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Assisted and Resisted Sprint Training in Swimming

Sébastien Girold,[1] Paul Calmels,[2] Didier Maurin,[1] Nicolas Milhau,[1] and Jean-Claude Chatard[1]

[1]*Laboratory of Physiology, PPEH, Faculty of Medicine Jean Monnet, Saint-Etienne, France;* [2]*Department of Functional Rehabilitation, Hospital of St-Etienne, France.*

Abstract. Girold, S., P. Calmels, D. Maurin, N. Milhau, and J.-C. Chatard. Assisted and resisted sprint training in swimming. *J. Strength Cond. Res. 20(3):547–554. 2006.*—This study was undertaken to determine whether the resisted-sprint in overstrength (OSt) or the assisted-sprint in overspeed (OSp) could be efficient training methods to increase 100-m front crawl performance. Thirty-seven (16 men, 21 women) competition-level swimmers (mean ± *SD*: age 17.5 ± 3.5 years, height 173 ± 14 cm, weight 63 ± 14 kg) were randomly divided into 3 groups: OSt, OSp, and control (C). All swimmers trained 6 days per week for 3 weeks, including 3 resisted or assisted training sessions per week for the groups OSt and OSp respectively. Elastic tubes were used to generate swimming overstrength and overspeed. Three 100-m events were performed before, during, and after the training period. Before each 100-m event, strength of the elbow flexors and extensors was measured with an isokinetic dynamometer. Stroke rate and stroke length were evaluated using the video-recorded 100-m events. In the OSt group, elbow extensor strength, swimming velocity, and stroke rate significantly increased ($p < 0.05$), while stroke length remained unchanged after the 3-week training period. In the OSp group, stroke rate significantly increased ($p < 0.05$) and stroke length significantly decreased ($p < 0.05$) without changes in swimming velocity. No significant variations in the C group were observed. Both OSt and OSp proved to be more efficient than the traditional training program. However, the OSt training program had a larger impact on muscle strength, swimming performance, and stroke technique than the OSp program.

Key Words. exercise, muscular strength, overspeed, overstrength, performance

Introduction

Strength and speed are two major elements determining a sprint swimmer's training program, and physiological and technical parameters are known to affect sprint swimming performance. Physiological parameters mainly concern strength and power of the upper limbs (11, 12, 21). The main technical parameters are stroke rate and distance per stroke or stroke length (1, 13, 15, 24). In sprint swimming, physical strength is considered more important than technique to reach a high level of performance, although some variations have been observed with gender and morphological parameters (13).

Several training methods have been described to develop strength in swimming (6, 10, 19, 28). Their efficiency depends on the specificity of the event (7, 25) and the intensity of the training sessions (2, 5, 6, 15, 18, 26).

The effects of high-resistance (strength) and high-velocity (speed) training programs on sprint performance have been studied but only in running (8, 9). The results of these studies showed that the high-resistance training method improves muscular strength without improving 100-m performances, while the high-velocity training method increased 100-m performances without increasing muscular strength. This type of study has not been performed with swimmers.

The main purpose of the present study was to determine whether strength and performance can be developed in swimmers using a resisted-sprint (high-resistance) and an assisted-sprint (high-velocity) training program. A second purpose was to determine whether there is a relationship between development of strength, technical parameters, and performance in the different training programs.

Methods

Experimental Approach to the Problem

The main purpose of this study was to increase the performances of swimmers over 100 m using resisted- and assisted-sprint training methods. It was thus decided to perform these conditions while swimming using specific elastics in resisted (high-resistance) and assisted (high-velocity) conditions.

Specific sets were developed to develop sprint abilities over 100 m (with an anaerobic capacity dominant work). For practical reasons concerning the swimmers and coaches, it was impossible to keep the training conditions for more than 3 weeks for the whole group of swimmers. However, it was considered that adaptations could appear considering results of other studies. Indeed, Pichon et al. (19) and Strass et al. (26) reported adaptations after training programs that lasted only 3 weeks.

