Response to the reviewers

We would like to thank the recommender and the reviewers for their time and their very useful comments to improve our manuscript. Importantly, following the remarks of some reviewers, two substantial sets of analyses have been added to the revised manuscript: an analysis of the motivational profiles (clustering approach) and a latent class trajectory modelling analysis. In the responses below, the reviewers' comments are highlighted in bold.

Notes to all the reviewers:

- The numbering (and related content) of the html supplementary materials (from 3 to 9 now) has been updated after the creation of additional supplementary files.
- In the initial version of the manuscript, the description of the information delivered to the participants during the 6MWT was not correct. The initial description was as follows: "At each test, the principle of the test was explained to the participant, and the same information was provided during the test, that is, **the time elapsed at the first two minutes of the test, the time at the middle of the test, and the remaining time at the last two minutes of the test**." (p. 3). The corrected version of the description is as follows: "At each test, the principle of the test was explained to the participant, and the same information was provided during the test, that is, **the time elapsed at each minute of the test.**" (p. 4, revised manuscript).

Response to Baraa Al-Khazraji

Review for: Change in exercise capacity, physical activity and motivation for physical activity at 12 months after a cardiac rehabilitation program in coronary heart disease patients: a prospective, monocentric and observational study

Study authors: Paul Da Ros Vettoretto, Anne-Armelle Bouffart, Youna Gourronc, Anne-Charlotte Baron, Marie Gaumé, Florian Congnard, Bénédicte Noury-Desvaux, Pierre-Yves de Müllenheim

Thank you for putting together a well-written manuscript. The study objectives are clearly outlined, and the study's findings hold great promise in helping us understand how to implement lasting changes in cardiac rehab participants, and to prevent future cardiovascular events.

The researchers should be particularly commended for executing a difficult study, as retention with cardiac rehab-based studies is difficult, and particularly to acquire such success in retention with the 1-year follow-up. Congratulations on your efforts.

Below I have some comments that may be of interest to you, hopefully to further showcase the impact of your hard work.

- We thank the reviewer for her positive feedbacks regarding our work. We hope our responses to her comments will be satisfactory.

METHODS/RESULTS

1. **Great work highlighting and incorporating a minimal clinically important difference (MCID) of 50m into the sample size justification.**

- Thank you for having taken the time to highlight this point.

2. **How soon after the cardiac event were people enrolled into the 4-week cardiac rehab program? (e.g., 3 weeks post-MI, etc.).**

- We have added this information into the revised version of the manuscript (Results section) as follows:
  - "The participants enrolled in the CR program on average 17 (± 2.5) weeks after their first cardiac event (minimum: 4 weeks; maximum: 46 weeks, which is a very high number concerning only one patient due to planning difficulties)." (p. 8)

3. **As part of standard intake/CR, what were the VO2max values for these patients at the start and end of the 4 week CR? How did these values relate to the 6MWT data that were collected during the 4 week CR? It's understandable that VO2max was not collected at the 1-year follow-up, but it is good to see how 6MWT relates to the VO2max values where these data are available.**

- VO_2max, on average, was 21.8 (± 5.5) ml/min/kg (min: 10.6; max: 35.0) at the entry in the program for our group of participants. Unfortunately, we did not have VO_2max data for all patients for the subsequent time points since VO_2max follow-up measurements (including the measurement corresponding to the end of the program) were not systematically performed at the hospital where the study was completed. Moreover, the collection of these data was not planned in the project validated by the ethics committee and thus it could not be appropriate to ask the different structures, where VO_2max follow-up evaluations were performed, to provide these data and then to report them in the present article. Finally, the study of the correlation between the 6MWT distance and VO_2max was not one of the aims of the present study, and such a correlation has already been reported to be approximately 0.5 to 0.6 (Bellet et al. 2012; doi: 10.1016/j.physio.2011.11.003), as described in the manuscript (Methods section). For these reasons, we have added no information about this point in the revised version of the manuscript. We hope this answer will be acceptable for the reviewer.

4. **Please change to LIKERT not LICKERT**

- Thank you for this. Below is the corrected sentence:
  - "Each item was scored using a 7-point Likert scale (1 = "Does not correspond at all"; 7 = "Corresponds very strongly")". (p. 5)

5. **What medications were these patients on during CR, but most importantly in the 1 year post CR.**

- During the CR program, all patients took the same treatment. This information has been added in the revised manuscript at the end of the paragraph regarding the content of the CR program as follows:
  - "During the program, all participants were treated with β-blockers, antiplatelet agents, statins and angiotensin-converting enzyme inhibitors." (p. 4).

For information, at the entry in the program, the distribution of the treatments was as follows (not added in the manuscript):

- β-blockers: 90.7%
- antiplatelet agents: 100%
- statins: 100%
- angiotensin-converting enzyme inhibitors: 74.7%

After the end of the program, we could have information regarding the treatments only for the patients who were followed at the hospital center of Cholet (53 patients). We have added the information related to these patients in the Results section of the revised manuscript as follows:

- "Information regarding the treatments taken by the participants during the follow-up period of the study was available only for those who were medically followed at the hospital center of Cholet (N = 53). This information was obtained at 9.4 ± 2.7 months post-CR program during a follow-up visit that was not a part of the study. At this visit, the distribution of the treatments was the following: 87% with β-blockers, 96% with antiplatelet agents, 96% with statins and 53% with angiotensin-converting enzyme inhibitors. (p. 8)

6. **For the women in your study, how many were on hormone therapy and/or can you provide any menopausal information (e.g., duration) available for these women?**

➢ Two women were on hormone therapy to control hypothyroidism. Unfortunately, we had no menopausal information for these women. We have added these details into the revised version of the manuscript as follows:

- "Two women were on hormone therapy to control hypothyroidism." (Results section, beginning of the section, p. 8).

