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# Effects of the COVID-19 confinement period on physical conditions in young elite soccer players

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**Abstract**

*Background*: The rapid spread of the SARS-CoV-2 infection required general confinement measures reducing or even preventing sport practice, which was a risk of detraining in athletes. In adolescents, detraining is poorly known as well as its prevention by home-exercises. This article aimed to assess the effects of Covid-19 confinement on detraining in young high-level soccer players despite a multimodal training program conducted at home.

*Method*: Twenty-five elite soccer players, aged 14, were included to perform physical exercises at home during the Covid-19 confinement. Two cardio-training sessions and two upper and lower limb muscle strengthening sessions were performed per week. The exercise program was monitored remotely via the web. Hooper, training and mental indexes allowed a psychological follow-up. The effect of Covid-19 confinement on aerobic capacity was measured using a pre- and post-confinement Yo-Yo test.

*Results*: Out of the 25 adolescences who completed the exercises program, 19 performed the post-confinement Yo-Yo test. The running distance decreased by 614 +/- 630 m (-25%) (p = 0001) and the maximal running speed by 0.97 +/- 1 km/h (-5%) (p=0.001), confirming detraining. Hooper, training and mental indexes remained stable showing a well-supported home Covid-19 confinement.

*Conclusions*: The 2-month period of strict home confinement due to the SARS-CoV-2 pandemic was responsible for a decrease of aerobic abilities in adolescent soccer players, despite a remotely monitored multimodal exercises program.

**Keywords**: Coronavirus, Detraining, Sport, Adolescents, Hooper's index

## Introduction

Strict home confinement due to the pandemic by the SARS-CoV-2 has been responsible for an exceptional and unprecedented shutdown of all collective outdoor sports practices. This cessation of sport raised fear of detraining in athletes, especially if the duration of the confinement was to last for several weeks.[1] In adults, a sport cessation of more than 4 weeks is responsible for a significant loss of aerobic abilities.[2] In 14-15 year-old athletes, little data exists. A 4-week sport stoppage does not seem sufficient to induce a significant loss of knee strength in soccer players.[3] Moreover, after 12 to 16 weeks of sport cessation, anaerobic performances such as strength, jumps and sprints are not or very little changed.[4–7] Yet, a 15% loss of endurance performances following a 5-week sport stoppage was recently reported.[8]

Assuming that Covid-19 confinement was likely to create detraining, home-exercise programs were widely broadcast on the web, within sports and non-sports communities.[9] Among young elite soccer players, we implemented a multimodal home-exercises program with remote monitoring via the web, to fight against the effects of Covid-19 confinement and comply with barrier measures.[10] These effects were measured using a pre-containment test of repeated sprints (Yo-Yo-test). The level 1 Yo-Yo test, inspired by Luc Leger's 20-metre shuttle test, was used as it explores the ability to perform intermittent repeated running exercises, requiring maximum aerobic activation.[11,12] This test, easy to perform and inexpensive, is particularly adapted to the practice of intermittent sports like soccer.[13,14] Psychological markers were also daily evaluated based on various indexes (Hooper, training and mental) to determine how adolescents experienced training during Covid-19 confinement.[15] The objective of this study was therefore to measure Covid-19 confinement effects on the decrease of aerobic capacity despite a multimodal home-program of exercises, monitored at distance in adolescents who played soccer at an elite level.

## Materials and Methods

### *Population*

In France, the confinement period lasted from March 17 to May 11, 2020, i.e. for 55 days. All young soccer players aged 13 and 14, who played at the Pole Espoir of Saint Sébastien sur Loire, France, were eligible to this study if their aerobic capacity had been measured by the Yo-Yo test before the Covid-19 confinement period. Adolescents who had not been physically assessed before the confinement were excluded. The written consents of the adolescents and of their parents were sought to participate to the study. The study was allowed with the agreement of the Ethics Committee and the Research Direction of the Nantes University Hospital.

