subjects: Four participants suffering different grades of MS (1 to 4, from the lowest grade to the highest) took part in the study. They were two women and two men; age 29±4 ys; weight 57,03±12,51 kg; height 1,60±0,12 m and BMI 22,1±3,4 %). Materials: indoor swimming pool of 25 x 12.5 m and a track of 43 m; Thermometer, hygrometer, and barometer (Oregon Scientific); 4 heart rate (HR) monitors (S610i; Polar Electro, Finland); 1 Chronometer (Casio, Japan); Diaries and observation sheets. Protocol: Three pretest sessions were developed, and subjects completed in each 3 different exercises (walking in a track out of the water, walking in the water -to the sternum-, and swimming) at three different intensities during 3 min each one and constantly developed (3, 6, and 9 in Borg's CR10 scale (1)), corresponding to low, intermediate, and high intensities, respectively, in a randomized order each session (to eliminate the potentially contaminant effect of the order of prescribed intensities). Later, a treatment of 6 sessions during 3 weeks (2 per week, lasting 30 min each) was carried out using different tasks combining the 3 different intensities and giving the subjects feedback abut their performance: HR, distance, velocity, time, or repetitions; significant, useful and easy to measure indexes (9). The postest was developed repeating the 3 pretest sessions, to evaluate if subjects could produce the prescribed intensities more accurately after the treatment period. Environmental conditions were controlled in each session, reporting temperatures of 25.5° C (1.87), pressure of 1020.8 mb (3.9), and humidity of 67.3 % (6.9). Temperature of the water was 29°C. Also, heart rate -each 5 s-, distance covered -m-, a personal diary -reporting sensations, mood state, perceived fatigue,... before, during and after the sessions-, were registered. Statistical analysis: intrasubject repeated measures ANOVA with Bonferroni *post hoc* were developed (SPSS 12.0 statistical software) to determine if the 3 intensities (HR) were clearly differentiated and produced by the participants, and also to determine the possible differences between each activity of the pretests and postests. Statistical difference was accepted when $p<0.05$.

RESULTS AND DISCUSSION

Subject 1, the less affected participant, (figure 1) was able to discriminate the 3 levels of intensity ($p<0.001$), in the majority of the proposed tasks, although after the treatment this is done in a more stable way. It was found changes in the correct perception of intensity when walking in the water, as in the second session of pretest (PRE2), HR for 6 points task was lower than for intensity of 3.

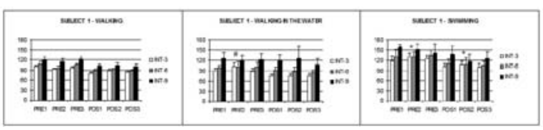

Figure 1. HR showed by Subject 1 for the pretest and postest tasks.

Swimming, subject 1, could not discriminate between 3 and 6 intensities ($p>0.05$) during PRE 2 and POS2 sessions. These correspond to the sessions that started with intermediate intensity, showing a greater difficulty to distinguish between intensities when the order was not incremental or detrimental. This feeling is reported by this subject in the personal diary. The lack of affectation of the MS symptoms in this subject and the greater experience in sport practice could explain the capacity of this subject to measure out when executing the prescribed intensities.

Subject 2 was more affected of MS (described as type 2, this subject was moderately affected -normally walking with a crutch-), and shows in figure 2 significant differences ($p<0.001$) just when the sessions started gradually increasing intensity from 3 to 9 (sessions PRE1 and POS2). When tasks were presented in detrimental order of intensity, difficulties to discriminate levels 6 and 9 of intensity ($p>0.05$) appear in PRE3 when walking, and in PRE3 and POS3 when swimming.

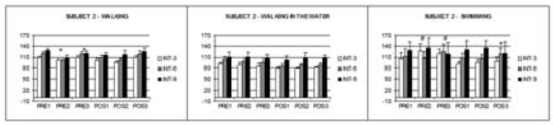

Figure 2. HR showed by Subject 2 for the pretest and postest tasks.