Subjects

A group of 45 competitive (19 men, 26 women) swimmers (mean ± *SD*: age 16.5 ± 3 years, height 171 ± 13 cm, weight 67 ± 21 kg), from regional to national level, was studied. An institutional review board approval for the project was obtained from the University Committee on Human Research. The swimmers under age of 18 and their parents signed an informed consent form, and the subjects participated in the study on a voluntary basis. Swimmers trained an average 12 ± 1.5 hours per week. All swimmers were sprinters, 100-m, or 200-m front crawl specialists. Due to injuries or missed training sessions, only 37 swimmers (16 men, 21 women, age 17.5 ± 3.5 years, height 173 ± 14 cm, weight 63 ± 14 kg) completed the whole program, inducing some heterogeneity in the main characteristics of the 3 groups defined below.

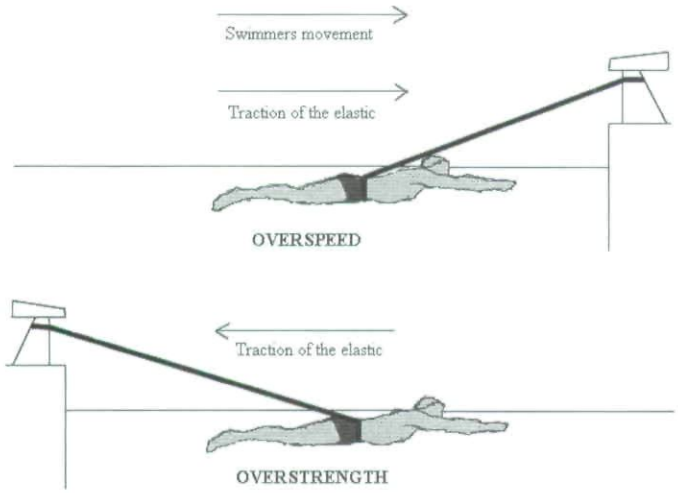

FIGURE 1. View of the swimmers situations during the exercises in overstrength and in overspeed.

Procedures

Swimmers were randomly divided into 3 groups: (a) overstrength (resisted-sprint) group (OSt; $n = 15$; age 16.5 ± 2 years, height 170 ± 7 cm, weight 58 ± 9.5 kg), (b) overspeed (assisted-sprint) group (OSp; $n = 11$; age 18 ± 3 years, height 176 ± 7 cm, weight 67 ± 10.5 kg), and (c) control group (C; $n = 11$; age 17 ± 3 years, height 168 ± 9 cm, weight 62 ± 11 kg).

The training program lasted 3 weeks during the February month, at the beginning of the second macrocycle of the season. Average training volume and intensity were the same for all swimmers throughout the study protocol. A total of 10 sessions per week, from Monday to Friday (2 sessions per day, 1 in the morning and 1 in the evening, 1.5 hours per session) were performed during the training period. During the 3 weeks, the training volume was 45 ± 5 km per week. The training program included a dominant aerobic work in front crawl during the morning training sessions and a dominant technical work in medley during the evening training sessions, at a moderate intensity.

Swimmers in the OSt group swam 6 all-out 30-second front crawl sprints with a 30-second recovery period between each sprint (total duration 6 minutes). The swimmers were tethered to the starting platform. They wore a belt around the pelvis that was attached to one end of a 5-m-long elastic surgical tube (Paul Factory, Saint-Etienne, France; inner and outer diameters 8 and 12 cm, respectively); the other end of the tube was attached to the starting platform (Figure 1). The elastic tube imposed a length (Y; in meters)–strength (X; in Newtons) relationship on the swimmers expressed by $Y = 4.5008\,X - 12.95$. The elastic stretched over an average distance of 15 m. During recovery, the swimmers held onto the swimming lane to keep the tube taut.

Swimmers in the OSp group swam 12 25-m freestyle front crawl sprints. These swimmers were also attached to an elastic surgical tube under the same conditions as for OSt except that the tube was 8 m long and attached to the point of arrival. The point of departure was set at the 25-m line so that the elastic tube pulled the swimmer toward the point of arrival with an initial force of 60 N. As the swimmer advanced, an assistant maintained the elastic as taut as possible to maintain the same force throughout the sprint. The swimmers were asked to follow the speed given by the elastic by having a high stroke rate and trying to not decrease their distance per stroke. Between each sprint, the swimmer got out of the pool, walked back to the point of departure, and jumped into the water. This walk back was considered as a recovery period so the total duration was about the same as for the OSt group (about 6 minutes).

