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# The effect of a strength training program on the improvement of power among senior Algerian road cyclists

# أثر برنامج تدريبي لتدريب القوة مقترح لتنمية القدرة عند دراجي الطريق أكابر

**SADOUKI Kamel [1], ABDELMALEK Mohammed [1], LAROUI Ilies [2], SLIMANI Aissa[3]**

[1] Laboratory of biological sciences applied to Sport, ES/STS, Algiers, sadouki_kamel@yahoo.fr

[1] Laboratory of biological sciences applied to Sport, ES/STS, Algiers , inesmine1012@live.fr

[2] ISTAPS Oum el Bouaghi, ilaroui@live.fr

[3] IEPS, Algiers university 3, slimsport21@gmail.com

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**Abstract** : The purpose of this study is to verify the effect of a training program including strength-training exercises on improving power. Eighteen (18) senior Algerian road cyclists (boys) divided into two (02) groups (experimental and control) have participated in our study. They carried out two tests (force-velocity test and maximum aerobic power test (Wmax)). For the comparison of the means, we used the Mann-Whitney test and the Wilcoxon test. The results obtained during our experiment show that the increase in the power of the cyclists in the experimental group is significant compared to the control group. The quantitative appreciation of the different parameters allowed us to confirm our initial hypothesis.

**Keywords:** Strength training ; Road cyclists ; Wmax ; Force-velocity

**الملخص:** الهدف من هذه الدراسة هو التحقق من تأثير برنامج تدريبي متضمن تمارين تنمية القوة على تحسين القدرة. شارك في دراستنا ثمانية عشر (18) دراج (رجال)، مقسمين إلى مجموعتين (02)، مجموعة تجريبية ومجموعة مراقبة. قاموا بإجراءإختبارين (إختبار القوة المميزة بالسرعة وإختبار القدرة الهوائية القصوى (PMA)). للمقارنة بين الوسائط الحسابية إستخدمنا إختبار مان ويتني وإختبار ويلكوكسون. أظهرت النتائج التي تم الحصول عليها خلال تجربتنا أن الزيادة في قدرة راكبي الدراجات في المجموعة التجريبية كبيرة مقارنة بمجموعة المراقبة. سمح التقدير الكمي للمؤشرات المختلفة بتأكيد فرضيتنا الأولية.

- **الكلمات المفتاحية:** تدريب القوة، دراجي الطريق، القدرة الهوائية القصوى، القوة المميزة بالسرعة

Corresponding author: SADOUKI Kamel e-mail: sadouki_kamel@yahoo.fr

## Introduction

In order to move in response to his own demands and according to the possibilities of the moment, the sportsman develops a certain level of mechanical power. The production of power is the result of a fairly complex process that responds to the activation of different functional systems that all work in synergy to meet the demand of the exercise according to the available energy potential (Frédéric Grappe, 2012).

Cycling is a worn sport. The cyclist transforms his muscular energy into kilometers browsed at a certain speed through his machine. The most important work is done by the lower limbs and the lumbar muscles. The arms and the top of the ribcage only provide pulling work for the former and ventilation work for the latter. The cyclist is highly specialized. This results in an often disproportionate morphology where the lower muscle masses predominate over the rest of the body (Jean François Mayer, 1988).

Cycling, like any other sporting activity, requires a strong and solid endurance basis. This is essential to achieve the best possible performance, to avoid injuries and to be able to practice one's sport for a long time. Climbing to the top requires that all muscle systems work together in a coordinated manner. Some cyclists make the mistake of thinking that cycling is only about the legs. Unfortunately, it's not that simple. While the legs, hips and buttocks produce most of the power needed to move forward, powerful abs, backs and pectorals are needed to stabilize the lower body. All parts of the body must work in a coordinated manner to stabilize the bike and transmit maximum power to the pedals (Frédéric Grappe, 2018).