In these two tasks, there were no differences between 3 and 6 points ($p>0.05$) when the first intensity was intermediate -6 points- (PRE2), situation that was corrected after the treatment. In this case, similarly to subject 1, difficulties to perform different intensities were related to the order of execution, being more complex when the tasks were not developed in an incremental order of intensity, although this was corrected after the treatment. The best results were obtained walking in the water, requiring lower HR and showing a better grade of discrimination of intensities, so that it could be justified by the better stability and security that subject feels when walking without the necessity of any additional implement. The greater effort observed -HR- is when swimming, possibly due to the technique limitations (this was confirmed in the personal diaries).

Subject 3 presented in the initial measurements (figure 3) difficulties to discriminate correctly the different intensities when the order was not presented in an incremental way; for the order 6-9-3 when walking in the water, no significant differences were found -$p>0.05$-, lower HR were shown at higher prescribed intensities when walking and swimming, although these situations were corrected after the treatment except walking. The grade of affectation of subject 3 allows walking in the water without implements because of flotation. In the same way than for subjects 1 and 2, for subject 3 the greater effort appeared when swimming as the domain of the technique was not great.

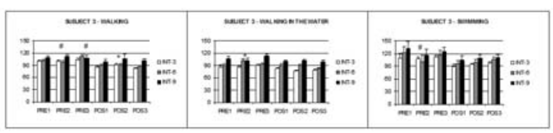

Figure 3. HR showed by Subject 3 for the pretest and postest tasks.

Subject 4 is the more affected by MS, using normally a wheelchair for the displacements. This is reflected in the greater difficulty during walking (using two crutches). In figure 4 it is observed that in PRE1, PRE2, and PRE3, subject when walking is not able to discriminate between the 3 grades of intensity, showing small differences for the HR of all the different tasks ($p>0.05$).

After the treatment, subject 4 could discriminate moderately when walking between the 3 types of intensity for POS1 and with more difficulties for POS2 (not between 3 and 6), and POS3. Walking in the water, for PRE1 intensities were developed the contrary than prescribed, decreasing HR when the order was 3-6-9. After the treatment, it is observed an improvement although with difficulties between intensities of 3 and 6 ($p>0.05$). Swimming, before and after the treatment the subject was able to discriminate between the 3 intensities (except in PRE1 for intensities 3 and 6), although after the treatment this differentiation was more clear. This subject seemed not to show clearly the order in which the different intensities were presented. The functional limitations, greater in this subject, determined the executions so that the main problem to discriminate the intensities was due to this problem more than to the subjective perception -this was corroborated in the diaries-. The best results were observed in the water, mainly because flotation effect of the water allowed this subject to execute better by decreasing the functional limitations.

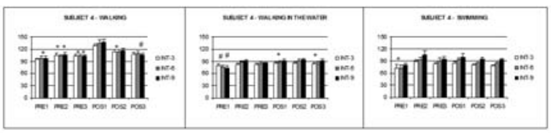

Figure 4. HR showed by Subject 4 for the pretest and postest tasks.

It can be argued that, when the affectation is moderate to high -grades 2 to 4-, it is easier to discriminate intensities for the tasks developed in the water, so that we hypothesize that hydrostatic pressure favours subjects' movements and, therefore, subjects' focusing on exercise perception rather than in the technique. Also, subjects with more affectation (2 to 4) reported in their diaries that hot conditions clearly affect them so that in the water they feel better to exercise physically.

CONCLUSIONS

1. Subjects suffering MS can use RPE scales to better discriminate and produce different and individual exercise intensities. This can be especially useful to avoid APF.
2. Special and singular characteristics of water favour perception and regulation of effort, although this is mediated by the type of task and its domain by the subject. Specifically, flotation makes easier some tasks for the subjects when the affectation is moderate or higher.