### *Program of exercises*

The Covid-19 confinement led to a cessation of soccer practice, which raised the question of detraining in adolescents and its counterbalance by setting up a home-exercises program. Prior to the confinement, a typical week consisted in 4 training sessions of 45 to 90 minutes and a competitive match (Table 1). During Covid-19 confinement, 4 sessions of 45 minutes per week were requested to work strength of the upper and lower limbs, and to preserve aerobic abilities: cardio-training and HIIT (High Intensity Interval Training).[16] These aerobic sessions were performed at only 80% of the maximum heart rate due to an unknown potential cardiac risk in case of coronavirus infection.[17] Heart rate monitoring was carried out using the Polar® H10 belt connected by Bluetooth® and ANT+™ to the Polar Beat® firmware. The program of exercises was multimodal in order to stimulate all the physical abilities of the players, considering that all physical dimensions must be developed at this age (Table 1). The demonstration of the exercises was carried out using videos addressed to the players via the web. The number of sessions was reported throughout the Covid-19 confinement.

*Psychological follow-up*

Psychological monitoring of the training sessions was performed remotely on a dematerialized and computerized support, so that the adolescents could fulfill Hooper, training and mental indexes. Hooper's index quantified sleep, stress, overall fatigue and muscle soreness, based on a 0 to 7 scale.[18,19] The difficulty to perform exercises was assessed using the training index divided into 3 items: “physical fatigue”, “enjoyment of performing the exercises” and “performance feeling during the exercises”, measured using an analog scale from 0 to 10. A mental index on 5 items was also performed to determine the consequences of the Covid-19 confinement: mental state, physical strength, mood and feelings in personal and collective life (measured using an analog scale from 0 to 10). These last two indexes were derived from the mood profile questionnaire (POMS: Profile of Mood States).[20–22]

*Physical consequences of Covid-19 confinement*

The consequences of Covid-19 confinement were assessed by measuring aerobic capacity using a level 1 Yo-Yo test.[12,23] The Yo-Yo test consisted in a 2 x 20m shuttle run at an increasing speed, interspersed with 10-second active recoveries. The running speed was controlled by an automated acoustic device, indicating start, turn and finish. The test started at a speed of 8 km/h with stepwise of 0.5 km/h every minute. The test stopped when the subject could not maintain the speed required by the acoustic beep. Two parameters were then measured: the distance covered and the maximum speed reached at the end of the test.[23] Oxygen consumption can be calculated from the distance covered according to the equation established by Bangsbo et al.: $VO_2$ (ml/min/kg) = distance (m) x 0.0084 + 36.4.[12] This test is particularly suitable for 14-year-old athletes who play intermittent sports such as soccer.[24] The

reliability of the covered distance during the test is excellent (ICC: 0.85 [0.74-0.92]).[25] The validity of the Yo-Yo test in 14-year-old children is excellent for the distance covered during the test, which is correlated to the high-intensity runs (r=0.77) and the distance covered during a soccer match of 2 periods of 30 minutes (r=0.65).[13] The first Yo-Yo test was performed 10 days before the Covid-19 confinement and the second 3 days after the confinement.

*Statistical analysis*

The statistical analysis was performed using SPSS 23.0® software (Chicago, Illinois, USA). Quantitative variables are given in means and standard deviation, and qualitative variables in number and frequency. Values into brackets provide minimal and maximal values. Variance normality was tested by the Kolmogorov-Smirnov and the Levenne tests. The Covid-19 confinement effect was measured by comparison of the Yo-Yo-test variables before and after the confinement with a paired t-test. Differences between subjects for Hooper, training and mental indexes were assessed by an analysis of variance (ANOVA for repeated measures) after weekly averaging of the different indexes values (4 per week during 2 months).[19] The assumption of sphericity was assessed and corrected using the epsilon of Greenhouse-Geisser. Paired-comparisons were performed with Bonferroni test. Effect sizes were assessed by partial eta squared $\eta^2$, which were defined as trivial, small, moderate and large for values $\eta^2 \leq 0.1$, $\leq 0.3$, $\leq 0.5$ and $>0.5$, respectively.[26] Pearson's correlation coefficient (r) was calculated to assess the association between the modification of distance of the Yo-Yo test (i.e. the difference between the 1st and the 2nd Yo-Yo tests) and the percentage of completion of the training program. The alpha level of statistical significance was set at $p< 0.05$.

