



Deliverable D4.3

Title: Adherence data report

SFL ADHERENCE STUDY

Introduction

Multi-domain interventions seem to offer interesting prospects for an aging population. However, any intervention has its limitations and adherence to the intervention program is one of them. The second objective of the SFL project is to study adherence to the SFL intervention, i.e. adherence to the physical and cognitive program developed by the consortium.

The adherence sub-study will rely on a pragmatic quasi-experimental design. At the end of the 26-week RCT, participants in the experimental group will be asked to continue using the programme and participants in the control group will 'cross-over' to the StayFitLonger programme. Initially, this sub-study was supposed to last 22 weeks, however Covid19 led to an extension of data collection and analyses will be presented over 26 weeks. Indicators of adherence have been recorded throughout the entire duration of the StayFitLonger study (52 weeks).

This report is aiming to present data on SFL program adherence and answer to questions on whether adherence can be maintained over time and whether it is influenced by personal characteristics, the presence or not of supervision and the type of intervention.

Primary outcome: adherence to the training of the experimental program by evaluating the average training dose over time and the regularity of training of the subjects (see Table 1 of the ethics protocol).

Secondary outcome: Separation of adhesion profiles into good and bad adherents (according to the criteria defined for the 1st outcome). Individual correlation with:

- Technological & gaming profile of the subject (Q. gaming & technology)
- The user experience of the product (AttakDiff)
- Program acceptability Q&final feedback
- The effects of the adhesion profile on the different outcomes (primary & secondary) of the RCT

Material & method

Experimental design.

The adhesion study was conducted over 12 months, including the 6 months of training of the RCT part (1st part: months 1 to 6) and continuing after the T1 evaluations on 6 months of additional training (2nd part: months 7 to 12).

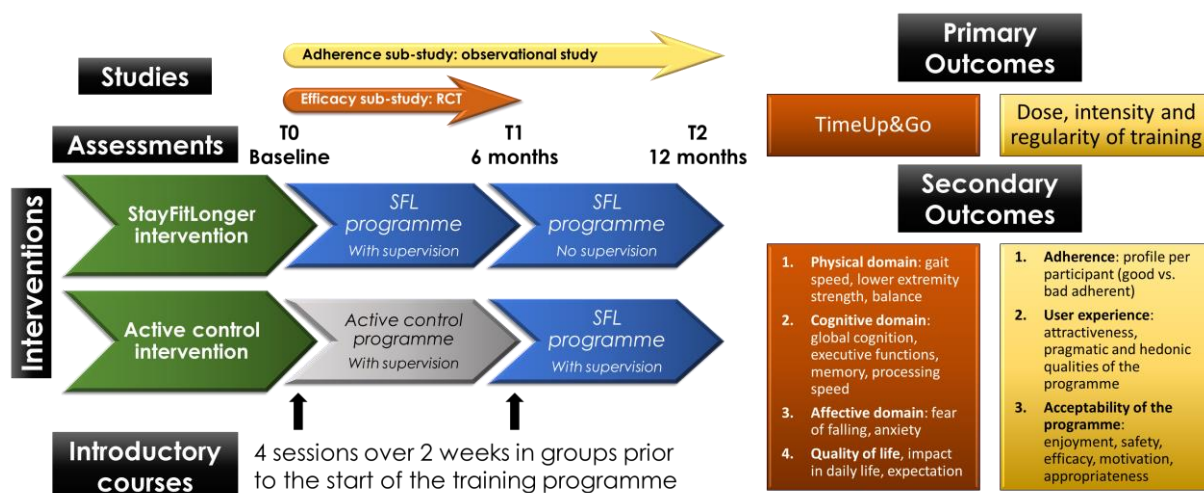


Figure 1. SFL study experimental design (in courtesy of Marc Cuesta). See RCT report for more information.

During Part 1 (RCT over 6 months), only half of the subjects included in the study received 26 weeks of SFL intervention. During the first two weeks, the subjects are coached by professionals and the measures taken during this period cannot be attributed to adherence to the program. This first group will therefore be referred to as the SFL₃₋₂₆ group (3 to 26 indicating the weeks of SFL intervention without coaching).

In the second part (ADH over 6 months), all Swiss and Canadian subjects who did not give up during the 1st part had to benefit from 22 weeks of SFL intervention. The Covid19 outbreak prevented the T2 assessments from being completed on schedule and subjects continued to train for an additional 10 weeks. In order to minimize the impact of Covid and compare similar periods during the 2 parts of the experimental design, the analyses were carried out on all subjects who maintained their training over 26 weeks in this second part. The subjects can therefore be separated into two groups: on the one hand the SFL_{group 27-52} (i.e. all the subjects of the SFL_{group 3-26} who continued to train on the same program; 27 to 52 indicating the weeks of intervention followed by these subjects during this second part) and, on the other hand, by the SFL/Ctrl_{group -26} (i.e. all subjects in the control group who changed intervention and received the SFL intervention; 3 to 26 indicating the weeks of intervention, without coaching).

Subjects selection. According to the statistical plan of the study, a per-protocol analysis, including only Swiss and Canadian, was recommended for the adherence part. Only subjects from these two countries who completed their 26 weeks of training were therefore included in the adherence analyses. During the *first part of the study (RCT part)*, 48 subjects (33 Swiss and 15 Canadian) benefited from the SFL intervention. After 26 weeks of training, there are 15 drop-outs, respectively, 10 for Switzerland and 5 for Canada (9 Swiss and 4 Canadian benefiting from the SFL intervention). The SFL₃₋₂₆ group is therefore made up of 35 subjects who have completed part 1 (RCT) of experimental design, i.e. respectively 24 Swiss and 11 Canadian (see Table 1). Nine subjects dropped out after physical and cognitive assessments at T1. The rest of the subjects followed the 2nd training and continued the study. During the *second part of the study (ADH part)*, 72 subjects (48 Swiss and 24 Canadian – see Table 1) benefited from the SFL intervention. After 26 weeks of training, there are 8 drop-outs (1 Swiss plus 2 Canadians from the SFL₂₇₋₅₂ group and 1 Swiss plus 4 Canadians from the SFL group/Ctrl₃₋₂₆). The group sizes are therefore 25 subjects (19 Swiss and 6 Canadian) for the SFL₂₇₋₅₂ group and 39 subjects for the SFL/Ctrl₃₋₂₆ group (27 Swiss and 12 Canadian) respectively.