DISCUSSION

1. **Please talk about the lack of women enrolled in your study – why do you think this is? Talk about it as a future direction and why women in general have barriers to cardiac rehab/less like to participate.**

➢ Thank you for raising this important point. The lack of women in our study was largely related to a lack of women who were following the cardiac rehabilitation program. This lack of attendance of women in cardiac rehabilitation programs has already been described (Clark et al., 2012; doi: 10.1016/j.ahj.2012.08.020). In France, it may also be related to a largely higher proportion of men vs women who are hospitalized for an event related to CHD. We have elaborated on this point in the Discussion section of the revised manuscript by considering it as a study limitation, as follows:

- "Finally, the weak representation of women in the present study makes the generalization of the findings to women difficult. This is largely related to the lack of women who attended the CR program. Such a lack of attendance has previously been highlighted in the scientific literature and could be related to the reported difficulties from women to meet social costs of participation to CR programs, including dealing with domestic and family demands, while women would report little support from their communities and significant others (Clark et al., 2012). In France, this underrepresentation of women could also be partly related to their large underrepresentation in people hospitalized following a CHD-related event (Fourcade et al., 2017). Future researches on the present topic should consider strategies to allow a higher representation of women in clinical trials and thus to contribute to a better health equity (van Diemen et al., 2021)." (p 17)

2. Why aren't medications discussed or even provided in results?

➢ As explained above, medications information was not available for all patients for the period post-program. This is because getting such information was not initially planned in the study. Moreover, we were not aware of any particular influence of medications on walking performance in coronary artery patients. These elements explained why such information was not considered in the initial version of the manuscript. We have added the pieces of information we had regarding the treatments followed by the participants during the follow-up period into the revised version of the manuscript. However, as this information is not complete, it was still difficult to use it to correctly discuss the results. We agree with the reviewer that medication could have been relevant information to have a clear idea of the context in which the results were obtained. We have thus added this point as a limitation into the revised manuscript, as follows:

- "Seventh, the lack of information regarding participants' medications during the follow-up period prevents a full understanding of the context in which the results were obtained." (p. 17)

3. Nowhere in the discussion is the comparison with VO2max made.

Indeed, as explained in our answer to the point 3 of the METHODS/RESULTS section shown above, VO_2max was not an outcome we assessed in the present study. This is why the Discussion section does not deal with any comparisons with VO_2max data.

4. Context of the differences in 6MWT values and minimal clinically important difference (MCID)?

➢ We were not sure of the nature of the details expected here by the reviewer. We managed the remark by recalling what was the MCID we have used and the context in which it was obtained. To do this, we have modified the following sentence from the initial manuscript:

- "Beyond the fact the mean change in 6MWT distance we found at 12 months seems to be relatively small, it could be difficult to consider that change as clinically relevant for the group of patients since it clearly remained within the learning effect zone of the 6MWT (Bellet et al., 2012)." (p. 10, initial version of the manuscript).

We have replaced it by the following sentence:

- "Beyond the fact the mean change in 6MWT distance we found at 12 months seems to be relatively small (12.56/605.44 = 2%), it could be difficult to consider that change as clinically relevant for the group of patients since it likely remained within the learning effect zone of the

6MWT, that is a test-retest mean change between 2% and 8% with tests separated by several days (the between-test duration actually is unclear in the literature) (Bellet et al., 2012)" (p. 14)

5. **Unclear how the barriers to PA ended up relating to the 6MWT outcomes at 1 year. How do we know which of the deciles from the functional data were related to which of the barriers to PA? The data are there and could provide further context and deepen the discussion on 6MWT values 1-year postCR. This provides even more impact to their work, and circles back to a line in the Introduction "…but also the evolution over time of motivation for physical activity as it could be related to physical activity behaviour in cardiac patients after a CR program (Russell & Bray, 2009)."**

- Thank you for this remark. Initially, the set of analyses we proposed was quite restricted in order to stay close to the kind of analyses for which the study was powered. However, we agree with the reviewer that it may be unfortunate not to try to exploit as best as possible the data we have. The present remark from the reviewer was quite similar to the remark provided by another reviewer (Dr Escriva- Boulley, point 6), who suggested us to perform an analysis of the predictors of the change in exercise capacity and PA. To comply with the suggestion from Dr Escriva-Boulley (the other reviewer), we choose to build models to put into relationship classes of changes in exercise capacity or physical activity as response variables, and baseline level of exercise capacity, physical activity and motivational profile for physical activity, and the two main barriers to physical activity as potential predictors. We have thought such analyses could comply with the present reviewer remark and this why we have not directly addressed the reviewer remark by performing additional analysis. The details of the procedure we have implemented for this point were as follows:
    - Determination of the motivational profiles at 0 and 12 months post-program (based on a clustering approach to better capture the actual complexity of the motivational profiles compared to taking the forms of motivation separately).
    - Building latent class mixed models to categorize the changes in the outcomes of interest (exercise capacity or physical activity).
    - Building multinomial regression models to assess potential predictors of the classes of changes previously defined in the latent class mixed models.