## Problematic

There's nothing better than feeling your best at exactly the right time, "flying over" a Pyrenean pass or finishing first on the finish line in a time trial pays for all the effort put into training in the gym and on the road. All cyclists know that they have to train to ride fast on their bikes. However, many do not realize that it is the entire body, all muscle groups and not just the legs that move the bike. Indeed, our observation of the cyclists of the Algerian national team shows that, due to a busy international competition program and inappropriate with the periodization of training, they often neglect the training of muscular strength out of situation (without a bike), especially for muscle groups not solicited by the specific gesture that is pedaling. This leads us to ask the following question: Does the integration of strength training in physical preparation for cycling have a beneficial effect on the development of muscle power in road cyclists?

**Hypotheses**

In order to answer this question, we have hypothesized that a training program including weight training exercises lasting 19 weeks, with a volume of 63.5 h and intensities varying from 40 to 85% of (1RM) improves power in road cyclists.

**The objectives**

The main objective of our study was to investigate the effect of training including strength-training exercises on improving power.

## 1. Research terms and definitions

### 1.1. Strength training

The first step in any training program begins with general strength training. This is a fundamental type of work, in which increasing muscle volume and improving weak points or imbalances between different muscle groups is a priority. Under these conditions, we deviate from the gestures that correspond to those of competition, in other words, we voluntarily neglect a certain number of specific parameters that will be considered later on, (Jacques Duchateau, 1997).

### 1.2. Strength Training in Road Cycling

Traditional strength training found in road cyclists is characterized by a high number of repetitions with low loads, which is traditionally considered more "sport-specific" and therefore more beneficial to cycling performance (Nathaniel P Jackson and others, 2007). On the other hand, a non-traditional approach to strength training suggests that the inclusion of maximal efforts (high loads) with a low number of repetitions and maintaining a portion of these sessions during the season (Bent R Rønnestad and others, 2010b) may be more beneficial to the cyclist.

It has become increasingly popular that training programs used by endurance athletes include strength training to improve neuromuscular and anaerobic characteristics (i.e., simultaneous training), (Javier Ruiz Botella and others, 2016).

### 1.3. The Power

Performance in road cycling races depends on a number of factors (Kamel SADOUKI, 2020). One of these factors is the ability to produce high power over a short period. This ability is essential when the cyclist needs to close a gap, break away from the pack or win a final sprint, (Bent R Rønnestad and others, 2010a).

## 2. Previous and related studies

**Study n° 01:** Bent R Rønnestad and others (2010a)

**Title:** In-season strength maintenance training increases well-trained cyclists' performance.

Bent R Rønnestad and others (2010a), equipped 20 well-trained cyclists with either habitual endurance training combined with high-load strength training [E + F; n = 11 (men = 11)] or habitual endurance training only [E; n = 9 (men = 7, women = 2)]. High load strength training was performed with emphasis on maximum mobilization in the concentric phase (lasting about 1 s), while the eccentric, non-cycling specific phase was performed more slowly (lasting about 2-3 s). At the beginning of each strength training session, the cyclists did a 10-minute warm-up at an intensity chosen by them on a home trainer, followed by two or three half-squat warm-ups with a progressively increasing load. The weight training exercises performed were: half-squat, one-legged leg press, one-leg hip flexion and guided frame standing extension.

**Study n° 02:** Arnstein Sunde and others (2010)

**Title:** Maximal Strength Training Improves Cycling Economy in Competitive Cyclists.

Arnstein Sunde and others (2010), offer in addition to normal endurance training, 2 to 3 sessions per week of maximum strength training in a Smith machine (see figure n°08), consisting of 4 series of half squats of 4WD (90%), divided by 3 minutes of rest between each,. Each time the cyclist managed to do 5 repetitions during a series, 2.5 kg were added for the next series. The workout lasts only about 20 minutes, ensures maximum activation of the neuronal-muscular system, and has been shown to result in no or minimal weight gain and does not affect maximum oxygen consumption.