The control group (C) swam 6 50-m all-out front crawl sprints, without an elastic tube, with a 30-second recovery period between sprints, for a total duration of about 6 minutes.

The training sets described above were the only differences in training between the 3 groups. These sets were performed 3 times per week, in the first part of the training sessions, after a 1,500-m standardized warm up, on Monday, Wednesday, and Friday evening of each week (Table 1). No dry-land training program was performed during the 3 weeks. Swimmers were asked to refrain from any other sport activity.

Muscle Strength Measurements

The flexion-extension peak torque of the 2 forearms, expressed in newton-meters (N·m), was measured with an isokinetic dynamometer (Cybex; Medimex Factory, Tassin la Demi Lune, France) before the training program (week 0) and after 2 (week 2) and 3 (week 3) weeks of training. Forearm peak torque was retained for study because measurement is easier than with the whole arm, and, as demonstrated by Shleihauf et al. (22), forearm forces account for a large part of total arm propulsion. Before the measurements, a 5-minute standardized warm up and familiarization period was performed with the apparatus at several submaximal intensities (60°, 180°, and $0°\cdot s^{-1}$). These different angular velocities have been chosen because they seemed to be most representative of a swimmer's movement speed, as reported by Pichon et al. (19). The measurements took place at the end of each week, on a Saturday afternoon (24 hours after the last training session in assisted sprint). Swimmers sat with the torso strapped at the shoulders and pelvis. The arm was maintained parallel to the Cybex's arm lever. The spindle of the motor was positioned in line with the center of rotation of the elbow joint. The measurements were made under concentric conditions at 60° and $180°\cdot s^{-1}$ and under isometric conditions at $0°\cdot s^{-1}$. The subjects were asked to perform 2 maximal efforts with 3 repetitions alternating flexion and extension at $60°\cdot s^{-1}$ and at $180°\cdot s^{-1}$. The best performance was retained. A 30-second rest period separated each effort, and a 2-minute rest period separated each velocity. In isometric condition, the subjects were asked to perform 2 maximal efforts in flexion and in extension. The efforts lasted 5 seconds with a 2-minute rest period between repetitions; the elbow angle between the arm and forearm was set at 90°. Intraclass correlations (ICC R) of the physical strength measurements, assessed in 18 swimmers using the coefficient of variation of the difference between 2 measurements, were 4.2%.

Swimming Performances and Technical Parameters

Swimming performances were measured at weeks 0, 2, and 3, the same weekday at the same time of the day, during a 100-m front crawl competition in a 25-m pool after a 30-minute warm up. The 100-m event was chosen

TABLE 1. Daily training volume of the 3 groups.*

Group	Monday		Tuesday		Wednesday		Thursday		Friday	
	Morning (m)	Evening (m)	Morning (m)	Evening (m)	Morning (m)	Evening (m)	Morning (m)	Evening (m)	Morning (m)	Evening (m)
Overstrength group (n = 15)	5,500 (500)	3,500 (500)†	6,000 (500)	4,000 (500)	6,000 (500)	3,000 (500)†	5,500 (500)	3,500 (500)	4,500 (500)	3,500 (500)†
Overspeed group (n = 11)	5,500 (500)	3,500 (500)‡	6,000 (500)	4,000 (500)	6,000 (500)	3,000 (500)‡	5,500 (500)	3,500 (500)	4,500 (500)	3,500 (500)‡
Control group (n = 11)	5,500 (500)	3,500 (500)§	6,000 (500)	4,000 (500)	6,000 (500)	3,000 (500)§	5,500 (500)	3,500 (500)	4,500 (500)	3,500 (500)§

* Values are mean (± *SD*); n = number of subjects.
† Including overstrength group–specific set.
‡ Including overspeed group–specific set.
§ Including control group–specific set.

for study because it is the most common sprint distance in competition, midway between the 50-m short sprint and the 200-m long sprint. In addition, it is generally the most popular distance for swimmers. All the races were video recorded. The stroke rate, expressed as the number of strokes per minute, was measured twice every 50 m, once every 25 m, using a stroke base 3 stopwatch (Seiko; Seiko Factory, Besançon, France). The average value was retained. The distance per stroke was calculated by dividing the mean velocity of each 50 m by the mean stroke rate.