## Results

Out of the 29 eligible players, 27 were evaluated by the Yo-Yo test before the Covid-19 confinement and 25 completed the program of exercises (Table 2). Two players refused to participate to the study. After 8 weeks of confinement, 19 adolescences were assessed. The reasons for not carrying out the post-confinement Yo-Yo test were in 3 cases a refusal to achieve it, in 3 other cases the lack of interest because players had already been engaged in a professional club for the next sports season and in 1 case the impossibility of organizing the Yo-Yo test at home. The average age at the time of Covid-19 containment of the 19 players who completed the follow-up was 14.2 years (from 13.4 to 15.2 years). Prior to confinement, the weight was 52.2 kg +/- 7.4 and height was 166.0 cm +/- 9.0, Body Mass Index of 18.0 kg/m$^2$ +/- 0.4. No injury and no coronavirus infection were reported.

*Compliance to the program of exercises*

The training program was performed at 79.7% +/- 17.0 [43.7 - 96.8%]: cardio-training 82.2% +/- 18.3, HIIT 75.0% +/- 19.0, upper limbs strengthening 80.9% +/- 19.7 and lower limb strengthening 79.6% +/- 18.6.

*Psychological consequences of the Covid-19 confinement*

The training index was not different over the 8 weeks of Covid-19 confinement for HIIT and limb strengthening (Figure 1). Only cardio-training exercises were different during the 2 months of confinement [$F(7,49) = 10.4$, $p<0.05$ $\eta^2 = 0.59$]. However, the training index increased significantly only between the first (index = 17.7 +/- 4.1) and the second week (index = 20.8 +/- 3.8) of confinement [$t(18) = 3.75$ ; $p = 0.011$] (Figure 1). Hooper's index and mental index did not vary significantly during the confinement period [$F(7,70) = 2.48$, $p=0.06$ $\eta^2 = 0.19$] (Figure 2), [$F(7,70) = 0.93$, $p>0.05$ $\eta^2 = 0.08$] (Figure 3).

*Physical consequences of the Covid-19 confinement*

The distance covered during the Yoyo test decreased on average of 614 m +/- 630 (-25%), from 2524 m +/- 406 to 1915 m +/- 652 (p=0.0001). The maximum speed reached also decreased on average of 0.97 km/h +/- 1.0 (-5.2%) and went from 17.4 km/h +/- 0.6 to 16.5 km/h +/- 1.0 (p=0.001). Calculated oxygen consumption decreased of 5.1 ml/min/kg +/- 5.2 (-9%), from 57.6 ml/min/kg +/- 3.4 to 52.4 ml/min/kg +/- 5.5 (p = 0.0001). No correlation was found between the distance decrease of the Yo-Yo tests and the percentage of program completion (r = 0.118; p > 0.05).

## Discussion

The 2-month Covid-19 confinement period was responsible for a significant loss of aerobic abilities in young players who practiced soccer at an elite level, despite a supervised home-program of exercises.

*Physical detraining*

To our knowledge, only Chatzinikolaou et al. showed in adolescents (14-15 years) a 15% loss of aerobic capacity after a 5-week detraining.[8] The loss of running distance measured by the level 2 Yo-Yo test was significant, approximatively 144 meters, which represented a loss of oxygen consumption of 2 ml/min/kg according to the equation: $VO_2$ = distance x 0.00136 + 45.3.[12] The level 2 Yo-Yo test explores the ability to perform intense intermittent exercises with a greater anaerobic component than the level 1 Yo-Yo test we used, due to a higher test start speed (11.5 km/h) and a shorter stepwise to reach faster the maximum speed.[12,27] However, the level 1 Yo-Yo test seems more suitable for adolescents playing soccer because of the still underdeveloped anaerobic abilities in 14-year-old children trained

to play soccer.[13,14] Despite a different Yo-Yo test procedure, our results showed that Covid-19 confinement was the cause of a detraining responsible for a loss of aerobic capacity. This loss, which we measured at 25% for the distance covered, was greater than that reported by Chatzinikolaou et al. (-15%).[8] This result is probably due to a longer period of detraining, 2 months compared to 5 weeks. Physiologically in adults, the loss of aerobic capacity after 4 weeks of detraining is due to a decrease in peripheral adaptations which associates a decrease of the use of energetic substrates, a decrease of mitochondrial energy production, and a reduction of muscle fibers capillarization.[28]