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INJURIES INCIDENCE IN BRAZILIAN SWIMMERS OF DIFFERENT STROKES

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The aim of this study was to identify the incidence, place and diagnosis of injuries in competitive Brazilian swimmers, according to the stroke. The sample was composed by 137 competitive elite swimmers. The instrument used was a mixing questionnaire. Seventy (51%) of the evaluated athletes suffered some kind of injury. During competition, 19 athletes referred injury. The most affected segment was the shoulder (53%) and the tendinitis was the most frequent diagnosis (72%). According to each kind of stroke, it was verified: a) tendinitis was the most frequent injury for the butterfly (80%), crawl stroke (86%) and breaststroke (75%) swimmers. For medley, both the tendinitis and the muscle strain were the most observed injuries (43%); b) the most affected segment was the shoulder for the butterfly (50%), backstroke (63%), crawl (56%) and medley (44%) swimmers. The knee was the most affected segment for the breaststroke swimmers (62%).

Key Words: injuries, swimming, different strokes, epidemiology, Brazil, incidence.

INTRODUCTION

According to Ciullo and Stevens (2), elite swimmers generally are submitted to 11 or more sessions of 2 hours of duration per week. The swimmer makes in average about 12000 m of swim per day. In crawl swimming, during the training, the athlete carries through 8 to 10 cycles of arm to each swimming pool, totalizing about 1 million of shoulder rotations per week (5).

Thus, the competitive and high level swimming expose the athletes to situations of constant stresses. These innumerable repetitions of technical gestures, allied to an eminent factor to the training, the unbalance between the work and the time of recovery, are considerable predisponents for injuries. The accumulation of stress or microtrauma in a region of the body depends on the movement that is executed by the athlete. For example the arm and leg movements in the crawl stroke are executed with physical valences and different mechanical requests than in breaststroke. Thus, it can be expected that the accumulation of stress/microtrauma locates differently for crawl and breast strokes.
To verify if this different muscular and mechanics requests between the swim styles will cause different forms of injury this study was carried through. It aims to identify the incidence, the place and the diagnosis of the injuries in Brazilian elite swimmers according to the stroke through the descriptive epidemiology.
To carry through the survey of which injury is more common according to the stroke is the first step in a work of injuries prevention approaching each style of different form, once the diagnosis of which injury is more frequent for each stroke is made.

METHODS
The study was characterized as descriptive study and the sample was composed by 137 swimmers that participated of the Brazilian Championship of Swimming – Brazil's Trophy 2004, in Rio de Janeiro, RJ. The characteristics of the athletes are presented in Table 1.

Table 1. Main characteristics of the swimmers.

	number	Male	Female	Age (yy)	Swim start age (yy)	Years (yy) of practice
Swimmers	137	77	60	19±3	6±3	14±4

The used instrument was a mixing questionnaire elaborated by the National Center of Sports Excellency for the National Project "Champion Profile", which objective was to identify the profile of Brazilian athletes of several modalities in order to improve the public politics of sports in Brazil. In order to stimulate the sample participants, the questionnaire has a brief explanation about the investigated topics and the importance of the research, including the guarantee of the answers secrecy. All the procedures had been taken and of this form the questionnaire was applied during the events.
The data collection was carried out generally before the beginning of each competition, through a previous contact with coaches and athletes. The questionnaire was answered at the moment of the application when the athletes were able to do it, with the researcher's accompaniment, who redressed doubts about the questions. From the gotten answers the data base was formed and analyzed through the descriptive statistics.

RESULTS
With the questionnaire data and fulfilling with the objective of tracing a profile of the incidence of the injuries in Brazilian swimmers of the elite, it was observed that from the 137 athletes, 70 (51%) had already suffered some injury We cross the data of the corporal region affected with the diagnosis of the injury to obtain the most affected body region, and these data are in Table 2.

Table 2. Data of the place of the body and diagnosis for the former injuries.

Body´s Place	Diagnosis	Tendinitis	Back pain	Muscular Strain	Instability	Ligament Rupture	Total
	Shoulder	28	-	-	2	1	31
Upper	Arm	6	-	2	-	-	8
Limb	Wrist	1	-	-	-	-	1
	Thigh	-	-	7	-	-	7
Lower	Knee	5	-	-	-	-	5
Limb	Leg	-	-	1	-	-	1
	Foot	1	-	-	-	-	1
Trunk	Back	1	2	1	-	-	4
Total		42	2	11	2	1	58

The data between the place of the body where the injury occurred and the swim style are in Table 3.

Table 3. Data of the body place and stroke for the former injuries.