RCT part	Switzerland		Canada		RCT part
	Included	Finished	Included	Finished	Analysed data files
All	64	54	32	27	-> 24 + 11 = 35
SFL ₁₋₆	33	24	15	11	
CTRL	31	30	17	16	
ADH part	Switzerland		Canada		ADH part
	Included	Finished	Included	Finished	Analysed data files
All	48	46	24	18	-> 19 + 6 = 25
SFL ₇₋₁₂	20	19	8	6	
SFL/Ctrl ₁₋₆	28	27	16	12	
					-> 27 + 12 = 39

Table 1. Effective of subjects (included and that finished their training period) for each part of adherence design.

In summary, adherence analyses were performed on data from all subjects who completed their 6 consecutive month training period, for a total of 99 data files in total – 35 subjects for the RCT period and 64 subjects for the DHA period.

Data extraction. The data were extracted from the study's monitoring website by HES-SO engineers. The CSV files transmitted had raw data of individual tablet usage day by day for each subject: the dose (time spent on the tablet with a breakdown by application), the number of activities completed per day per application. These CSVs were already categorized by country and intervention (intervention SFL Versus intervention control). Each subject was identified by their tablet number (REF### for "let's stay in shape" ###). Using a Python script (using the PANDAS library), the 3 data sets were extracted CSV files: the set SFL₃₋₂₆, the set SFL₂₇₋₅₂ (which is a subset of the topic from the previous group) and the set SFL/Ctrl₃₋₂₆. The set SFL₃₋₂₆ and SFL₂₇₋₅₂ were extracted from a single batch of Files CSV which contained all the training data of the group SFL over nearly 62 weeks (the restriction of access to the program during the 4 weeks – T1 assessments – made it possible to delimit data belonging to the group SFL₃₋₂₆ of those to be attributed to the group SFL₂₇₋₅₂). On the contrary, the CSV of the topics of the group SFL/Ctrl₃₋₂₆ only concerned the 32 weeks spent training with the program SFL during months 7 to 12 of the study. Only data from the first 26 weeks of this second training were analyzed.

The adherence analyses cover 99 data files (35+25+39 = 99; i.e. 68.75% of the expected data: 99/144*100; 48+96=144 if all subjects had completed the entire study). To get an overview, an Excel file was generated (thanks to Python) with 11 tabs respectively for the dose, the training frequency per week and the volume of activities completed per week. The first 3 of these 11 tabs correspond to the measures collected for the entire SFL training program, for the physical activity program (PA), all exercises combined, and for the cognitive activity program (CA) in the broad sense (activities in the form of cognitive games (CG) and features of the cognitive program); the following 8 tabs detail the cognitive activities separately, i.e. the 4 cognitive games: *RecallTask*, *4Images/1Mot*, *Quiz*, and *Attention!*; and the features: the creation of material to enhance cognitive games - *Quiz Creation* and *4Images/1 Mot Creation*, ainsi that a *Chat Room* and *psychoEducation*. A second Excel file contains the activity rates completed per unit of time for each week (it also contains 11 tabs with the same breakdown).

Theoretical adhesion curve

The theoretical adhesion curve corresponds to the curve that would be obtained by a subject who scrupulously follows the recommendations in dose and frequency, that is to say:

- Trains every week 3x for both physical and cognitive activity;
- Performs the recommended dose at each workout, namely:
 - 15' for cognitive activity (i.e. 3x 45' or 0.75h/week)
 - + between 30 and 45 minutes of physical activity (i.e. 3x 30' to 45', i.e. 1.5 to 2.25 h/week).

The total theoretical dose per week (physical and cognitive activities combined) is therefore between: 2.25 and 3 hours.

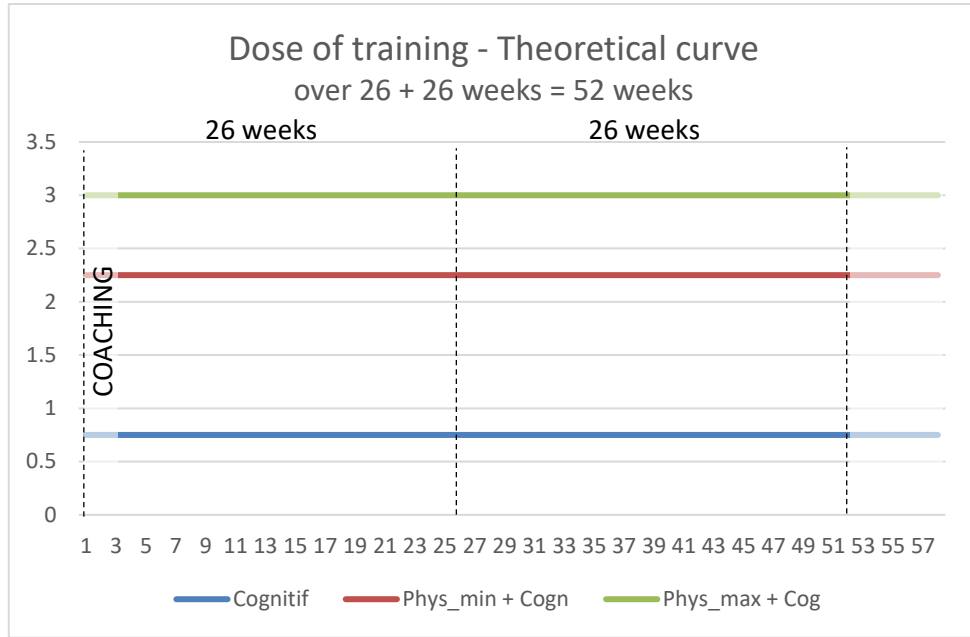


Figure 2. Theoretical adherence curve. Cognitive recommendation (blue), minimal overall recommendation (cognitive + physical activity training; red); optimal overall recommendation (cognitive + physical activity; green).

Classification into good and bad adherents

By definition, a good adherent is a person who trains at a high dose and on a regular basis. To take advantage of the multi-domain intervention, he must also train to follow both physical and cognitive training on a regular basis.