*Inefficiency of the program of exercises*

The program of exercises we proposed during the Covid-19 confinement period was not sufficient to fight against the loss of aerobic capacity despite a good compliance of approximatively 80%. This excellent compliance was probably related to the remote monitoring of the trainings which likely contributed to the motivation of the adolescences when the duration of the confinement was not known. However, the aerobic system may have not been sufficiently stressed, because only 2 sessions a week (cardiotraining and HIIT) were dedicated to this objective. The duration of the sessions was probably too short compared to the duration of usual soccer training sessions (Table 1). The intensity of the exercises may also not have been sufficient due to the limitation of the heart rate at 80% of the maximum, chosen because of the potential cardiac risk in case of SARS-CoV-2 infection.[17] Thus, it was not possible to reproduce sufficient metabolic stresses to maintain aerobic abilities at home. Resistance and endurance training might have been more appropriate but probably more difficult to achieve at home.[5]

*Psychological follow-up*

The follow-up of psychological markers showed that Covid-19 confinement was well supported while performing physical exercises at home. No overtraining occurred as shown by the Hooper index, which remained weak and stable still below 5.[18] Stress and sleep were reported on average at 2 out of 7, with no significant individual variation throughout the confinement period. By comparison, values of 1.75 to 2.8 for these 2 items are reported in case of high training loads.[29] The mental index also remained stable with a rating of mood and personal and family life which remained good on average at 8 out of a maximum of 10. Daily remote monitoring may have contributed to a well psychologically supported confinement during performing physical exercises, even if it was unable to limit detraining.

*Limitations*

Results are limited because anthropometric parameters were not followed and anaerobic parameters such as strength, speed or jumps were not measured. This is explained by the fact that the beginning of the Covid-19 confinement period had not been known and therefore not anticipated in order to carry out pre- and post-confinement assessments. Yet, we were lucky enough to have organized a Yo-Yo test 10 days before this period, which allowed us to measure the consequences of the Covid-19 confinement using a new Yo-Yo test.

## Conclusions

The Covid-19 confinement period represented an exceptional situation that led to a detraining in 14-year-old elite soccer players, despite a home-program of exercises. The loss of the running distance covered during the level 1 Yo-Yo test was of 25%. This loss of aerobic capacity might have been greater if no exercise had been performed. Psychological markers remained good and stable throughout the confinement, possibly due to the maintenance of the

physical exercises and the link with the sport technical staff that was maintained via the web. The exercise program was well supported without any reported injury.

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**Competing interests**

The authors declare that they have no competing interests.

**Authors' contribution**

MD conceived the study and participated in its design and drafted the manuscript. PM participated in coordination of the study and helped draft the manuscript. AFC performed the statistical analysis and helped draft the manuscript. All authors have read and approved the final version of the manuscript.

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Table 1: Typical weeks of training before and during the Covid-19 confinement

| | **Soccer training before Covid-19 confinement** | **Exercises during Covid-19 confinement** |
|---|---|---|
| Monday | Aerobic recovery (45 min) | Cardio-training (45 min) |
| Tuesday | Aerobic power (75 min) | Lower leg strengthening (45 min) |
| Wednesday | Anaerobic power (90 min) | Upper legs strengthening (45 min) |
| Thursday | Speed and sprint (60 min) | Rest or Stretching |
| Friday | Intensity (45 min) | High Intensity Interval Training (45 min) |
| Saturday | Match in competition | Rest or Sophrology or Juggling |
| Sunday | Rest | Rest |