## 3. Methodological procedures of the study

### 3.1. Research methodology

We opted for the experimental method, which is adapted to the nature of the problem and the variables in our study.

### 3.2. Society and sample study

Subjects' participation in the experiment was based on the provision of a Free and Informed Consent (FIC) document. The study sample was selected in a deliberate manner. The choice of senior road cyclists (men) was made for the achievement of our experiment. They were divided into two (02) groups, intervention and control, each composed of 9 riders, used to participate in national and international competitions. The experimental group represents the National Security Sports Association (ASSN), the control group represents Vélo Club SOVAC. The content of our strength-training program is reserved for the intervention group. The control group trains only on the road. Subject characteristics are presented in table 1 and 3.

**Table 1**. Characteristics of the two groups (intervention and control)

| Groups | Age (y) | Height (cm) | weight (kg) | Max hr (bpm) | Seniority (y) |
|---|---|---|---|---|---|
| **Intervention group (n= 9)** | 22±2 | 176,83±4,06 | 71,72±6,37 | 196,11±5,60 | 8±2 |
| **Control group (n= 9)** | 20±2 | 179,67±8,82 | 70,78±4,70 | 197,56±6,60 | 9±3 |

*Max hr : maximal heart rate, bpm : beats per minute.*values are mean±SD*

### 3.3. Research tools and data processing

#### 3.3.1. Procedures

For the intervention and control group a pretest proceeded 19 weeks of strength training reserved to the intervention group. After the intervention period, a posttest, the same as the pretest, was performed. The control group only performed their training on the road. The posttest and pretest consisted of measurements of peak power and maximal aerobic power. Peak power is evaluated with different tests (Rachid MEDDAH, SACI, 2019; Chaker BOUNAB, 2014). In our study, peak power was measured using **the force-velocity Test**. The subject uses his personal bike attached to an Elite Realaxiom electromagnetic home trainer to put him in situations similar to the field ones. The data is measured with a powertap G3 hub power sensor with an accuracy of 1,5%. The test begins with a 15-minute warm-up at medium intensity. After 5 minutes of recovery, the cyclist performs two maximum 7-second sprints with braking force (simulation of a 5% gradient) and with two different developments (6,51 meters; 7,38 meters) interspersed with at least 5 minutes of active recovery with low intensity. The cyclist must give the maximum of his potential during the test. It is the cyclist who starts his sprint when he is ready. The data were recorded on a Garmin Fénix 3 watch and processed using Garmin connect software (Frédéric Grappe, 2012).

After 15 minutes of rest, a **maximum Aerobic Power Test** was performed using an incremental protocol. The subject is on his personal bike attached to an Elite Realaxiom electromagnetic home trainer, using the same equipment as the one in the force-velocity test. The slope simulation brake must be set to 4%, at the start signal, the stopwatch is engaged. The athlete controls the power level on each step, with a Cycleops joule 2.0. As warm-up is part of the test, the test starts at 100 Watts, the mechanical power increases by 30 Watts every 2 min. This increment of mechanical power corresponds to what happens in the field in real conditions of locomotion when the cyclist, for a given pedalling frequency, changes gear (plus or minus one tooth on the freewheel). The subject must resist as long as possible in the last bearing even if it is not possible to finish it completely, each second gained increases the maximum power and encourages the rider during the last bearings. Note the exact duration of the test (moment when the rider can no longer maintain the required power). The maximum aerobic power (Wmax) will be calculated according to the following formula (Frédéric Grappe, 2012):

Wmax (Frédéric Grappe, 2012) = Mechanical power lower bearing + ((Mechanical power last bearing - Mechanical power lower bearing)* time last bearing).

### 3.3.2. Training intervention

The program is spread over 19 weeks, consisting of 36 sessions with a total volume of 63.5 h. The program is detailed in table 2.