Please see below the text describing this procedure in the Methods section (cf. pp. 7-8 from the revised manuscript):

"*Change in the profile of motivation for physical activity*

The change in motivation for physical activity over time was also explored throughout the change in the motivational profile analysed using a clustering approach. The rationale for this analysis was that a single form of motivation may not capture the actual complexity of a motivational profile, as in people who would present both high levels of autonomous and controlled motivation for example (Gillet et al., 2009, 2010; Friederichs et al., 2015). To perform such an analysis at each of the time points of interest (0 and 12 months post-CR program), we first scaled the motivation variables (EMAPS scores). Then, we confirmed the possibility to conduct a clustering analysis both graphically (using a dissimilarity matrix image) and statistically (Hopkins statistic >0.7) (Kassambara, 2017). Then, we implemented a k-medoid approach to partition the considered EMAPS scores dataset into k groups or clusters, each cluster being represented by a participant in the cluster (i.e., the medoid). This approach was deemed more appropriate than the classically used k-means approach (Gillet et al., 2009, 2010; Friederichs et al., 2015) as our datasets presented several multivariate outliers as assessed using the minimum covariance determinant

(Thériault et al., 2024), and the k-medoid approach is less sensitive to outliers (Kassambara, 2017). More precisely, we used the Partitioning Around Medoids (PAM) algorithm that aimed at building k clusters so that the global average sum of the intra-cluster dissimilarities (based on the Euclidean distances from the medoid) was minimal. The optimal number of clusters k to be build by the algorithm was determined using the average silhouette method that measures the quality of a clustering: the higher the value of the average silhouette, the better the clustering (i.e., higher intra-cluster similarities, higher inter-cluster dissimilarities). The clusters we obtained were named using a similar approach as in Gillet al. (2009) consisting of introducing, in the name of the cluster, information related to the motivational concepts and the magnitude of the motivational scores that highlighted the between-cluster differences. The pertinence of the clusters we obtained was also assessed by comparing their respective EMAPS scores using nonparametric multivariate analysis (Burchett et al., 2017), both at 0 month and at 12 months post-CR program. We considered that the participants related to the identified clusters came from different multivariate distributions when the P value associated to the ANOVA Type statistic (F-approximation) was below or equal to 0.05. When there was an overall difference between the compared clusters, multiple comparisons were performed to determine for which EMAPS scores and combinations of EMAPS scores there were differences between the clusters, again using the ANOVA Type statistic (F-approximation) while maintaining the overall Type I error rate at 5%. The proportions of participants related to a given scenario of profile transition between 0 and 12 months post-CR program were computed along with their respective 95% Clopper and Pearson CIs.

(…)

Predictors of the change in 6MWT distance and IPAQ-SF MET-min/week

We finally explored the possibility to identify predictors of the change in 6MWT (0 – 12 months) distance and IPAQ-SF MET-min/week (6 – 12 months) using a latent class trajectory modelling approach (Proust-Lima et al., 2017). This approach consisted first of building an initial linear mixed model with the outcome of interest as response variable and the month of measurement as explanatory variable and a random intercept on the participants. Then, a series of models were derived from this initial model and tested to determine whether the change in the outcome of interest over the follow-up period could be categorized into different classes depending on the direction and the magnitude of the change. These new models were latent class mixed models as they included a term allowing the determination of a class-specific fixed effect (here the month of measurement) in the mixed model (Proust-Lima et al., 2017). Four groups of latent class linear mixed models were tested for the possibility to have 2 to 5 classes of change in the outcome of interest as previously proposed (Limpens et al., 2023). As these models needed initial values to allow the model building algorithm to converge, we implemented, as recommended (Proust-Lima et al., 2017), a grid search strategy. In the present analysis, this consisted of testing, for a given number of expected latent classes, 100 models respectively based on 100 random vectors of initial values obtained from the parameters defined with the initial linear mixed model (1 class). The best model for a given number of classes obtained from the grid search strategy was then retained for subsequently comparing the different models related to the different numbers of latent classes. For a given outcome of interest, the most appropriate latent class mixed model (i.e, the most appropriate number of classes) was chosen based on a combination of the Akaïke Information Criterion (AIC), the Bayesian Information Criterion (BIC), entropy, the numbers of study participants posteriorly assigned to a given class by the model considered (Proust-Lima et al., 2017), and also the possibility to have a model able to converge during the subsequent analysis of the predictors of the latent classes. The analysis of potential predictors of the assignment to a given class was performed using a multinomial regression model (with the class showing the best mean change as reference class) with the following potential predictors: six-minute walking distance, physical activity level and motivational profile at the end of the program; and the two main barriers to physical activity (unfavourable weather and lack of time). The inference technique related to this analysis was a 2-stage estimation of the joint likelihood of the primary (final) latent class mixed model and the secondary regression. Covariates in the latent class mixed models and the multinomial regression models were considered as statistically significant when the P values associated to the corresponding Wald tests were ≤ 0.05. (Proust-Lima et al., 2017).”

Please also see the results from these new analyses (cf. pp. 11-13 of the revised manuscript):

“We identified two motivational profiles both at 0 and 12 months after the CR program among the 76 participants with complete EMAPS scores data (Figure 3): a profile with a very high level of autonomous motivation and a high level of controlled motivation (introjected regulation), thereafter named the ‘Very High AU-High C’ profile); and a profile with a high level of autonomous motivation and a moderate level of controlled motivation (introjected regulation), thereafter named the ‘High AU-Mod C’ profile. Multivariate analysis suggested that the sets of the EMAPS scores from these two profiles were indeed different both at the end of the program and at 12 months post-program (P < 0.001), with significant differences for intrinsic motivation, integrated, identified and introjected regulations ($P \leq 0.05$). The ‘High AU-Mod C’ profile was more prevalent (57.9% of the participants) than the ‘Very High AU-High C’ profile at the end of the program and inversely at 12 months post-CR program (36.8% vs 63.2%). The proportions [95% CI] of participants related to a given scenario of cluster change were the followings: 57.9% [46.0%; 69.1%] of participants were associated to the same profile; 10.5% [4.7%; 19.7%] transited from the ‘Very High AU-High C’ profile to the ‘High AU-Mod C’ profile; and 31.6% [21.4%; 43.3%] transited from the ‘High AU-Mod C’ profile to the ‘Very High AU-High C’ profile (Figure 3B). Importantly, information available in Supplementary Material 8 suggest the good consistency between the actual individual changes in motivational profile and the data-driven categories of profile change assigned to the study participants.