Method based on a metric defined by the mean & the training variance

It is a question of defining a metric based on the average m (training dose: the higher it is, the better the adhesion) and the variance s or standard deviation from the average dose (the more you train regularly week after week, the lower the s).

So, for each subject i , we define the adhesion score ADH_i by:

$$ADH_i = \frac{\mu_i}{(1 + \sigma_i)}$$

This adherence score is calculated for the dose of physical activity and for the dose of cognitive activity respectively. The higher the score, the more *adherent* subject i is. The physical and cognitive adherence score are measured over 24 weeks for the SFL3-26 and SFL/Ctrl3-26 and 26 weeks for SFL27-52 groups, respectively. In order to design a score that best fits all the available data (a so-called "data driven" score), the adherence score was calculated for all 99 data files that all represent a duration of 6 months of intervention, regardless of the fact that some subjects are represented twice (subjects in the SFL27-52 group who were previously part of the SFL3-26 group). The scores obtained were then ranked from smallest to highest (ranking), both for cognition and for physical activity independently. For each of these two domains, a data file thus obtains a rank score ranging from 1 to 99. Finally, the total score is obtained by summing the rank scores of the physical and cognitive dimensions. This makes it possible to define adherence by taking into account the 2 dimensions in equal parts: to be a good member of the SFL program, you must have been both cognitively and physically efficient. One cannot have dropped one of these two dimensions.

Finally, the classification into good, medium and bad adherents is obtained by subdividing the overall scores into quartiles.

Results & Discussion

Tto attrition:

The attrition rate is higher for the SFL intervention than for the control intervention during the 1st period (RCT part: months 1 to 6). This difference, quite consistent (22.6% additional drop-outs) can be explained by the fact that the SFL intervention was less easy to access than the control intervention (casual games) and that it discouraged some of the subjects attributed to this intervention. The SFL intervention also suffered from some youth bugs and was more restrictive than the intervention controls, in particular by sending a series of notifications to guide and encourage the subjects to train via the virtual coach. A brief survey administered to subjects randomized to the SFL intervention during these first 6 months highlighted the fact that 76% of subjects (86% in Switzerland and 63% in Canada) reported not having appreciated the coach's notifications and in particular those that offered rewards in a points format.

RCT period	Switzerland	Canada
All	15,63%	15,63%
SFL_1-6	27,27%	26,67%
CTRL	3,23%	5,88%
ADH period	Switzerland	Canada
All	4,17%	25,00%
SFL_7-12	5,00%	25,00%
SFL/Ctrl_1-6	3,57%	25,00%

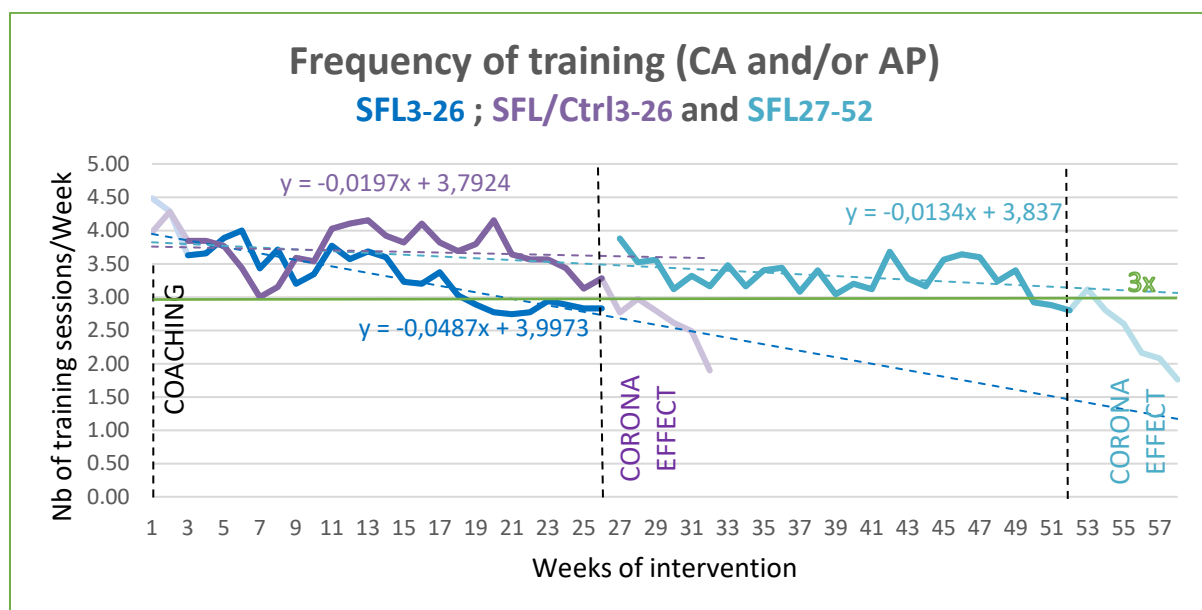
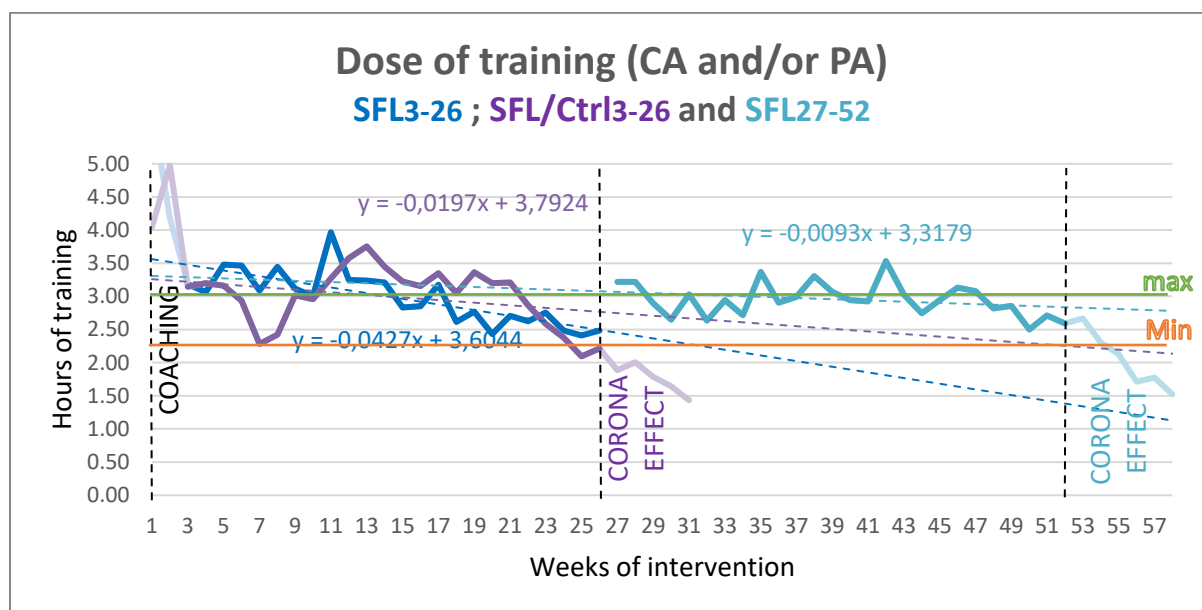
Table 2. Attrition rate by country and groups.