Statistical Analyses

Results are presented with their mean and *SD* values. Analyses of variance were used to compare the main characteristics, performances, muscular strength, stroke rate, and distance per stroke of the 3 groups. A Tukey-Kramer test was used as a post hoc test. Correlation coefficients were calculated between the performance and the different measured parameters. For the whole group stepwise regressions were calculated between the 100-m front crawl velocity (independent variable) and the other variables (dependent variable) using the StatView 512+ program (SAS Institute Inc., Cary, NC). In all of the statistical analyses, significance was accepted at $p \leq 0.05$.

RESULTS

Before training, there was no significant difference between stroke rates and distances per stroke for the 3 groups (Table 2). However, between OSt and OSp groups, there was a significant difference in body weight, performance ($p < 0.05$, Table 2), and elbow extensors isometric ($0°\cdot s^{-1}$) and isokinetic ($60°\cdot s^{-1}$) strength ($p < 0.05$, Figure 2). For the entire study population, 100-m performance was related to the strength of the elbow flexors and extensors under isometric conditions ($r = 0.57$; 0.54; $p < 0.05$) and concentric conditions at $60°\cdot s^{-1}$ ($r = 0.67$; 0.66; $p < 0.05$) and $180°\cdot s^{-1}$ ($r = 0.64$; 0.66; $p < 0.05$). It was also related to stroke rate ($r = 0.45$; $p < 0.05$) and stroke length ($r = 0.48$; $p < 0.05$). These relationships were also found in each of the 3 study groups.

Effect of Training on Muscle Strength

The effect of training on muscle strength is presented in Table 3 and Figure 2. For OSt, muscle strength was significantly ($p < 0.05$) increased in 3 conditions: the isometric condition for the elbow extensors and the 2 concentric conditions for the flexors ($p < 0.05$). For OSp, muscle strength was significantly ($p < 0.05$) increased only in 1 condition: the concentric condition at $180°\cdot s^{-1}$ for the flexors. For the control group (C), muscle strength was significantly ($p < 0.05$) increased in the isometric condition ($0°\cdot s^{-1}$), for the flexors.

Data from week 2 (not presented) did not further modify the effect of training on muscle strength. Data presented in Table 4 were obtained after 3 weeks of training.

Effect of Training on Swimming Performance

For OSt, the gain in swimming performance was significant ($p < 0.05$) over the whole training period (Table 2), while for OSp it was significant ($p < 0.05$) only between the second and third weeks. For the 2 groups (OSt and OSp), the gain was significant during the second 50 m of the 100-m swim ($p < 0.05$) but not during the first 50 m.

TABLE 2. Comparison of the stroke rate and stroke length per 50 m for the 100-m performances of the 3 groups.*

Group	Stroke rate (cycle·min^{-1})						Stroke length (m·cycle^{-1})					
	Week 0		Week 2		Week 3		Week 0		Week 2		Week 3	
	1st 50 m	2nd 50 m	1st 50 m	2nd 50 m	1st 50 m	2nd 50 m	1st 50 m	2nd 50 m	1st 50 m	2nd 50 m	1st 50 m	2nd 50 m
Overstrength group (n = 15)	44.74 (5.08)	42.32 (4.98)	45.58 (3.94)	42.2 (3.66)	45.15 (4.51)	43.01‡ (3.91)	2.10 (0.17)	2.03 (0.18)	2.07 (0.15)	1.99 (0.16)	2.12 (0.20)	2.01 (0.18)
Overspeed group (n = 11)	46.09 (3.78)	41.92 (2.75)	46.43 (3.66)	41.65† (2.85)	47.38 (3.67)	43.47‡ (3.11)	2.20 (0.14)	2.16 (0.13)	2.17 (0.15)	2.15 (0.15)	2.15 (0.17)	2.11‡ (0.15)
Control group (n = 11)	46.21 (3.38)	43.5 (4.92)	46.18 (3.61)	43.43 (3.74)	44.97 (3.48)	42.2 (3.56)	1.99 (0.21)	1.95 (0.2)	1.99 (0.2)	1.91† (0.19)	2.05 (0.19)	2.01 (0.19)

* Values are mean (± *SD*); n = number of subjects; significant at $p < 0.05$.
† Significant difference between 2nd 100 m and 3rd 100 m.
‡ Significant difference between 1st 100 m and 3rd 100 m.