Body Segment	Stroke	Butterfly	Backstroke	Crawl Stroke	Breaststroke	Medley	Total
	Shoulder	8	5	13	3	4	36
Upper	Arm	5	-	3	-	1	9
Limb	Wrist	-	-	1	-	-	1
	Thigh	-	1	2	2	2	7
Lower	Knee	1	1	-	5	1	7
Limb	Leg	1	-	-	-	-	1
	Foot	-	1	-	-	-	1
		-	-	1	-	-	1
Trunk	Back	1	-	3	-	1	5
Total		16	8	23	10	9	

The data between the diagnosis of the injury and the swim style are in Table 4.

Table 4. Data of the diagnosis and stroke for the former injuries.

Diagnosis	Butterfly	Backstroke	Crawl Stroke	Breaststroke	Medley	Total
Tendinitis	12	6	13	6	3	42
Back Pain	-	-	2	-	-	2
Muscular Strain	1	1	4	2	3	11
Instability	1	-	-	-	1	2
Ligament Rupture	1	-	-	-	-	1
Total	15	7	19	8	7	58

Intending to investigate the number of injured athletes at the moment of the questionnaire application, or either, during the accomplishment of the competition, it was investigated incidence of current injury and its respective place and diagnosis. The data of the body region where the injury occurred and the diagnosis of the injury are in Table 5.

Table 5. Data of the body region and diagnosis for the current injuries.

Region	Diagnosis	Tendinitis	Back pain	Muscular Strain	Instability	Synovitis	Total
Upper Limb	Shoulder	8	-	-	1	-	9
Lower	Thigh	-	-	1	-	-	1
Limb	Knee	-	-	-	-	1	1
Trunk	Back	-	2	-	-	-	2
total		8	2	1	1	1	

The data between the body region where the injury occurred and the swim style, for the current injuries, are in Table 6.

Table 6. Data of the body region and style of I swim for the current injuries.

Region	Style	Butterfly	Backstroke	Crawl Stroke	Breaststroke	Medley	Total
Upper Limb	Shoulder	4	3	5	1	1	14
Lower	Thigh	-	-	1	-	-	1
Limb	Knee	-	-	1	-	-	1
	Foot	-	-	1	-	-	1
Trunk	Back	-	1	1	-	-	2
total		4	4	9	1	1	19

The data between the diagnosis and the swim style, for the current injuries, are in Table 7.

Table 7. Data of the diagnosis and swim style for the current injuries.

Diagnosis	Butterfly	Backstroke	Crawl Stroke	Breaststroke	Medley	Total
Tendinitis	2	2	2	1	1	8
Back Pain	-	1	1	-	-	2
Muscular Strain	-	-	1	-	-	1
Instability	1	-	-	-	-	1
Synovitis	-	-	1	-	-	1
Total	3	3	5	1	1	13

DISCUSSION

In this study half of the athletes (70 athletes or 51%) had already suffered some injury during its career in this sport. Blanch (1) report greater frequency of former injuries in the athletes with bigger competitive level and relate this bigger number of injuries the biggest requirement in the training allied to a bigger time of practice of these athletes. Tendinitis was the former injury with bigger incidence. Since tendinitis is an injury characterized by stress located in the region of the tendon, it is credited that the biggest frequency of this injury is associated with the strong and constant training loads and the repetition of gestures that induces this dysfunction.

According to Concatorro (3) the tendinitis can result from the effort to which the athlete submits himself in the training. In this research the percentage of this type of injury increased approximately in 20% with the increase of the competitive level, passing from 54% in the athletes of the group 2 for 70% in the 3.Such results indicate that the tendinitis is related to the load increase in the training. Studies of Blanch (1), Kammer, et al. (5), Johnson, et al. (4) confirm such rank emphasizing the cause of tendinitis related to the high demand in the training and to the gestures repeatability.

The region where the biggest number of injuries occurred was the shoulder, result already expected, since this is a region of great requirement during the practice of this modality. The same data was found by Blanch (1), Kammer, et al. (5) and Johnson, et al. (4).