**Table 2.** Strength Training Program

| **Cycles** | **Familiarization** | **Maximal strength** | **Power** | **Endurance-strength** | **Strength Recall Sessions** |
|---|---|---|---|---|---|
| Number of weeks | 2 | 4 | 2 | 4 | 7 |
| Number of training /weeks | 2 | 2-3 | 3 | 3-2 | 1 |
| % 1RM | 50-60% | 85 | 45-60% | 40-60% | 40-60% |
| Speed of execution | Medium | Medium | Fast | Medium | Medium |
| Number of series | 3 | 3 | 4-6 | 3-4 | 3 |
| Number of repetitions | 10-15 | 6 | 6 | >15 | 10-15 |

### 3.3.3. Statistical methods

For the descriptive statistic, we calculated the mean and standard deviation using Xlstat computer software. For the analytical statistics, we used the Mann Whitney test for the comparison between the control and experimental groups and the Wilcoxon test for the pre-test and post-test comparison of the two groups. In all cases, $p<0,05$ was taken as the level of significance.

## 4. Exposure, analyses and results exam

The results of the two tests (pre- and post-test) for the two groups are presented in Table 3.

**Table 3.** Test results of the intervention and control groups before and after the tests

| Intervention Group | | |
|---|---|---|
| **Powers** | **Pre-test** | **Post-test** |
| **Wmax(W)** | 352,91 ± 35,61 | 404,78 ± 22,37 |
| **Wmax BM (W/kg)** | 4,95 ± 0,57 | 5,67 ± 0,49 |
| **Peak power (W)** | 917,44 ± 134,71 | 1062,89 ± 117,90 |
| **Peak power BM (W/kg)** | 12,96 ± 1,60 | 14,84 ± 1,45 |
| **Control group** | | |
| **Wmax(W)** | 327,37 ± 21,52 | 345,11 ± 17,62 |
| **Wmax BM (W/kg)** | 4,64 ± 0,40 | 4,93 ± 0,34 |
| **Peak power (W)** | 906,78 ± 113,43 | 959,44 ± 96,93 |
| **Peak power BM (W/kg)** | 12,85 ± 1,63 | 13,70 ± 1,48 |

Wmax: Maximal aerobic power, BM : variable adjusted to body mass. *values are mean±SD

According to the results presented in the table, the results obtained by the control group and the intervention group in the two tests before and after the intervention) indicate higher post-test averages for all parameters.

### 4.1. Comparative analysis of test results

The results of the comparative analysis are presented in tables 4 and 5.

**Table 4.** Comparison between intervention and control groups at the beginning and at the end of the intervention.

| | beginning | End | Effect size |
|---|---|---|---|
| **Wmax(W)** | Ns | S*** | +59,67 |
| **Wmax BM (W/kg)** | Ns | S** | +0,74 |
| **Peak power (W)** | Ns | S* | +103,45 |
| **Peak power BM (W/kg)** | Ns | S* | +1,14 |

Wmax: Maximal aerobic power; Ns : non significant difference for p>0,05 ; * p<0,05 ; ** p<0,01; *** p<0,001. BM : variable adjusted to body mass.

The comparison between the intervention group and the control group at the beginning of the experiment (Table 4), indicates the non-existence of differences at the significance level p>0,05. However, the comparison at the end of the intervention showed significant differences at significance level p<0,001 for maximum aerobic power, at significance level p<0,01 for maximum aerobic power in relative value and at p<0,05 for peak power in absolute and relative value.

The intervention and control group data between the first and second tests show a progression for all the parameters studied (Table 5). The pre-test and post-test comparison of the intervention and control groups showed significant differences at the significance level p<0,01.