No significant difference was observed for the control group.

Effect of Training on Technical Parameters

For OSt and OSp, stroke rate was significantly ($p < 0.05$) increased over the whole training period (Table 2). The gain was significant only during the second 50 m of the 100-m swim ($p < 0.05$). No significant difference was observed for the control group. For OSt, the distance per stroke was maintained during the second 50 m (Table 2), while for OSp, it decreased significantly ($p < 0.05$). No significant difference was observed for the control group. Considering all swimmers together, stroke rate variations, expressed in percentage of baseline, correlated with performance variations, expressed in percentage of baseline performance ($r = 0.68$; $p < 0.05$; Figure 3). These relationships were also found in each of the 3 study groups; for the OSt ($r = 0.65$; $p < 0.05$), for the OSp ($r = 0.73$; $p < 0.05$), and for the C ($r = 0.59$; $p < 0.05$).

Training Effect: Comparison between Strength and Technical Parameters

Considering all swimmers, stepwise regression analysis between swimming performance and physical strength and technical parameters revealed that stroke rate during the second 50 m (SR 2nd 50) was the only factor exhibiting significant correlation ($r = 0.68$; $p < 0.05$).

For the OSt group, SR 2nd 50 was the most significant factor, while physical strength of the elbow flexors in concentric conditions at 60°·s^{-1} (ISA-60) was the second most important factor. The effects of these 2 factors was additive, the effect of ISA-60 significantly increasing the coefficient of correlation between performance and SR 2nd 50 from 0.77 to 0.84 ($p < 0.05$), according to the following equation:

$$\Delta\text{Performance} = (0.263 \times \text{SR 2nd 50}) + (-0.91 \times \text{ISA-60}) + 1.321$$

For the OSp group, stroke rate during the first 50 m (SR 1st 50) was the most significant factor, while stroke length during the first 50 m (SL 1st 50) was the second most important factor. The effects of these 2 factors were again additive, significantly increasing the correlation coefficient from 0.62 to 0.82 ($p < 0.05$), according to the following equation:

$$\Delta\text{Performance} = (0.13 \times \text{SR 1st 50}) + (0.328 \times \text{SL 1st 50}) + 0.827$$

For group C, SR 2nd 50 was the most significant factor, while physical strength of the elbow flexors in concentric conditions at 180°·s^{-1} (ISA-180) was the second most important factor. The coefficient of correlation increased significantly from 0.73 to 0.88 ($p < 0.05$), according to the following equation:

$$\Delta\text{Performance} = (0.149 \times \text{SR 2nd 50}) + (-0.63 \times \text{ISA-180}) + 0.824$$

Gender Effect

In each group, there was a significant difference between men and women in performance before training ($p < 0.05$). In the OSt group, there were significant differences in training effects between men and women on performances and stroke rate ($p < 0.05$). In this group, only