The notification dose was revised downwards for the 2nd period (1x/week, as requested by the respondents) and there was a lower attrition rate over this 2nd period (15% on average) although, nevertheless, 3x higher than that recorded in the control group in the 1st period (4.2% on average).

Adherence curves: DOSE – FREQUENCY – VOLUME

The adhesion curves are represented by the three graphs in Figure 3. The dose, frequency and volume of completed activities were averaged over each week of intervention for the three groups independently. The training was coached during the first 2 weeks of use (week 1 & 2), so these data were truncated to obtain only adherence to the SFL intervention excluding coaching. The effect of the arrival of Covid19, with the resulting period of insecurity and uncertainty, is well apparent with curves that are gradually collapsing. This justifies the decision to limit the analysis period of adherence measurements to 26 weeks instead of the 32 recorded (weeks 27-32 and 52-58 in transparency respectively for groups SFL/Ctrl₃₋₂₆ and SFL₂₇₋₅₂).

First, it is found that the recommendations, on average, were respected for all three groups, with a tendency to train beyond the recommendations (at least beyond the recommended dose, for frequency, subjects generally exceeded the recommended training periods per week, however, only the detail by physical and cognitive activity will allow to conclude on adherence to the frequency recommendation). Second, the respective slopes of the training dose of the three groups of subjects are negative ($m = -0.0427$ for the SFL₃₋₂₆ group; $m = -0.0197$ for the SFL/Ctrl₃₋₂₆ group and $m = -0.0093$ for the SFL₂₇₋₅₂ group). However, in subjects who did the most weeks of training without giving up (SFL group₂₇₋₅₂), the slope is very close to 0. Hence the SFL intervention did generate a significant drop-out rate during the first part of the experiment, but once loyal to the SFL intervention (after following the first 26 weeks of intervention and starting the second part of the experiment), the 25 subjects who conducted the study to term remained very stable in their way of training. In this, it can be said that adherence to the SFL intervention is excellent.



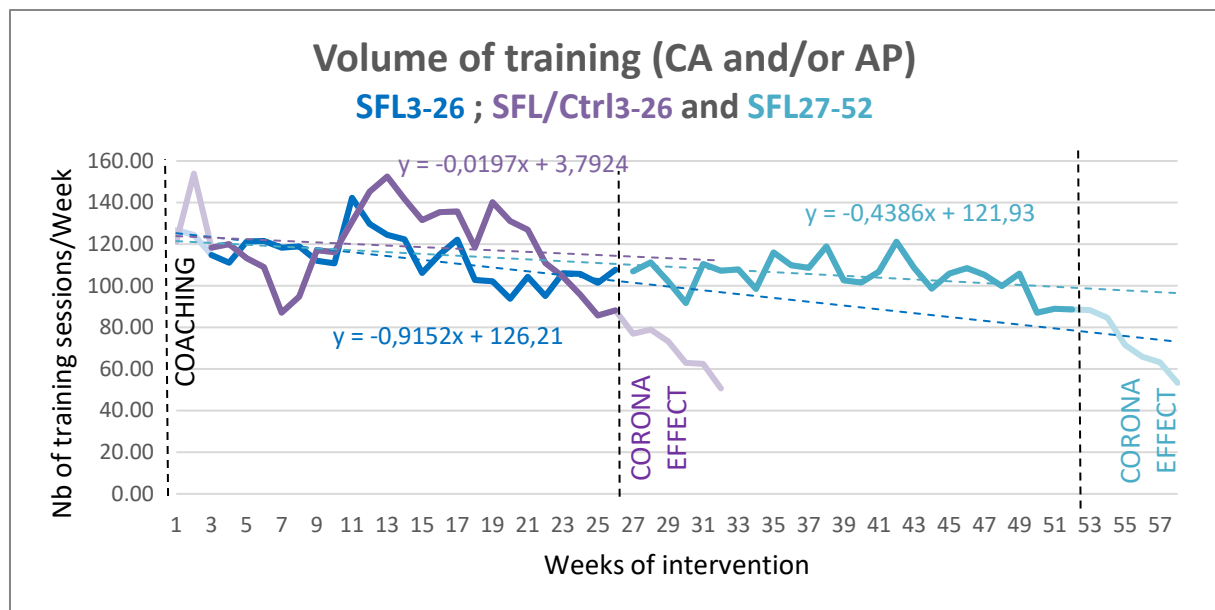


Figure 3. Dose, frequency, and volume of training over time in weeks of intervention (CA = cognitive activity; PA = physical activity).

Principal Component Analysis

One way to represent the entire data is to do a principal component analysis. The following graph shows that our data is highly correlated: the higher the dose, the higher the training frequency and the higher the number of completed activities as well.