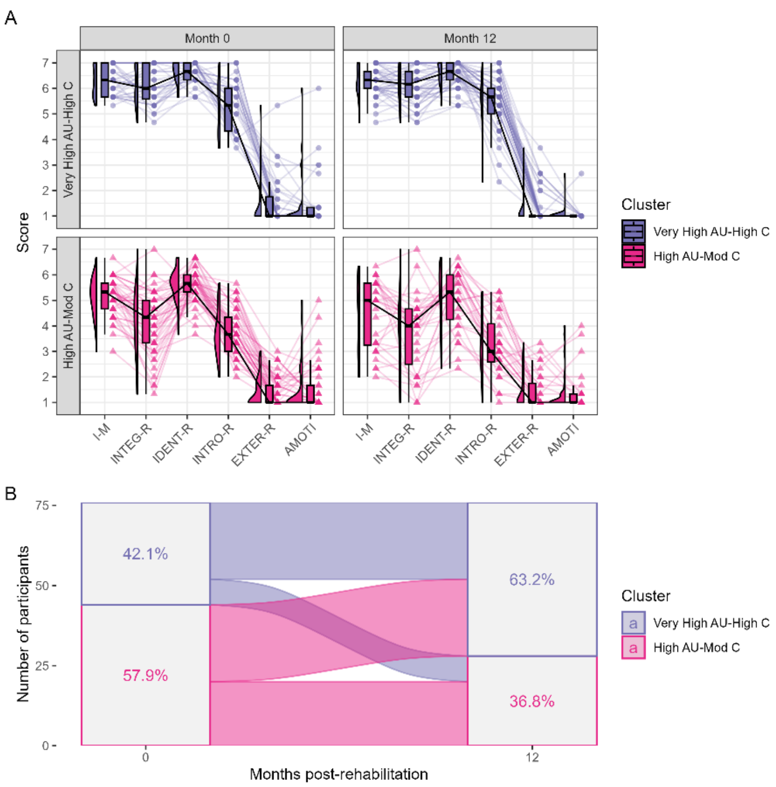


Figure 3 – Change in physical activity motivational profile between the end of the CR program and 12 months after the program. Panel A shows the distributions of the EMAPS scores for each of the two identified motivational profiles at the end of the CR program (Month 0) and at the end of the follow-up period (Month 12). The multivariate distributions related to the two motivational profiles were overall

significantly different both at the end of the program and at 12 months post-program, with significant differences for intrinsic motivation and all the forms of regulations excepted external regulation. Panel B shows the transition from a motivational profile to the other one between the end of the program and the end of the 12-month follow-up period. AU = autonomous motivation; C = controlled motivation; I-M = intrinsic motivation; INTEG-R = integrated regulation; IDENT-R = identified regulation; INTRO-R = introjected regulation; EXTER-R = external regulation; AMOTI = amotivation.

(…)

Based on the latent class linear mixed model analysis (Figure 5 and Supplementary Material 9), it could be considered that the change in 6MWT distance could be categorized into 3 classes (Figure 5A) with the following class-specific effects of time (month) on 6MWT distance and related percentages of posterior classification of the participants: Class 1, significant decrease (-8.1 m/month, $P < 0.001$, $N = 2$ [2.7%]); Class 2, non-significant change (-0.7 m/month, $P = 0.118$, $N = 39$ [52.0%]); Class 3, significant increase (+3.6 m/month, $P < 0.001$, $N = 34$ [45.33%]). As shown in Figure 5A, the model seemed to be able to globally propose correct classifications of the study participants. Regarding the analysis of IPAQ-SF MET-min/week (Figure 5B), it was possible to get a categorization of the changes into 2 classes: Class 1, no significant change (-58.7 MET-min/week/month, $P = 0.381$, $N = 72$ [93.5%]); Class 2, significant increase (+1355.8 MET-min/week/month, $P < 0.001$, $N = 5$, [6.5%]). Contrary to the model for 6MWT distance, the model for IPAQ-SF MET-min/week seemed to have a poorer performance of classification of the study participants, as shown in Figure 5B (poor correspondance between the predictions of the model and the participant trajectories). None of the tested variables significantly predicted the assignment to a given class of change both for 6MWT distance and for IPAQ-SF MET-min/week.

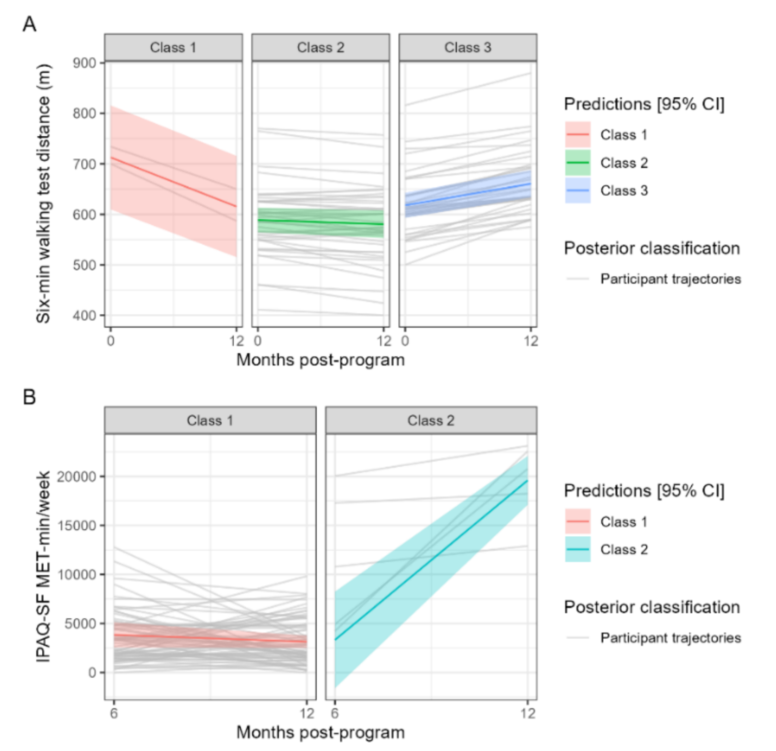


Figure 5. Predictions of the selected latent class linear mixed (trajectory) models along with the individual trajectories of the participants assigned to a given class of change for 6MWT distance (panel A) and IPAQ-SF MET-min/week.