**Table 5.** Pre-test and post-test comparison of the two groups

| | Intervention group | Effect size | Control group | Effect size |
|---|---|---|---|---|
| **Peak power (W)** | S** | +51,87 | S** | +17,74 |
| **Peak power BM (W/kg)** | S** | +0,72 | S** | +0,29 |
| **Wmax(W)** | S** | +145,45 | S** | +52,66 |
| **Wmax BM (W/kg)** | S** | +1,88 | S** | +0,85 |

**Wmax:** Maximal aerobic power; S**: significant difference for p<0,01 BM : variable adjusted to body mass.

## Discussion

At the end of our intervention, the comparative analysis of the test results for the intervention and control groups revealed significant differences (p < 0,001) in the performance at maximum aerobic power (Wmax) in favour of the intervention group. This fits well with the study by Bent R Rønnestad and others (2010a) and Arnstein Sunde and others (2010) which found that strength training has a positive effect on maximum aerobic power (Wmax) in cyclists. Other studies have found a beneficial effect on endurance performance as an improvement in time trial performance (Bent R Ronnestad and others, 2010a; P. Aagaard and others, 2011).

Comparison of the results of relative aerobic maximum power showed a significant difference (p < 0,01) for the intervention group. This significance is consistent with the study by Bent R Rønnestad, Mujika (2014). These results explain the integration of strength training characterized by a large number of repetitions with less load (40% to 60% of the maximum load) (Nathaniel P Jackson and others, 2007). Furthermore, one of the main reasons why cyclists abstained from weight training was the fear of gaining weight. The study by Bent R Rønnestad, Mujika (2014) showed that there is no significance in weight gain for weight-trained cyclists, therefore there is no effect on the relative values (relative Peak power and relative maximum aerobic power). The performance of the intervention group in peak power and peak power adjusted to body mass is better than that of the control group with a significance of ($p < 0,05$). These results are consistent with the study by Oyvind Støren and others (2008), which investigated the effect of maximum strength training on the performance of cyclists at peak power.

Comparative analysis of the pre- and post-test results of the control group showed a significant difference ($p < 0,01$) on all measured parameters. This significance is explained by the specific work on the bike with specific gear ratios and the training of velocity and strength, which also participates in that of power. A team of Australian researchers showed that after only four weeks of intensive interval training sessions, the improvement in maximum aerobic power (Wmax) was significant (Christian Vaast, 2008). Our initial working hypothesis that force development would promote power enhancement is supported by our results. These results are an argument in favour of the introduction of strength training programs aimed at developing all the muscular qualities in the preparation of a cyclist.

## Conclusion

The results obtained during our intervention show that the progression of the power of the cyclists in the intervention group is significant compared to the control group. Thus, the quantitative assessment of the different parameters allowed us to confirm our initial hypothesis, which states that a training program of 03 months with a frequency of 02 to 03 weekly sessions during the preparatory period has a positive influence on the improvement of power.

This work can provide us with benchmarks for the individualisation of training, which has become a performance requirement in modern cycling. To conclude this work, we can say that the determination of power levels in cyclists must address the various points, which we have detailed in our study.

**Practical applications**

For recommendations, we propose the following ones:

- An adapted muscular strengthening work with the circuit-training method is particularly suitable for the cyclist, as it combines several exercises with and without apparatus. The duration of the exercises of the breaks between the series, and of the recuperations between the exercises is such that it is possible to set up a type of interval training, intended to improve the general endurance of the body and mainly the muscular endurance.
- The training circuits can be completed or modified within the session itself in order to adapt them as best as possible to the cyclist's shortcomings and needs.
- With the exception of the lower limbs, for which specific training will be given, it is necessary to strengthen the muscles that are involved at the secondary level during a cycling event; in particular: lumbar, abdominal, pectoral, arm and shoulder muscles.
- The aim here is not to increase muscle mass, but to improve muscle performance without a noticeable increase in volume, thus improving endurance-strength.

- The integration of transfer exercises after each series of muscle-building exercises by performing 20-30 second sprints on a home trainer with a high velocity (over 100 rpm), or performing road trips from 1,5 to 2,5 hours after the end of the training session.
- Flexibility work is interesting because it allows a certain ease of movement and, perhaps, a better assimilation of the technique specific to pedalling. The latter is then more profitable and economical in terms of energy. This point is particularly interesting for young cyclists.

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