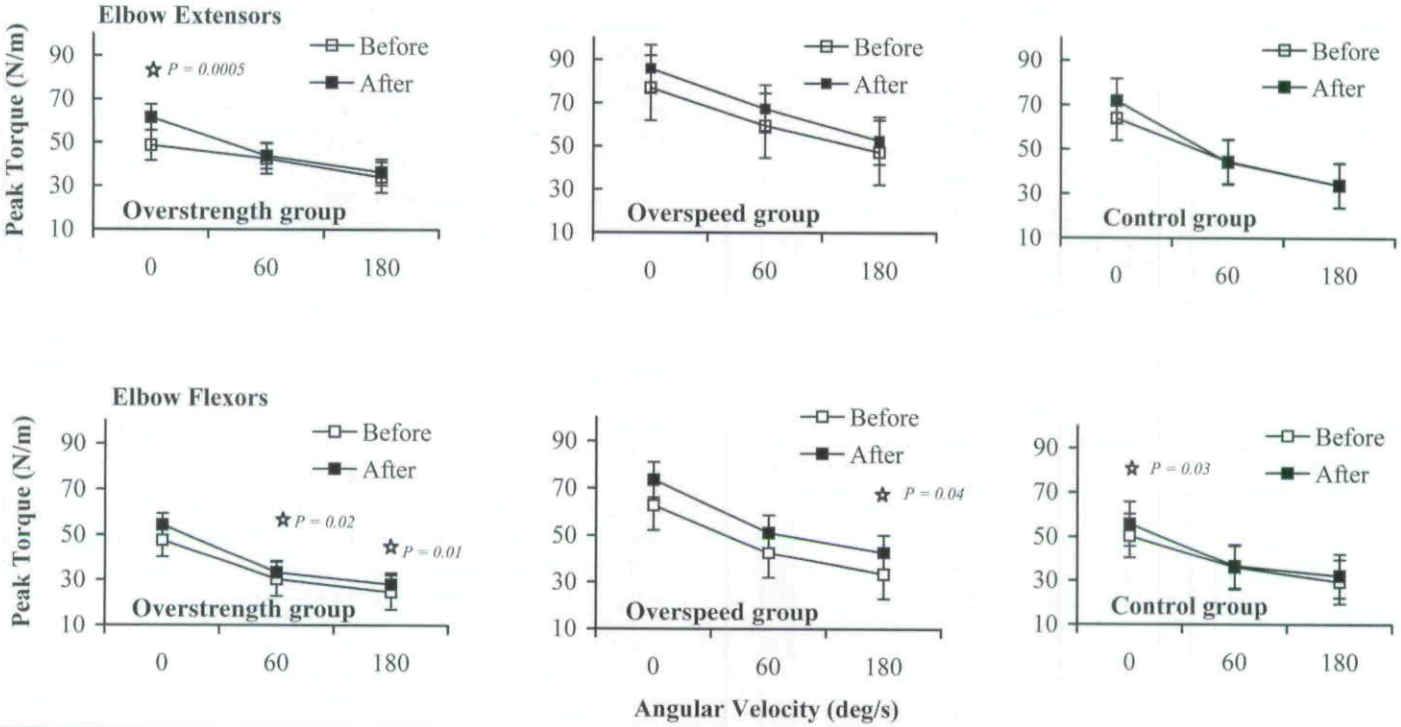

FIGURE 2. Relationship between the peak torque and the angular velocity before and after training for the different groups for the elbow extensors and flexors. *Significance ($p < 0.05$). Values are mean and *SEE*. For the extensors, overstrength group = A, overspeed group = B, control group = C. For the flexors, overstrength group = D, overspeed group = E, control group = F.

TABLE 3. Comparison of the variations of the physical strength between the flexors and the extensors at the different angular velocities, expressed in percentage of the initial values.*

	Flexors			Extensors		
	Isometric	Concentric		Isometric	Concentric	
	$0°\cdot s^{-1}$	$60°\cdot s^{-1}$	$180°\cdot s^{-1}$	$0°\cdot s^{-1}$	$60°\cdot s^{-1}$	$180°\cdot s^{-1}$
Overstrength group (n = 15)	11.4 (16.4)	8.6† (9.1)	14† (15.3)	31.5† (24.9)	7.8 (15.6)	8.2 (17.2)
Overspeed group (n = 11)	13.9 (29.5)	14.2 (27.2)	21.1† (23.1)	5.3 (23.3)	7.6 (11.9)	10.5 (11.9)
Control group (n = 11)	15.5† (16.8)	3.7 (10.7)	11.8 (13.4)	15.3 (18.3)	0.01 (6.9)	1.5 (10.2)

* Values are mean (± *SD*); *n*, number of subjects; significant at $p < 0.05$.
† Significantly different from pretraining values.

women increased significantly in performances and in stroke rate ($p < 0.05$). There were no significant differences in training effects between men and women in the other groups.

DISCUSSION

The main findings of the present study were (a) the resisted-sprint training program was more efficient than the assisted-sprint program in increasing muscle strength and 100-m performance and (b) physical strength and technical parameters were good predictors of 100-m performance.