Table 2: Yo-Yo tests and training follow-up during the COVID-19 confinement

| | | Distance (m) | Maximal speed (km/h) | $VO_2$ (ml/min/kg) | Distance (m) | Maximal speed (Km/h) | $VO_2$ (ml/min/kg) | Training (%) |
|---|---|---|---|---|---|---|---|---|
| Soccer players | Age | **Before confinement** | | | **After confinement** | | | |
| 1 | 13 years 5 months | 1640 | 16 | 50,2 | | Not carried out | | 53.1 |
| 2 | 13 years 8 months | 2200 | 17 | 54,9 | 1400 | 15,5 | 48,1 | 96.8 |
| 3 | 13 years 9 months | 2520 | 17,5 | 57,6 | 2040 | 16,5 | 53,5 | 59.3 |
| 4 | 13 years 10 months | 3000 | 18 | 61,6 | 3640 | 19 | 66,9 | 90.6 |
| 5 | 13 years 10 months | 2640 | 17,5 | 58,6 | 3040 | 18,5 | 61,9 | 81.2 |
| 6 | 13 years 11 months | 3120 | 18,5 | 62,6 | 1480 | 16 | 48,8 | 87.5 |
| 7 | 13 years 11 months | 2600 | 17,5 | 58,2 | 2280 | 17 | 55,5 | 81.2 |
| 8 | 14 years | 2160 | 17 | 54,5 | 1480 | 16 | 48,8 | 62.5 |
| 9 | 14 years 1 months | 1640 | 16 | 50,2 | 1560 | 16 | 49,5 | 43.7 |
| 10 | 14 years 1 months | 2800 | 18 | 59,9 | | Not carried out | | 59.3 |
| 11 | 14 years 1 months | 2560 | 17,5 | 57,9 | 2120 | 17 | 54,2 | 96.8 |
| 12 | 14 years 1 months | 3000 | 18 | 61,4 | 1520 | 16 | 49,1 | 87.5 |
| 13 | 14 years 2 months | 1960 | 16,5 | 52,9 | 1480 | 16 | 48,8 | 96.8 |
| 14 | 14 years 2 months | 2640 | 17,5 | 58,6 | 2440 | 17,5 | 56,9 | 56.2 |
| 15 | 14 years 2 months | 2480 | 17,5 | 57,2 | 1240 | 15,5 | 46,8 | 56.2 |
| 16 | 14 years 3 months | 2480 | 17,5 | 57,2 | 1200 | 15,5 | 46,4 | 96.8 |
| 17 | 14 years 5 months | 2320 | 17 | 55,9 | | Not carried out | | 96.8 |
| 18 | 14 years 8 months | 2760 | 18 | 59,6 | 1880 | 16,5 | 52,2 | 62.5 |
| 19 | 14 years 9 months | 1920 | 16,5 | 52,5 | 2080 | 17 | 53,8 | 90.6 |
| 20 | 14 years 9 months | 3080 | 18,5 | 62,3 | 2440 | 17,5 | 56,9 | 87.5 |
| 21 | 14 years 11 months | 2960 | 18 | 61,3 | | Not carried out | | 56.2 |
| 22 | 14 years 11 months | 2440 | 17,5 | 56,9 | 1160 | 15,5 | 46,1 | 81.2 |
| 23 | 15 years | 2320 | 17 | 55,9 | | Not carried out | | 68.7 |
| 24 | 15 years | 2400 | 17,5 | 56,6 | | Not carried out | | 84.3 |
| 25 | 15 years 2 months | 2760 | 18 | 59,6 | 1920 | 16,5 | 52,5 | 87.5 |

Figure 1: Weekly evolution of the 30-point training index of cardio-training, HIIT, and lower (LLS) and upper limbs strengthening (ULS) exercises during COVID-19 confinement