”

In the Discussion, these results have been discussed in the following paragraph (cf. p15):

“We took the opportunity of having both functional (6MWT distance), behavioural (IPAQ-SF MET-min/week) and motivational (EMAPS-based clusters and barriers to physical activity) data to explore, via a latent class trajectory modelling analysis, the possibility to determine the predictors of particular classes of changes both in exercise capacity (6MWT distance) and physical activity (IPAQ-SF MET-min/week) over time. This analysis could add a value compared to the decile shift analysis we conducted by more clearly highlighting the different profiles of changes in the outcomes of interest, thus reinforcing the idea that patients may have different needs to get the best trajectory as possible for a given outcome after a CR program. A few previous studies had already identified different clusters of trajectories in physical activity outcomes over time after a CR program (Sweet et al., 2011; Blanchard et al., 2014; Limpens et al., 2023) but to our knowledge not for exercise capacity. Based on these studies, it could be expected that the baseline motivational profile (Sweet et al., 2011), exercise capacity and physical activity (Blanchard et al., 2014; Limpens et al., 2023) here measured at the end of the CR program in the present study, are identified as predictors at least of physical activity (here between 6 and 12 months post-CR program). Unfortunately, we were not able to identify any predictor that could allow clinicians to anticipate the trajectory a patient would be likely to have after a CR program depending on their profile. The relatively high level of 6MWT distance for all participants, the potentially high measurement error related to the IPAQ-SF and the relative lack of differences between the motivational profiles of our participants were clearly not in favour of their identification as potential predictors of a particular change in exercise capacity or physical activity after the CR program. Of note, our relatively low sample size to conduct such exploratory analyses imposed us important constraints in the definition of the structure of the models (e.g., impossibility to get models converging with several covariates when using random effects on slopes), which is line with the fact that such a kind of analyses generally require several hundreds of participants to ensure robust results (Sinha et al., 2021). For these reasons, the results from these analyses should be considered with great caution.”

6. **Please speak to the lack of time control – i.e., in a given year, what do you anticipate 6MWT to change by for a non-exercising group? Or a non-CR group? Please speak to how “time” affects anticipated change (if any) for 6MWT values and the reproducibility in measures of 6MWT as we are assuming that CR, and 1-year postCR are the main exposures that are contributing to 6MWT values 1-year postCR.**

➢ Thank you for the opportunity to discuss this point. We agree that this point was lacking and that this prevented a more comprehensive judgment of the results. To address this remark, we have conducted a literature search to capture studies that would have reported a change at 12 months/1 yr in clinical populations (COPD and coronary artery disease patients) or in older adults. In general, information was reported in controlled trials. It seems COPD patients are a clinical population that has been well studied regarding this point but we have had some difficulties to find studies with coronary artery disease patients or older adults. Based on the most appropriate studies we have found, it seems one could expect, in populations not involved in exercise programs, an absence of a change or a decrease in 6-min total walking distance at 1 yr, in particular when participants are sedentary. Thus, the small positive change we observed in 6MWT distance could be viewed as an encouraging result in comparison with an absence of change or a decrease in functional capacity over time. We have added this information in the Discussion section of the revised manuscript as follows:

- “The small positive change we found in 6MWT distance actually could be considered as an encouraging result regarding the interest of the CR program to allow a given group of CHD patients to maintain the highest walking capacity as possible over time, in particular when considering the possible trajectory of 6MWT distance observed in other studies, including those with other clinical populations or older adults. Indeed, Oerkild et al. (2011) observed in cardiac patients (≥65 years), who had followed a program in centers and at home, a decrease respectively of -27 m (baseline: 376 m) and -45 m (baseline: 346 m) in mean 6MWT distance between 3 and 12 months after the end of the program. In older adults, Manning et al. (2024) observed at 12 months a mean increase in 6MWT distance of about 40 m in active older adults (N = 318; 72.5 yr on average; exercise 3 days/week; baseline 6MWT distance: 457 m) and a mean decrease of about 76 m in sedentary older adults (N = 146; 74.4 yr on average, no moderate exercise in the past 5 yrs; baseline 6MWT distance: 421 m). Finally, in chronic obstructive pulmonary disease (COPD) patients, Frei et al (2022) observed at 12 months, in the control group (N = 51; routine care; baseline 6MWT distance: 417 m) of a randomized trial, a mean decrease of -24 m in 6MWT distance. While the results of the CR program we implemented compare well with several studies that reported changes in 6MWT distance at 1 yr, especially considering the relatively high 6MWT distances of our participants who were de facto more prone to a decrease at 1 yr, it seems possible for a cohort of patients to have a maintained 6MWT distance at 1 yr without having followed a rehabilitation program, as previously observed in COPD patients (n = 294; baseline: 388 m; median age: 66 yr) (Casanova et al., 2007)." (p. 14)

Response to Géraldine Escriva-Boulley

Based on the knowledge that in CHD patients, mortality risk is associated with exercise capacity and physical activity, and that the evolution of these variables could predict health maintenance, the present study aims to investigate the change in mean exercise capacity of CHD patients 12 months after completing a CR program compared to the end of the program. The second aim is to explore how the distributions of exercise capacity, physical activity level and motivation for physical activity evolve between the end of the CR program and 12 months after the program, as well as the typical individual changes in these outcomes over this period of time.

The study is interesting because it investigates variables after a CR program (follow up measure) and examine change of mean and distribution. This kind of studies is scarce. The code used for the analyses is available.