The resisted-sprint program was the most efficient training method to increase muscle strength after 3 weeks of training when compared with the assisted-sprint program and standard training (control group). The significant increase in the strength of the elbow extensors measured in isometric conditions was 32% in the OSt group vs. 5% and 15% for the OSp and control groups, respectively (Table 3). These results are close to the 24% gain for 3 weeks of training reported by Pichon et al. (19) and to the 20–40% gain reported by Strass et al. (26). The OSt group also exhibited a 2% increase in 100-m performance compared with 0.8% for the OSp group and −0.3% for the C group. These data do not corroborate those reported by Delecluse et al. (8, 9) who worked with runners and found that the assisted-sprint training method was the most efficient. In their studies, the gain in running performance was related to a gain in departure reaction time but not in muscular strength. Departure reaction time was not measured in the present study, but for a 100-m swim (taking about 1 minute) departure time is relatively less important than that for a 10–12-second 100-m run, and may explain the observed differences. In the OSt group, the fact that females significantly increased their performance, and not males, was probably

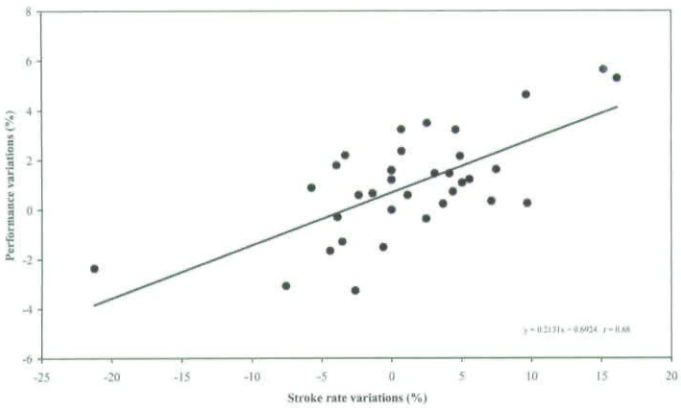

FIGURE 3. Relationship between the variations of performance and the variation of stroke rate during the second 50 m of the 100-m swim for the whole study population.

due to differences in their levels at the beginning of the training program. As males were significantly faster than females in the 100-m distance before training, it was harder for them to significantly enhance their speed than it was for females who had a lower level.

Muscle strength and technical parameters were good predictors of 100-m swimming performance. Strength of elbow flexors and extensors was correlated with 100-m performance measured in isometric and concentric conditions. These data are in agreement with previous studies reported by Hawley and Williams (11, 12) and Miyashita and Kanshisa (17) showing a strong relationship between the power of the upper limbs and 100-m swimming performance. In the present study, strength gain was greater in isometric conditions. Under these conditions, the arm-forearm angle is 90°. This angle corresponds to the specific mid-stroke swimming position, between the pulling and pushing phases (16). In this position, the arm is deep in the water and requires greater power to overcome the resistance of the water. Thus, a gain in muscle strength in this position may be more efficient in terms of performance gain. The present data also confirmed work by Costill (7) and Stewart and Hopkins (25) emphasizing the importance of the specificity of training methods in improving swimming efficiency.

The gain in muscular strength was greatest for the elbow extensors, basically the triceps brachii. Birrer (3) also pointed out the importance of the triceps in the pushing phase for all strokes, and Rouard et al. (20) and Schleihauf et al. (22, 23) found that peak force occurs at the end of the aquatic phase of the stroke during forearm extension on the arm.

Two technical parameters, stroke rate and stroke length, were related to swimming performance, confirming reports by Arellano et al. (1), Hohmann et al. (13), Keskinen et al. (15), and Sidney et al. (24) indicating that technical parameters are directly related to sprint performance. Considering the entire study population, muscle strength was more important than technical parameters as demonstrated by the higher coefficient of correlation between muscle strength and performance ($r = 0.67$) than between technical parameters and performance ($r = 0.48$). However, stepwise regression analysis indicated that the most important factor directly related to gain in performance was stroke rate and not muscle strength (Figure 3). These results are probably related to the duration of the training program, which may have been long enough for nervous system adaptation to induce increased speed of movement but not long enough for the development of sufficient physical strength to have a determining effect on gain in performance.