For the crawl, back and butterfly strokes, tendinitis was the main diagnosis and the most affected region was the shoulder. In the butterfly style the arm was also a place with great incidence of tendinitis. In these three styles of swim the upper limb is very demanded during the execution of swim and it is the main propellant for the displacement of the swimmer. For the breaststroke the tendinitis was also the most frequent injury, even so the place where it occurred more frequently was the knee. In this stroke, according to Ramos and Redondo (6), great part of the propulsion of the swimmer is executed by the leg, in which the swimmer carries through a very aggressive movement to this joint, moreover, this is executed with great frequency and intensity, what ends up stressing the structures of this segment.

In the medley stroke there was the same distribution of tendinitis in the shoulder and muscular straining, probably by the great diversity of necessary abilities for each swim and, also, by the predominance of the swimmer in determined stroke, what demands from himself great effort for compensation in considered deficient strokes, in which its technique is not so refined.

The referring results to the former injuries confirm what literature praises (1, 4, 5, 6) about the concern with the "swimmers shoulder" or shoulder tendinitis, and still with the knee joint. These facts agree with the experience in swimming and point out that it must be emphasised the factors of training and prevention of injuries in these two joints that are commonly affected in the swimmers.

About the frequency of injuries, the incidence of the current ones was lesser than observed for the former injuries. The most observed pathology for the two situations was tendinitis, and the most affected regions had been respectively the shoulder, the knee and the column. Concerning the localization, for the current injuries the distribution was similar to the former injuries, even so observed greater incidence of injuries in the column that in the presentation of the former injuries. This high incidence of back injuries was expected because according to Kammer, et al. (5) this region is also very requested in swimming, mainly for the butterfly swimmers due to the movements of trunk for propulsion, typical of this swim stroke.

CONCLUSION

There was a great percentage of injured athletes and the diagnosis of the injuries points out with respect to the biggest incidence of the tendinitis, that can be provoked by repetitive efforts, suggesting more attention to the load of training and the repeatability of the gestures. About the injury region, the biggest focus was the shoulder, followed by the knee, what suggests a bigger concern with such joints during the training of this sports modality. In respect to the swim stroke; for crawl, back and butterfly shoulder tendinitis was the main injury. For the breaststroke the main diagnosis also was the tendinitis, even so the main cited segment has been the knee. Finally, for medley there was the same distribution between tendinitis and muscular strain.

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EFFECT OF SWIMMING TRAINING ON LEFT VENTRICULAR DIMENSIONS AND FUNCTION IN YOUNG BOYS

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The aim of the present study was to determine the effect of swimming training on left ventricular (LV) cardiac morphology and function in young boys. Antropometric measurements, body composition estimation and resting M–mode and Doppler echocardiography were performed in 24 boys (15/16 years), 12 swimmers and 12 age matched non athletes (control group). Swimmers had higher rest stroke volume, LV end-systolic volume and LV end-diastolic volume than the control group. Fifty percent of the swimmers exhibited end–diastolic LV internal chamber dimension above normal (> 54 mm). As showed by parameters measured, adaptation to exercise mode induced a typical "athlete's heart" with dominance of volume and diameter (eccentric LV hypertrophy) and mild changes in LV mass. The results supported the concept of an influence of systematic swimming training on the diastolic function.

Key Words: left ventricular hypertrophy, athlete's heart, cardiac function, echocardiography.

INTRODUCTION
It is well established that the cardiac muscle adapts to an increased hemodynamic load following the specificity of the exercise training: a volume load leads to eccentric left ventricular (LV) hypertrophy and a pressure load is associated with a thickening of the ventricular wall with unchanged internal dimension, inducing a concentric LV hypertrophy (10). Long–term athletic training is associated with morphologic left ventricular remodelling, which may be substantial in elite athletes, and raise the need for differential diagnosis regarding structural heart disease, especially hypertrophic cardiomyopathy (12, 13, 14), responsible for 1/3 of sudden deaths in young athletes (17). If in adults cardiac morphological and functional adaptive changes after training are well documented, in children and young boys far less information is available (11, 15), despite the increasing involvement of young athletes in intensive training regimens, little is known about the influence of such training on autonomic regulation and cardiac structure and function (19). The purpose of this study was to determine the effect of swimming training on LV cardiac morphology and function at rest in young boys.