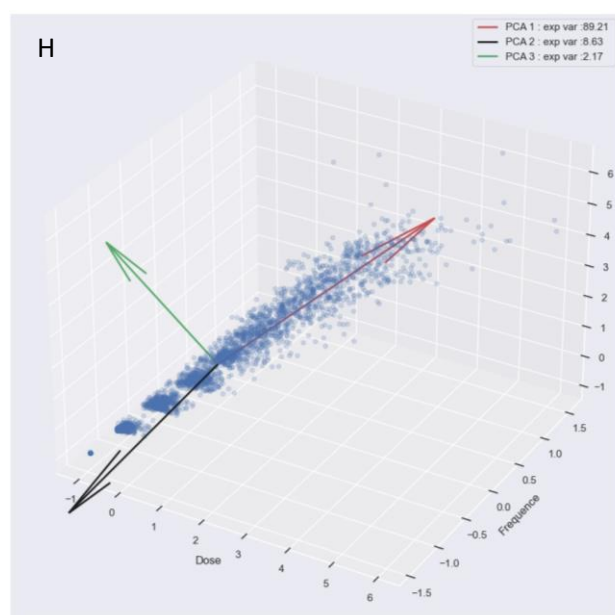
The decomposition into principal components gives the following 3 eigenvectors:

$$v_1 = 0.590 \ x + 0.554 \ y + 0.588 \ z$$

$$v_2 = 0.372 \ x - 0.832 \ y + 0.411 \ z$$

$$v_3 = -0.717 \ x + 0.024 \ y + 0.697 \ z$$

where: x = dose; y = frequency and z = Volume of activity.



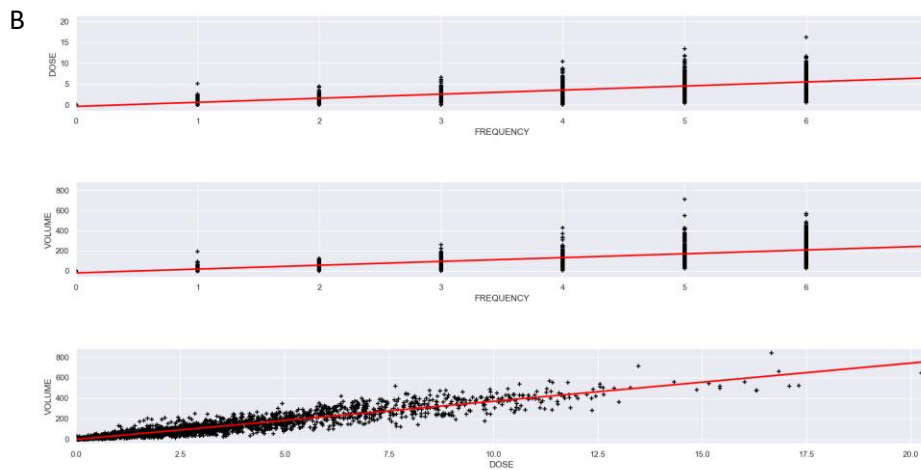
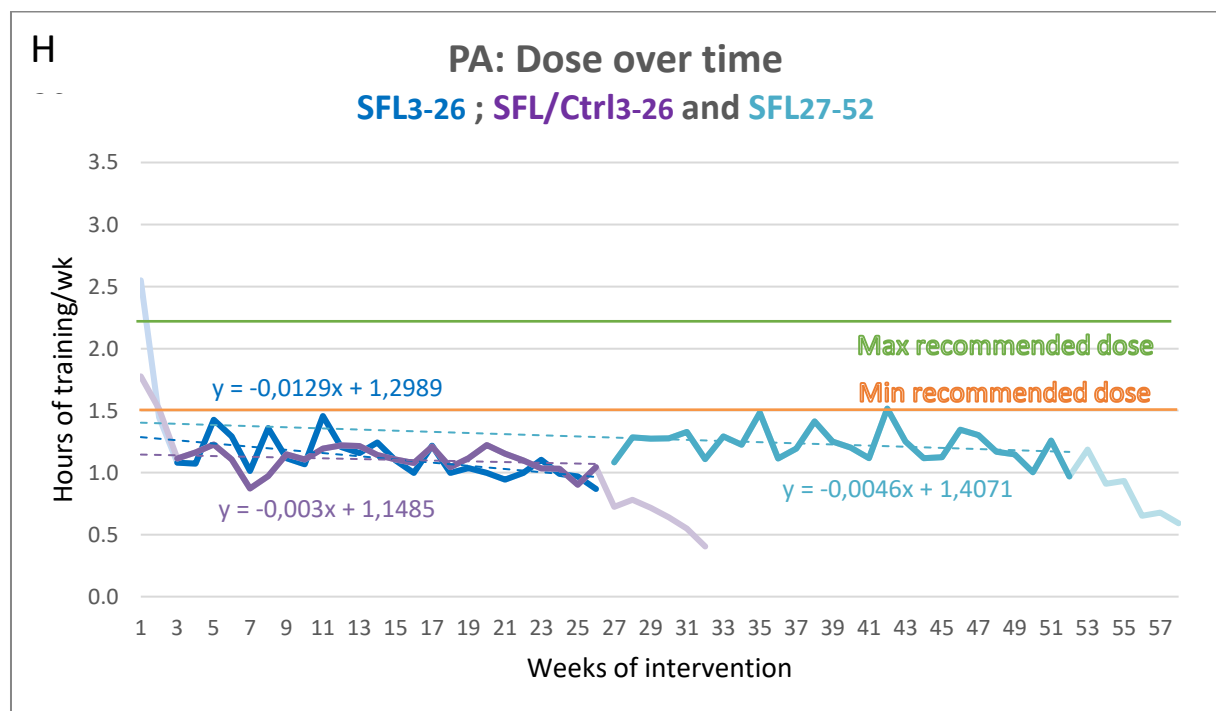


Figure 4. A. Principal components analysis (PCA): one dimension can explain 90% of the variance.
B. Projection on each dimension (Dose, Frequency and Volume).

The^{1st} eigenvector (in red in Figure 4. A) explains 89% of the variance, which means that the dose, training frequency and volume of activities done are correlated and can be represented at almost 90% by a single dimension.

Physical and cognitive adherence curve (DOSE – FREQUENCY)

Figures 5. A and 5. B have respectively the doses of physical and cognitive activity performed per week of intervention. Physical activity was practiced for just over an hour (67 minutes), on average, per week, less time than had been recommended (1.5 to 2.25 hours). There is no significant difference between the groups. Interestingly, the 2 groups that worked during months 7 to 12 of training get very similar training slopes (-0.005 and -0.003 for groups SFL₂₇₋₅₂ and SFL/Ctrl₃₋₂₆ respectively). This means that the training rate of these 2 groups is well maintained on the 2nd part of the experimental design.