- We appreciate the overall positive feedback from the reviewer. We also thank the reviewer for her comments and hope our responses will be satisfactory.

General comments

Introduction :

Although, the aim of the main objective of the study is clearly justified based on results from previous studies, the introduction could be strengthened adding details:

1) First of all, hypotheses are missing

- Thank you for pointing this out. The present study has been powered to detect, if any, a change in the mean of the 6MWT distance using a two-sided t test. In other words, the null hypothesis was an absence of change at 12 months (change = 0). We did not expect a decrease since it could be expected, thanks to the education content of the program, that patients would keep an active lifestyle in favour of a maintenance of walking capacity; we also did not expect a particular increase since it was not particularly expected that patients engage in more physical activity than during the program, thus allowing a further increase in their exercise capacity. Regarding the other analyses, there was no a priori hypotheses since the idea of performing these analyses has emerged after the beginning of the study. However, it is true that the *P* values related to the decile analyses were computed assuming a null difference between the considered deciles.

Based on these explanations, we have modified the last paragraph of the Introduction section of the revised manuscript as follows (see added/modified text in bold below):

- "The main objective of the present study was to determine if there is a change in mean exercise capacity of CHD patients 12 months after completing a CR program compared to the end of the program, with no consideration of the results at the entry in the program. **As we expected patients adopt a physically active lifestyle after a CR program without looking for a progression in the dose of physical exercises over time, we hypothesized there is no change in exercise capacity at 12 months after the program.** A first secondary objective was to explore how the distributions of exercise capacity, physical activity level and motivation for physical activity evolve between the end of the CR program and 12 months after the program, as well as the typical individual changes in these outcomes over this period of time. **As these last analyses were exploratory, we had no particular rationale to set specific hypotheses and, therefore, the classically used hypothesis of the absence of change was again considered here. Other secondary objectives were (i) to describe the change in the motivational profile for physical activity using a clustering approach, (ii) to describe barriers to physical activity reported by CHD patients 12 months after the CR program, and (iii) to explore the potential classes of change over time in exercise capacity and physical activity and their respective predictors."** (pp. 1- 2)

2) What the authors mean by physical activity level (intensity? MET? EE? By day? By week?)§1 L5? by exercise capacity (how it is measured? Is there specific results for this population?)§2 L1

➢ The expression "physical activity level" is classically used in the field of physical activity measurement to deal with the volume of physical activity over a given period of time, as presented by Strath et al (2013; doi: 10.1161/01.cir.0000435708.67487.da) in a scientific statement from the American Heart Association: "*Physical activity volume, or total physical activity level, can therefore be estimated by multiplying the dimensions of intensity, duration, and frequency over a given time period, typically 1 day or 1 week*." (p. 2261). Of note, in this definition, a day should be understood as an average day so that estimates over a week or a typical day provide the same general idea of the physical activity level, even if the actual procedure to get the estimate (ie, using a typical day or a week) is different. We acknowledge that potential readers may not have a clear idea of what this concept means. Therefore, to comply with the reviewer's remark, we have added a short explanation in the introduction section of the revised manuscript, after an expression "physical activity level", as follows (see added text in bold below):

   - "Moreover, beyond the physical activity level **(i.e., the volume or dose of physical activity performed over a typical day or week)** observed at a given time point (…)". (Introduction section, 2nd paragraph, p. 2)

Regarding the concept of "exercise capacity", it is a classical concept encountered when dealing with testing and training procedures in the general and clinical populations. In general, it refers more precisely to aerobic capacity, or in other words aerobic/cardiorespiratory/cardiopulmonary fitness, expressed in oxygen uptake units or metabolic equivalents of task (METs) (see for example the scientific statement from the AHA by Fletcher et al. in 2013; doi: 10.1161/CIR.0b013e31829b5b44; p.883). Depending on the material constraints, exercise capacity can be directly measured with a metabolic cart and a treadmill (or another ergometer) or it can also be estimated from different submaximal tests, as the six-minute walking test. This what we wanted to explain with the sentence "*In CHD patients, mortality risk is associated with exercise capacity as assessed using cardiopulmonary (Ezzatvar et al., 2021) and walking* *distance tests (Cacciatore et al., 2012)*" (Introduction section, first paragraph, p. 1). Again, we acknowledge the expression "exercise capacity" may not be clear enough. Thus, we have modified the second sentence of the Introduction section of the revised manuscript as follows (see added text in bold below):

- "In CHD patients, mortality risk is associated with exercise capacity **(i.e., cardiorespitarory fitness)** as assessed **(directly measured of estimated)** using cardiopulmonary (Ezzatvar et al., 2021) and walking distance tests (Cacciatore et al., 2012) (…)" (p. 2).

With these explanations in mind, the reader interested in specific results of exercise capacity in coronary artery patients could read the references provided in the Introduction section, as Ezzatvar et al. (2021; doi: 10.1016/j.jshs.2021.06.004). By reading this reference, that is a systematic review, the reader could get the idea that the VO_2peak is typically between 15 and 25 mlO_2/min/kg in coronary artery patients in prospective cohorts studies analysing the link between mortality risk and exercise capacity.

3) Links about physical activity and motivation are well documented. More explanations about why motivation could be an interesting variable to investigated could help to understand how and why the authors choose the variables. §2 L10 The same suggestion worth also to barriers to physical activity.

- Thank you for this suggestion. We have modified the end of the second paragraph in the Introduction section that was the following:
  - "These recent results support the interest of investigating the long-term evolution of exercise capacity and physical activity level in CHD patients after a CR program, but also the evolution over time of motivation for physical activity as it could be related to physical activity behaviour in cardiac patients after a CR program (Russell & Bray, 2009)."