METHODS
Twenty four boys took part in this study (table 1). They were separated into two groups: swimmers (SA) and control group (CG). The swimmers performed 7 – 8 training sessions a week, of about 110 min duration and with a volume of 5000 m each, 85/90% on aerobic zones, together with some out of water preparation, predominantly muscular endurance weight training. Both SA and CG groups attended physical education sessions at school, twice (90 min plus 45 min) or 3 times a week (45 min each).

*Table 1. Age, physical characteristics and body composition of subjects. BSA - body surface area; BMI - body mass index; BFP - body fat percentage; BFM - body fat mass; FFM - fat free mass. *p < 0.05; **p< 0.01.*

	Control Group			Swimmers		
	Mean±S.D.	Max	Min	Mean±S.D.	Max	Min
Age (years)	15.9± 0.2	15.8	14.3	15.9± 0.2	16.2	15.5
Height (m)	1.71± 0.06	182	160	1.75± 0.06	185	167
Body mass (kg)	58.3± 6.0	68.9	48	64.2± 6.8*	75	52.9
BSA (m^2)	1.66± 0.11	1.82	1.47	1.77± 0.12*	1.94	1.57
BMI ($kg.m^{-1}$)	20.0± 1.6	22.8	17.2	20.9±1.4	22.9	19.0
BFP (%)	11.0±1.4	13.4	9.0	9.4±1.3**	11.8	7.7
BFM (kg)	6.4±1.0	8.0	5.1	6.0±1.2	8.9	4.7
FFM (kg)	51.9±5.6	61.1	42.2	58.2±6.0*	66.1	48.1

Two dimensionally guided M mode recordings were obtained parasternally in accordance with the recommendations of the American Society of Echocardiography (16). All the measurements were performed by the same investigator. Left ventricular (LV) wall thickness and internal diameter were obtained by positioning the trackball cursor on the screen. The echocardiographic parameters measured included: end–diastolic LV internal chamber dimension (LVIDd), end–systolic LV internal chamber dimension (LVIDs), posterior wall thickness (PWT), septal wall thickness (ST), LV end-diastolic volume (LVedV), LV end-systolic volume (LVesV), resting heart rate (HRr), and cardiac output (Qc). Derived parameters were calculated as follows: relative end–diastolic wall thickness (RWTd) by the quotient (PWT + ST)/LVIDd, LV mass by 0,8 x (1,04 (ST + PWT + $LVIDd)^3$ – $LVIDd^3$) + 0,6 (7), LV volumes were obtained according to Teicholz formula (7/(2,4 + LVIDd) x $LVIDd^3$), LV shortening fraction (FS %) by the quotient (LVIDd – LVIDs)/LVIDd) x 100 and the ejection fraction (EF %) by (TDV–TSV)/TDV) x 100 stroke volume (SV). Early (E) and late (A) diastolic peak filling velocities, disacceleration E time (DT) and E/A ratio were estimated by pulse wave Doppler measurements in the 4 chamber apical view. Echocardiographic data was expressed in absolute units and then scaled allometrically for anthropometrical data - body mass (BM), height (H), body surface area (BSA), body fat percentage (BFP) and fat free mass (FFM). Exponents for allometric scaling were generated according to the dimensionality theory and supported by cardiological studies (4, 5), exercise science research (2, 3) and elite athlete studies (9). Mean values were compared using the "t" test for unpaired data. Differences at $p \leq 0.05$ were regarded as significant.

RESULTS AND DISCUSSION

SA and CG were of similar age, but with different anthropometric and body composition characteristics (table 1). The SA group was significantly heavier ($p < .05$), had greater BSA ($p < .05$), owing to significantly reduced BFP ($p < 0.01$) and had a greater FFM ($p < 0.05$), compared to CG.