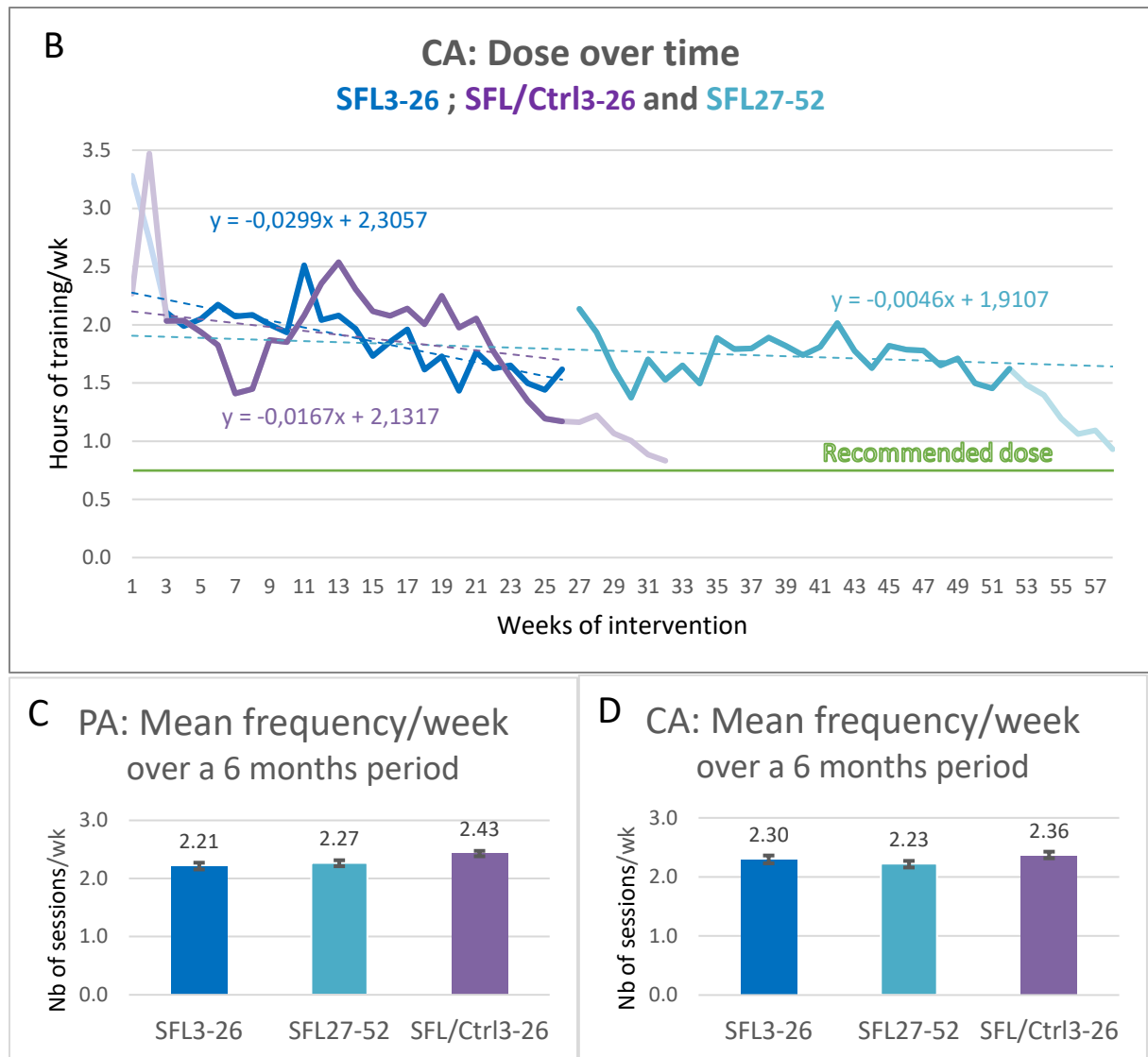


Figure 5. Evolution in time of dose per weeks of training: 4.A physical activity (PA); and 4.B cognitive activity (CA). Mean frequency of training (i.e., number of training sessions per week): for 4.C PA; and 4.D CA.

The dose of cognitive activity (in the broad sense, i.e. encompassing all activities that are not physical, including "social" activities such as chat discussions) is much higher than the recommendations (i.e. $3 \times 15 \text{ minutes} = 0.75 \text{ hours per week}$). In addition, the linear regressions obtained respectively over 24 weeks (SFL_{group 3-26} and SFL/Ctrl₃₋₂₆) and 26 weeks of training (SFL₂₇₋₅₂) are negative (indicating that the training time tends to decrease with the number of training weeks), but the slope of the SFL₂₇₋₅₂ group is less steep than those of the other two groups, indicating that subjects in the SFL₂₇₋₅₂ group appear to have been able to maintain a good rate of cognitive training for one year (52 weeks).

The same type of behavior is obtained for the frequency of training, with negative slopes for 3 groups, both for physical and cognitive activity. Figures 5.C and 5.D have, for each group, the average frequency of training, physical and cognitive respectively. Although the recommended dose per week was higher than the recommended one, the training frequency, on the other hand, is a little below that recommended (rather at 2 sessions per week, both for physical and cognitive activities, instead of 3 recommended sessions).

SFL program preferences

The SFL programme is a multi-domain platform. It is therefore interesting to analyze the habits of users by studying how they have distributed their time of use with the different applications available on the tablet. Recall that there was a cognitive program that allowed on the one hand to play with games cognitifs (CG), on the other hand to create content (Creation). In addition, the subjects of the study could also do the physical activity program (PA) and a Chat Room allowed them to exchange socially with each other. Finally, 22 subjects of *PsychoEducation* gave information on how to optimize one's lifestyle and cognitive functioning in everyday life.