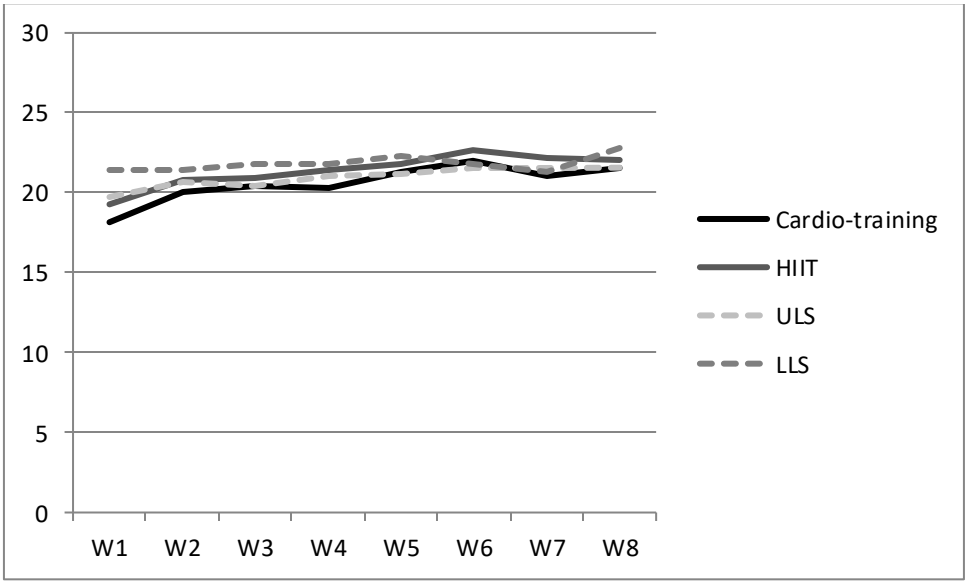


Figure 2: Weekly evolution of the 4 items of Hooper's index on 28 points during COVID-19 confinement

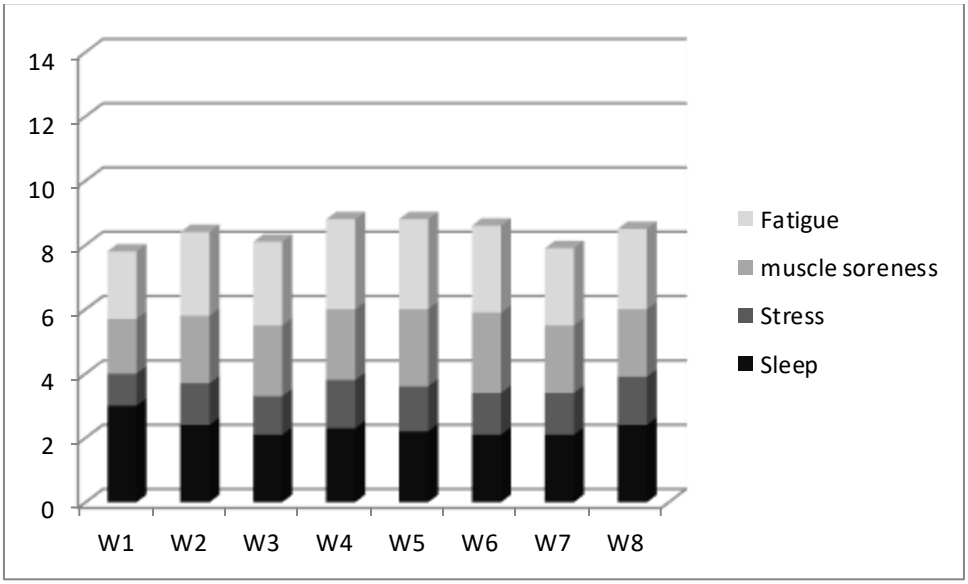
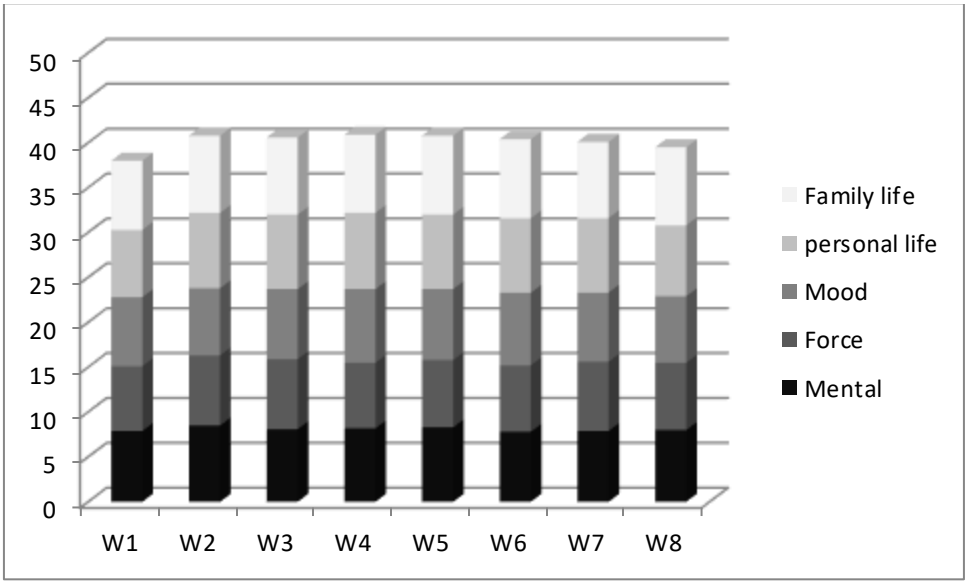