Mean values for cardiac dimensions (table 2) in the SA and CG group were within normal ranges (8, 18). Absolute LVIDd and LVIDs were significantly greater in SA than CG ($p < 0.05$). The differences between the groups persisted after allometric scaling of LVIDd by height, $BM^{-0.33}$, $BM^{-0.433}$, $FFM^{-0.33}$, $FFM^{-0.441}$, $BSA^{-0.678}$ and $BFP^{-0.251}$ ($p < .05$) and LVIDs by $BM^{-0.33}$, $BM^{-0.361}$, $FFM^{-0.33}$, $FFM^{-0.373}$, $BSA^{-0.584}$ and $BFP^{-0.253}$ ($p < .05$).

Fifty percent of SA exhibited LVIDd above normal (> 54 mm) (6, 18) and dilatation of LVIDd (mean ± 1.96 SD = 47.59 ± 1.96 (3.32) = 54.09 mm) (1,13) but not left ventricular hypertrophy, according to standard criteria of ST or PWT > 13 mm and LVIDd > 60 mm (13). CG displayed significantly greater mean values for relative end–diastolic wall thickness (RWTd) ($p < 0.01$) but both groups showed LV eccentric enlargement (RWTd < 0.44). The differences between the groups appeared after scaling of ST by $height^{-1}$ and $BSA^{-0.5}$ ($p < 0.05$) and PWT by height, $BM^{-0.33}$ and $FFM^{-0.33}$ ($p < 0.05$).

LVM was greater in SA than in CG, after allometric scaling by $BSA^{-1.5}$ ($p < 0.05$).

Table 2. Absolute and allometrical scaled left ventricular dimensions in control group (CG) and swimmers (SA).

	CG		SA			CG		SA	
	M	SD	M	SD		M	SD	M	SD
LVIDd (mm)	47.6	3.3	**53.6***	2.4	**LVIDs (mm)**	28.7	2.5	**32.7***	1.7
LVIDd.$BSA^{-0.5}$	57.4	3.3	61.0	4.4	LVIDs.$BSA^{-0.5}$	34.6	3.0	**37.2***	3.2
LVIDd.$height^{-1}$	27.9	1.8	**30.6***	1.6	LVIDs.$height^{-1}$	16.8	1.5	18.7	1.1
LVIDd.$BM^{-0.33}$	12.5	0.67	**13.6****	0.7	LVIDs.$BM^{-0.33}$	7.5	0.6	**8.3****	0.5
LVIDd.$FFM^{-0.33}$	12.9	0.72	**14.1****	0.7	LVIDs.$FFM^{-0.33}$	7.8	0.6	**8.6****	0.5
LVIDd.$BM^{-0.433}$	8.2	0.43	**8.9****	0.5	LVIDs.$BM^{-0.361}$	6.6	0.5	**7.3****	0.5
LVIDd.$BSA^{-0.678}$	33.7	1.80	**36.5****	2.1	LVIDs.$BSA^{-0.584}$	21.3	1.7	**23.5****	1.5
LVIDd.$FFM^{-0.441}$	8.4	0.46	**9.0 ****	0.5	LVIDs.$FFM^{-0.373}$	6.6	0.6	**7.2****	0.5
LVIDd.$BFP^{-0.251}$	87.3	7.8	**94.2****	4.1	LVIDs.$BFP^{-0.253}$	52.6	5.6	**57.5***	1.9
ST (mm)	8.9	1.1	9.0	1.1	**PWT (mm)**	9.3	0.9	8.8	1.0
ST.$BSA^{-0.5}$	10.8	1.3	**10.3***	1.1	PWT.$BSA^{-0.5}$	11.2	1.1	10.0	1.0
ST.$height^{-1}$	5.2	0.7	**5.2***	0.5	PWT.$height^{-1}$	**5.5***	0.6	5.1	0.5
ST.$BM^{-0.33}$	2.3	0.3	2.3	0.3	PWT.$BM^{-0.33}$	**2.4***	0.2	2.2	0.2
ST.$FFM^{-0.33}$	2.4	0.3	2.4	0.3	PWT.$FFM^{-0.33}$	**2.5***	0.2	2.3	0.2
ST.$BM^{-0.375}$	2.1	0.2	2.1	0.2	PWT.$BM^{-0.169}$	4.7	0.4	4.4	0.5
ST.$BSA^{-0.515}$	6.9	0.8	6.8	0.7	PWT.$BSA^{-0.229}$	8.3	0.8	7.8	0.8
ST.$FFM^{-0.329}$	2.4	0.3	2.4	0.3	PWT.$FFM^{-0.135}$	5.5	0.5	5.1	0.5
ST.$BFP^{-0.030}$	9.6	1.2	9.7	1.1	PWT.$BFP^{-0.004}$	11.4	1.2	10.7	1.1
LVM (gr)	150	33	177	33	**PWT/LVIDd**	**0.19****	0.02	0.17	0.17
LVM.$BSA^{-1.5}$	59.9	11.6	**66.8***	11.1	**ST/LVIDd**	**0.19***	0.02	0.17	0.02
LVM.$height^{-3}$	29.2	6.4	33.7	5.8	**RWTd**	**0.38****	0.39	0.33	0.37
LVM.BM^{-1}	2.6	0.5	2.8	0.5					
LVM.FFM^{-1}	2.9	0.5	3.1	0.5					
LVM.$BM^{-1.075}$	1.9	0.3	2.0	0.3					
LVM.$BSA^{-1.633}$	65.1	12.1	70.1	11.6					
LVM.$FFM^{-1.047}$	2.4	0.4	2.5	0.4					
LVM.$BFP^{-0.390}$	382	93	421	69					