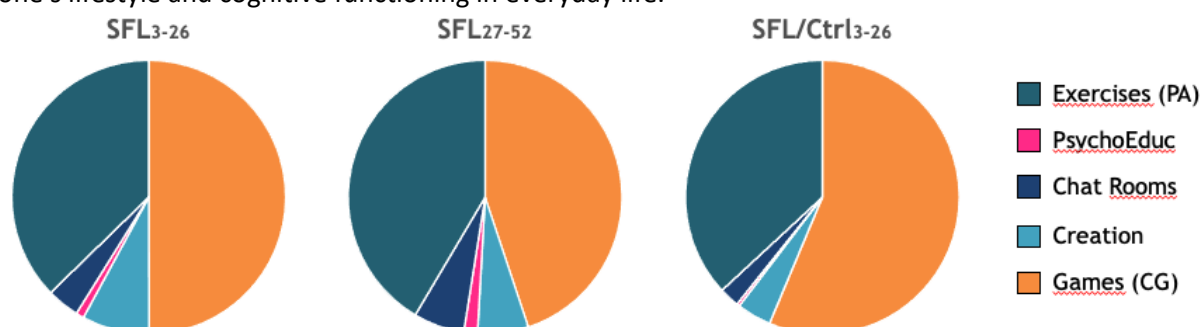


Figure 6. Proportion of time spent in the first parts of the SFL platform, with its physical training program (PA) and cognitive training program (CG, Creation, PsychoEducation and Chat Room).

	Game	Creation	Info	Social	PA	Total in hours
SFL3-26	90'	15'	< 2'	7'	67'	2,98
SFL27-52	80'	11'	3'	11'	73'	2,95
SFL/Ctrl3-26	101'	7'	< 1'	4'	66'	2,99

Table 3. Time (in minutes) spent in the various programmes offered by the SFL platform. For clarity, the total time is given in hours.

First, a significant temporal investment is observed, all groups combined, to engage in cognitive games since the subjects devote about 3x the duration recommended to them (i.e. or, on average, 90' per week, which corresponds, per week, to double the recommended dose – 45'; table 3). The time spent using the physical activity program is also significant, but does not reach the minimum time proposed in the recommendations (i.e. recommendation: 3x 30' = 90' per week vs. on average 70' per week; table 3). The other activities seem to be much less popular with the subjects since they devote about 11.3% of the time invested to training (vs. 50.4% for cognitive games and 38.3% for physical activity). It can be seen that the time spent creating material for Quizzes and concepts (4 images/1 word) is more substantial for the SFL₃₋₂₆ group. When this group started, there was indeed little material available (RCT part; months 1 to 6), which probably favoured the creation of material. On the contrary, during the 2nd part of the experiment (ADH part; months 7 to 12), the groups SFL₂₇₋₅₂ and SFL/Ctrl₃₋₂₆ had at their disposal a large set of material, which probably reduced their interest in creating material. It should also be noted that the group that used the "Chat" the most (i.e. the social part of SFL) was the SFL₂₇₋₅₂ group, i.e. the group that used the SFL intervention during the longest time interval.

Cognitive training: dose dedicated to each SFL app.

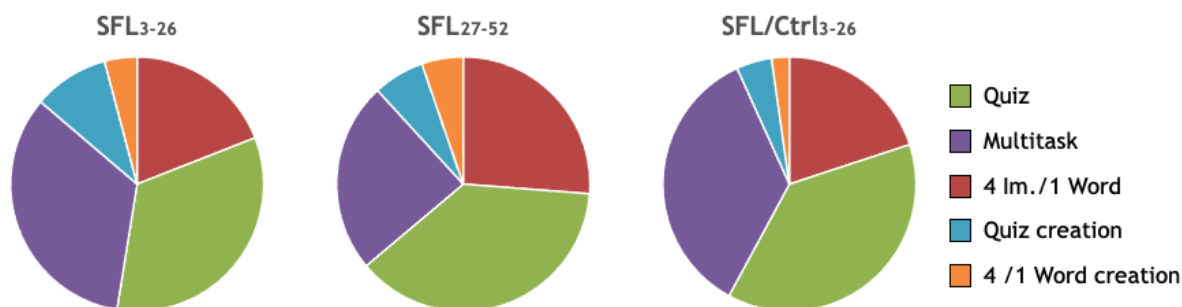


Figure 7. Detail of the proportion of time spent in 3 of the 4 cognitive games (Attention!, Quiz and 4 Images/1 word) as well as to create items to feed these last two cognitive games. The time allocated to the RecallTask has not been presented because it is independent of the user.

Cognitive Activities	SFL3-26	SFL27-52	SFL/Ctrl3-26	Mean/CA
4 Im/ 1 Word	20	24	22	22
Quiz	35	34	41	37
Careful!	35	22	38	32
Quiz Creation	10	6	5	7
4 / 1 Creation	4	5	2	4
Training time	104	91	108	101

Table 4. Time (in minutes), passé in the 3 cognitive games and in the creation of the material to enhance them.

Classification in good, medium and bad adherents

Table 5 gives the classification into good, medium and bad adherents using the quartile method for all data samples. As some individuals obtained the same scores, we do not find exactly 25% of the subjects in the categories "Good" and "Bad adherent", but a number quite close to this percentage (26%). The numbers by subgroups (SFL₃₋₂₆, SFL₂₇₋₅₂ and SFL/Ctrl₃₋₂₆) were then calculated.

	SFL ₃₋₂₆	SFL ₂₇₋₅₂	SFL/Ctrl ₃₋₂₆	
Bad	8	6	12	26
Middle	17	11	19	47
Good	10	8	8	26
	35	25	39	99

	SFL ₃₋₂₆	SFL ₂₇₋₅₂	SFL/Ctrl ₃₋₂₆	
Bad	22,86%	24,00%	30,77%	26,26%
Middle	48,57%	44,00%	48,72%	47,47%
Good	28,57%	32,00%	20,51%	26,26%
	35,35%	25,25%	39,39%	100,00%

Table 5. Good, medium and bad adherents, number in subgroups.

The SFL₂₇₋₅₂ group gets the highest percentage of good members ($8/25 = 32\%$). This group contains the most persevering subjects of the SFL₃₋₂₆ group, i.e. all those who have not given up during 12 months of SFL intervention. On the contrary, the SFL/Ctrl₃₋₂₆ group contains the lowest, respectively the highest

percentage, of good versus bad adherents, probably because some of the subjects in this group, who changed their intervention during the experiment, had more difficulty getting used to the SFL intervention.