Swimmers in the OSt group increased their stroke rate solely in the second part of the 100-m swim while the swimmers in the OSp group increased their stroke rate in both parts. But gain in performance was significant only for the OSt swimmers because they maintained their distance per stroke while the OSp swimmers did not (stroke length decreased in the OSp group). This finding is in agreement with the previous study of Maglischo et al. (16) indicating that assisted-sprint swimming exercises cause a greater increase in stroke rate than resisted-sprint swimming exercises. Maglischo et al. (16) observed that assisted-sprint swimming exercises also cause a greater decrease in stroke length than tethered-sprint swimming exercises. Delecluse et al. (8) suggested that a high-resistance and high-velocity sprint training program enhances power and movement speed due to adaptive changes in the nervous system. Nevertheless, adaptations resulting from the 2 training methods would be different. Delecluse et al. (8) suggested that a high-resistance sprint training program first develops motor unit recruitment combined with a gain in movement velocity, but that gain in velocity is limited by the time maximal motor unit recruitment takes to generate maximal strength. A high-velocity sprint training program first develops movement speed (despite the movement length), combined with a gain of power at high velocity. This could explain why the OSt (resisted-sprint) group exhibited increased physical strength in isometric conditions, while the OSp (assisted-sprint) group developed increased physical strength in concentric conditions at $180°\cdot s^{-1}$ (Table 4), as well as the differences in stroke rate and stroke length gains and variations between the 2 groups.

PRACTICAL APPLICATIONS

The present study indicated that, in a sprint training program, resisted-sprint training is more efficient than assisted-sprint training to achieve increased performance in 100-m front crawl swimming. The observed gain was explained by an increase in stroke rate. Physical strength was modified by both training methods at different angular velocities. Further investigations are required to determine the underlying muscular or neurological changes involved in these adaptations.

These training methods can be used all along the season. In a period of high training volume, resisted-sprint can develop strength endurance in the water while assisted-sprint may increase the hydrodynamic position and the stroke rate. In this period it must be realized with long sets at a moderate intensity with a short recovery time. In a period of competition, resisted-sprint can be used to increase strength and power, and assisted-sprint to increase stroke rate and strength at a high velocity. In this period, it must be realized with short sets at a maximal intensity with a long recovery time.

The corresponding time of the swimming velocity gain over 100 m after the 3-week training period was: 1.9 ± 0.9 seconds in OSt, 1.1 ± 0.8 seconds in OSp and 0.5 ± 0.9 seconds in C. The authors had realized another study (unpublished data) over a period of 12 weeks in resisted- and assisted-sprint. After this period, swimmers in-

TABLE 4. Comparison of the 100-m performances divided in two 50 m.*

Group	Week 0			Week 2			Week 3		
	1st 50 m (s)	2nd 50 m (s)	100 m (s)	1st 50 m (s)	2nd 50 m (s)	100 m (s)	1st 50 m (s)	2nd 50 m (s)	100 m (s)
Overstrength group (n = 15)	32.28§ (2.34)	35.22§ (2.18)	67.43§ (4.4)	32.07†§ (1.92)	35.20†§ (2.10)	67.14†§ (3.95)	31.75§ (2.05)	34.30‡§ (2.01)	66.05‡§ (4)
Overspeed group (n = 11)	29.86‖ (2.72)	32.59‖ (2.66)	62.46‖ (5.32)	29.93‖ (2.68)	32.75†‖ (2.78)	62.67†‖ (5.45)	29.69‖ (2.45)	32.25‡‖ (2.45)	61.9‖ (4.85)
Control group (n = 11)	32.64 (3.02)	35.51 (3.27)	68.15 (6.18)	32.49 (2.79)	35.89 (3.34)	68.39 (6.09)	32.85 (2.77)	35.50 (3.17)	68.35 (5.91)

* Values are mean (± *SD*); *n*, number of subjects; significant at $p < 0.05$.
† Significant difference between 2nd and 3rd 100 m.
‡ Significant difference between 1st and 3rd 100 m.
§ Significant difference between overstrength and overspeed.
‖ Significant difference between overspeed and control.

creased significantly their performances by 3.5% over 50 m vs. 2% in the present study over 100 m and after only 3 weeks of training. Thus, it can be supposed that the longer the training period, the stronger the effect on performances. However, performance improvements are always greater when new training methods are proposed, as their efficiencies decrease with time.

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Address correspondence to Dr. Sébastien Girold, xgirold@free.fr.