LVIDd: end–diastolic LV internal chamber dimension; LVIDs: end–systolic LV internal chamber dimension; ST: septal wall thickness; PWT: posterior wall thickness; RWTd: relative end–diastolic wall thickness; LVM: LV mass; BM: body mass; BSA: body surface area; FFM: fat free mass; BFP: body fat percentage; * $p < 0.05$; ** $p < 0.01$

*Table 3. Left ventricular function in the control group (CG) and swimmers (SA). HRr - rest heart rate; Qc - cardiac output; SV - stroke volume; E/A - E/A ratio; EF - ejection fraction; LVesV - LV end-systolic volume ; LVedV - LV end-diastolic volume; DT - desaceleration E time; Peak E - early (E) diastolic peak filling velocitie; Peak A - late (A) diastolic peak filling velocitie; FS - LV shortening fraction. ** p<0.01*

	CG		SA		
	M	**SD**	**M**	**SD**	
HRr (bpm)	55.5		55.5	6.4	
Qc(l.min^{-})	4.12		**5.3**	0.7	**
SV (ml)	74.9		**95.5**	11.2	**
E.A	2.8	0.3	2.6	0.5	
EF (%)	69.7	3.1	68.3	2.8	
LVesV (ml)	32.7	7.0	**44.2**	5.4	**
LVedV (ml)	107.6	18.0	**139.7**	14.2	**
TD (ms)	92.4	33.5	90.8	25.5	
Peak A (ms)	0.32	0.06	0.32	0.05	
Peak E (ms)	0.89	0.13	0.81	0.14	
FS (%)	39.1	2.6	38.5	2.4	

In accordance with structural differences, absolute and relative LV systolic functions were significantly greater ($p < 0.01$) in SA, namely LV end–systolic volume, SV and Q as well as LV diastolic function (LV end–diastolic volume). The E/A, FE, TD, Peak A, Peak E and FS data were similar in both groups. (table 3)

The results show increase in left ventricular chamber size and a little increase in LV mass, suggesting a pattern of eccentric hypertrophy. This adaptation is congruent with the nature of exercise undertaken by swimmers at this age, with strong emphasis on aerobic stimulation and high swim volumes, promoting an hemodynamic load that induces greater Qc, with associated greater SV. The changes in SV results from the increase of the venous return and a consequently greater LV end – diastolic volume. LV dilatation together with reduced wall thickness and reduced systolic and diastolic function was not observed in any of the swimmers evaluated, demonstrating that we are facing healthy physiological LV adaptations.

CONCLUSION

This study supports the influence of systematic swimming training on the diastolic function in 15/16 year old boys. As showed by parameters measured, adaptation to exercise mode induced a typical "athlete's heart" with dominance of volume and diameter (eccentric LV hypertrophy) and mild changes in LV mass.

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