Figure 8 shows that the classification thus defined makes it possible to separate the training profiles of the good, average and bad adherents, both in terms of their overall training (all exercises combined) and purely cognitive and physical training separately. These results show in particular that the good adherents of the three groups practiced cognitive exercises for more than 3 and a half hours per week AND physical exercise for nearly 2 hours per week over the 6 months of training. The adherence of these subjects was therefore excellent.

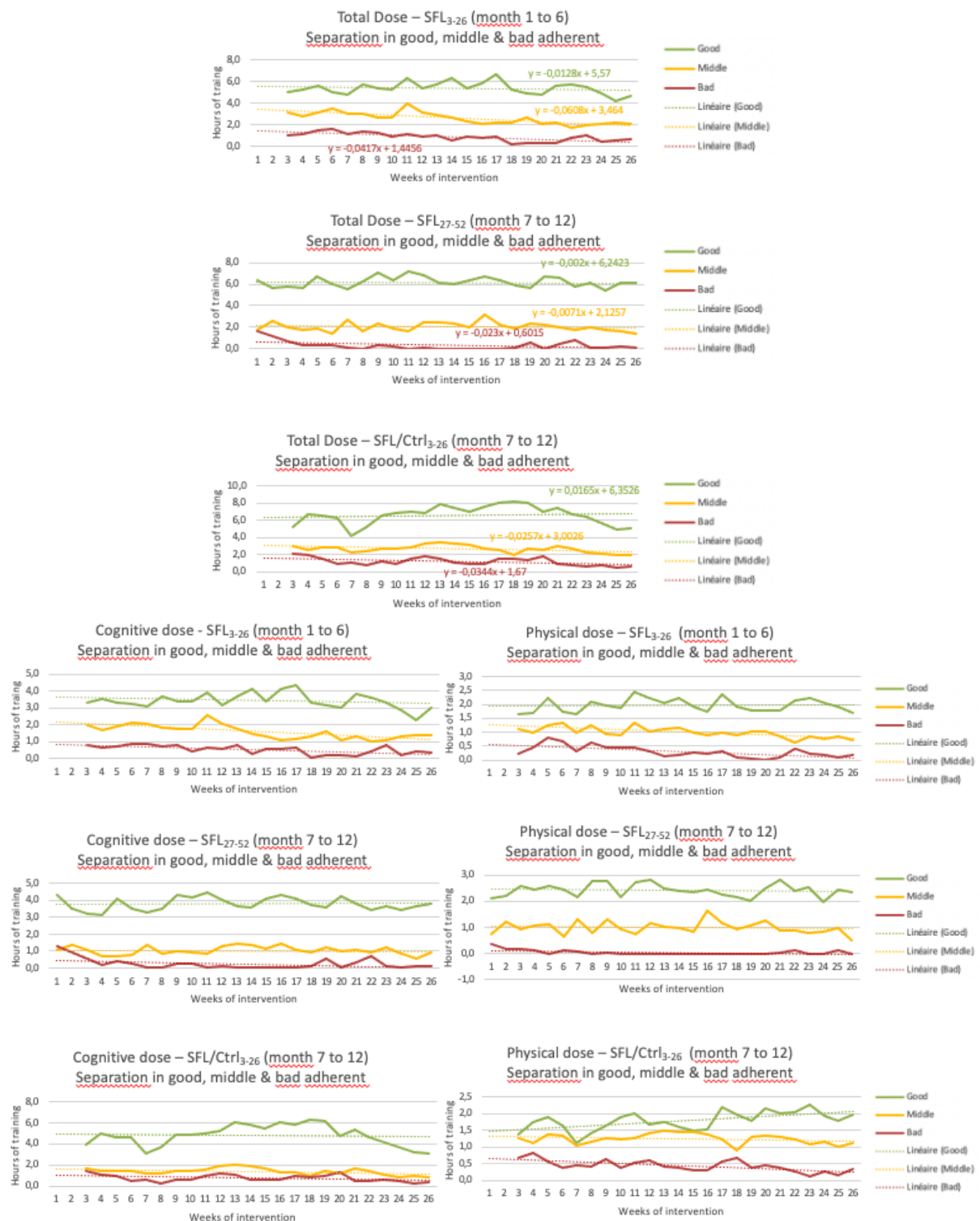


Figure 8. Total dose (cognitive and physical), cognitive only, physical only over the period of 6 months of training for each group divided into good, medium and bad adherents.

Adherence prediction

Further exploration of the data remains to be done to see if the training dose has an effect on efficacy (i.e., on the physical and intellectual performance found in the RCT). This is not the objective of this article, however, the following question can be answered: are the initial variables (clinical measures listed in T0) that predict whether a subject will become a good member of the SFL program. A multivariate model of type AIC (data driven) shows that several initial data (measurements taken at T0) can actually predict the overall adhesion score of a subject. These are the TUG at T0 ($R(1.68) = 10.311$; $p < 0.002$), the ZAVEN score at T0 ($R(1.68) = 5.787$; $p < 0.019$) and the socio-cultural level at T0 ($R(1.68) = 4.102$; $p < 0.021$). If we consider the cognitive score only, then, only the ZAVEN score at T0 can predict that a subject will become a good adherent to cognitive applications ($R(1.72) = 10.291$; $p < 0.002$): in other words, the higher the ZAVEN score at T0, the more the subject obtains a score high cognitive adherence. Regarding the physical side, the tug score of T0 ($R(1.68) = 8.973$; $p < 0.004$) and the socio-cultural level ($R(1.68) = 4.834$; $p < 0.011$) predict the adherence of a subject to physical training: the lower the TUG, the better the adherence to the physical program.

Conclusion

This preliminary report shows that adherence to the SFL program was maintained over 6 months versus 12 months of experience respectively for the SFL group versus SFL/Ctrl and, in particular, that adherence to the cognitive program is excellent since the time spent by users in this set of applications far exceeds the time recommended at the base and only decreases very slightly over time. It is likely that it is the repetitive use of cognitive applications that is the basis for the effectiveness of the program (see first report on the RCT).