Figure 3: Weekly evolution of the 5 items of the mental index on 50 points during COVID-19 confinement



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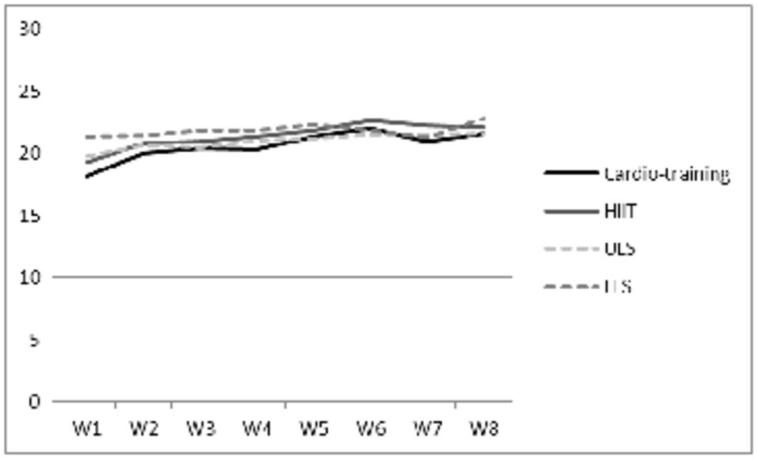

Fig. 2: Weekly evolution of the 4 items of Hooper's index on 28 points during COVID-19 confinement

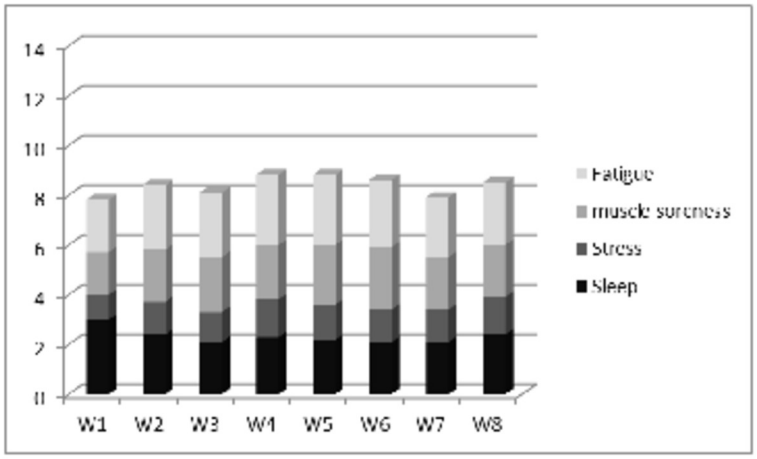

Fig. 3: Weekly evolution of the 5 items of the mental index on 50 points during COVID-19 confinement