The modified version of the paragraph shown in the revised version of the manuscript is the following:

- "Such an investigation could also be coupled with the characterization of the individual determinants (e.g., motivations, self-efficacy, exercise history, skills, and other health behaviours) and environmental determinants (e.g., access, cost, and time barriers and social and cultural supports) of physical activity behaviour (Sherwood & Jeffery, 2000). This could help to understand the reasons of a possible change in physical activity and hence exercise capacity over time in cardiac patients. In particular, analysing motivation for physical activity could be here an appropriate approach supported by the well-established self-determination theory framework stating that the adoption and maintenance of physical activity behaviour is dependent on the form of motivation (autonomous vs. controlled) and regulation (integrated, identified, introjected, external) related to physical activity, with a particular positive influence of autonomous (identified and intrinsic) regulations (Teixeira et al., 2012). This statement is based on both cross-sectional and longitudinal (observational and experimental) studies (Teixeira et al., 2012), including studies conducted in cardiac patients after a CR program (Russell & Bray, 2009)." (p.2)

4) The authors listed some previous studies but the reader could need information about the results founds and/or the tools used and/or the participants recruited in these studies. Doing this the authors could stress even more why this study is important.

➢ Thank you for this suggestion. We have modified the following paragraph:

- "Several studies investigated the evolution of exercise capacity and physical activity level after a CR program (Boesch et al., 2005; Giallauria et al., 2006; Mildestvedt et al., 2008; Steinacker et al., 2011; Pavy, Tisseau, et al., 2011; Ramadi et al., 2016; Nilsson et al., 2018; Racodon et al., 2019; Taylor et al., 2020; Kim et al., 2021; Batalik et al., 2021), but not all tested the change between the end of the CR program and the follow-up measurements (Boesch et al., 2005; Giallauria et al., 2006; Pavy, Tisseau, et al., 2011; Ramadi et al., 2016; Nilsson et al., 2018), and very few studies tested a change after a CR program with ≥1-year follow-up measurements (Boesch et al., 2005; Nilsson et al., 2018). To our knowledge, no studies analysed the change in motivation for physical activity over time in cardiac patients after a CR program. (…)"

The new paragraph in the revised manuscript is as follows (seed added/modified text in bold below):

- "Several studies investigated the evolution of exercise capacity and physical activity level after a CR program (Boesch et al., 2005; Giallauria et al., 2006; Mildestvedt et al., 2008; Steinacker et al., 2011; Pavy, Tisseau, et al., 2011; Ramadi et al., 2016; Nilsson et al., 2018; Racodon et al., 2019; Taylor et al., 2020; Kim, Choi, et al., 2021; Batalik et al., 2021), but not all tested the change between the end of the CR program and the follow-up measurements (Boesch et al., 2005; Giallauria et al., 2006; Pavy, Tisseau, et al., 2011; Ramadi et al., 2016; Nilsson et al., 2018). **Most of these last studies found no change in exercise capacity as assessed using either a maximal treadmill/cycling exercise test or the six-minute walking test (Boesch et al., 2005; Pavy, Tisseau, et al., 2011; Ramadi et al., 2016; Nilsson et al., 2018) and they found no change in physical activity using a questionnaire (Ramadi et al., 2016; Nilsson et al., 2018). However, very few studies actually tested a change after a CR program with ≥1-year follow-up measurements (Boesch et al., 2005; Nilsson et al., 2018).** Moreover, to our knowledge, very few studies analysed the natural change in motivation for physical activity over time in cardiac patients after a CR program (...)" (p.2)

Methods:

5) Details are given to facilitate replications but some are missing (e.g., what were the exercises proposed, what was the intensity of the exercises, what was the duration of the CR program session?

➢ Details regarding the content of the program have been added in the revised version of the manuscript as follows (see added/modified text in bold below):

- "The CR program used in the present study was based on the guidelines from the French Society of Cardiology (Pavy, Illiou, et al., 2011). Patients who followed the program had to come to the center four days (08:30 am to 4:30 pm) per week during four consecutive weeks. Patients could have five collective activities per day. A typical week included the following sessions: 4 indoor **(leg cycling)** aerobic training sessions **(content: 40 min with both continuous and intermittent exercises; intensity based on the training heart rate determined by the cardiologist following the exercise test at the entry in the program)**; 2 to 3 sessions of resistance training **(content: 45 min [10 exercises related to the main muscle groups], 3 series of 10 repetitions at 40% of 1 RM per exercise)**; **2 to 3 sessions of gymnastic (content: 60 min exercising the main muscle groups using body weight or small weights [e.g., swiss ball, medicine balls, barbells])**; **2 to 3 sessions of** adapted physical **activity (content: 60 min where various activities can be performed such as table tennis, badminton, blowgun, archery, volleyball, hockey, etc.)**; **2 to 3 sessions of outdoor** walking or Nordic walking **(content: 30 to 60 min at free pace following marked footpaths)**; (…)" (p. 3)

The way and the tool used to assess barriers to PA is not clear (it seems to be a questionnaire in the method section-"For each of the items, the participant had to indicate whether the item was considered as a barrier or not", then an interview –"most frequently evocated"- in method, result sections and NCT).

➢ We apologize for this lack of clarity. This was indeed a questionnaire. We have reformulated the sentences from the manuscript that could lead to some confusion:

The sentence "The most frequently evocated barriers to physical activity were mainly "unfavourable weather", "lack of time", "heavy effort / too tired", and "fear of injury / pain" (in order of importance), with corresponding percentages being between 18% and 35% of the participants (N = 77), and the remaining items reaching scores below 4% (Figure 3)." has been replaced by the following sentence:

- "The barriers to physical activity were mainly "unfavourable weather", "lack of time", "heavy effort / too tired", and "fear of injury / pain" (in order of importance), with corresponding percentages of concerned participants being between 18% and 35% of the participants (N = 77), and the remaining items reaching proportions below 4% (Figure 3). (p.12)

The sentence in the legend of the Figure 3 "The most frequently evocated barriers have been highlighted with darker colours." has been replaced by the following sentence:

- "The main barriers have been highlighted with darker colours." (p.13)

The sentence in the Discussion section "At the end of the follow-up period (12 months post-program), the most reported barriers to physical activity were an unfavourable weather, a lack of time, the fact to be too tired, and the fear of injury." (p12) has been replaced by the following sentence in the revised manuscript:

- "At the end of the follow-up period (12 months post-program), the main barriers to physical activity were an unfavourable weather, a lack of time, the fact to be too tired, and the fear of injury. (p.15)

The sentence in the abstract "Unfavourable weather, the lack of time, the fact to be tired, and the fear of injury were the most commonly reported barriers to physical activity at 12 months post-program" has been modified as follows:

- "Unfavourable weather, lack of time, fatigue, and fear of injury were the main barriers to PA at 12 months post-program." (p. 1)

6) In the statistical analysis part, it is strange to have a lot of variables able to explain/predict the evolution of exercise capacity or PA (e.g., sociodemographic, motivation, barrier, patient knowledge, treatment, benefits and risk of PA, PA) but no analysis about it. May be Cluster analysis? Regression? Path analysis? Cross-lagged? Mediation/moderation? Could be interesting, if it is feasible.

- This “lack of analyses” is explained by the fact that the study was initially planed to simply describe how some outcomes of interest evolve over time in coronary artery disease patients after a CR program and was thus powered for that objective only (at least, regarding the six-minute walking test). However, we agree with the reviewer that we could have attempted to propose a deeper exploration of our data so that clinicians and researchers may derive more benefits from the present study. To comply with the reviewer remark, we have conducted a new series of analyses:
    - First, we have implemented an analysis to characterize the change in the profile of motivation for physical activity between 0 and 12 months post-program so that we can use it for further analysis regarding the prediction of exercise capacity and physical activity. To do this, we have used a clustering approach because some authors suggested that characterising people motivation through only one variable (one form of motivation) or only a motivation index cannot take into account the actual complexity of a profile of motivation (Gillet al., 2009, doi: 10.1007/s11031-008-9115-z; Gillet al., 2010, doi: 10.3917/th.732.0141; Friederichs et al., 2015, doi: 10.1186/s40359-015-0059-2). Indeed, a person can present, for example, high scores for both the autonomous and controlled forms of motivation in the same time (and not only for one of these forms). Our results suggest that our participants presented one of the two following profiles both at 0 and 12 months post-program: (i) a very high level of autonomous motivation combined with a high level of controlled motivation (introjected regulation) or (ii) a high level of autonomous motivation and a moderate level of controlled motivation (introjected regulation) motivation. Multivariate analysis (using the EMAPS scores) confirmed that these profiles could be considered as coming from different multivariate distributions. Then, we could quantify the proportions of patients presenting a particular profile at 0 and 12 months post-program and then the proportions of patients who stayed in the same profile or who transited from a profile to another one during the follow-up period.
    - Second, we have implemented a latent class trajectory modelling analysis as in the reference suggested by the reviewer (https://doi.org/10.2340/jrm.v55.4343). This analysis consisted of building a model that could describe the most correctly the types of changes in a given outcome over time (either for six-minute walking distance or the IPAQ METs-min/week). We could identify 3 profiles of changes in the six-minute walking distance (decrease, no change, increase) and 2 profiles of change in IPAQ METs-min/week (no change, increase). The model seemed roughly correct for the 6-min waking test but unfortunately did not seem very appropriate for correctly describing data for IPAQ MET-min/week.
    - Finally, we tried to analyse the predictors of the classes of change in the outcome of interest but we failed to detect any significant predictors of exercise capacity/physical activity among the ones we tested (ie, initial level of exercise capacity and physical activity, initial profile of motivation for physical activity, and the two main barriers to physical activity). Of note, we tried to use a restricted list of potential predictors given the fact our sample size seemed low for this kind of analysis as compared with other studies (https://doi.org/10.2340/jrm.v55.4343).

The full details of the analyses, results, and related discussion, are shown below with the text we have added in the revised manuscript:

“*Change in the profile of motivation for physical activity*

The change in motivation for physical activity over time was also explored throughout the change in the motivational profile analysed using a clustering approach. The rationale for this analysis was that a single form of motivation may not capture the actual complexity of a motivational profile, as in people who would present both high levels of autonomous and controlled motivation for example (Gillet et al., 2009, 2010; Friederichs et al., 2015). To perform such an analysis at each of the time points of interest (0 and 12 months post-CR program), we first scaled the motivation variables (EMAPS scores). Then, we confirmed the possibility to conduct a clustering analysis both graphically (using a dissimilarity matrix image) and statistically (Hopkins statistic >0.7) (Kassambara, 2017). Then, we implemented a k-medoid approach to partition the considered EMAPS scores dataset into k groups or clusters, each cluster being represented by a participant in the cluster (i.e., the medoid). This approach was deemed more appropriate than the classically used k-means approach (Gillet et al., 2009, 2010; Friederichs et al., 2015) as our datasets presented several multivariate outliers as assessed using the minimum covariance determinant (Thériault et al., 2024), and the k-medoid approach is less sensitive to outliers (Kassambara, 2017). More precisely, we used the Partitioning Around Medoids (PAM) algorithm that aimed at building k clusters so that the global average sum of the intra-cluster dissimilarities (based on the Euclidean distances from the medoid) was minimal. The optimal number of clusters k to be build by the algorithm was determined using the average silhouette method that measures the quality of a clustering: the higher the value of the average silhouette, the better the clustering (i.e., higher intra-cluster similarities, higher inter-cluster dissimilarities). The clusters we obtained were named using a similar approach as in Gillet al. (2009) consisting of introducing, in the name of the cluster, information related to the motivational concepts and the magnitude of the motivational scores that highlighted the between-cluster differences. The pertinence of the clusters we obtained was also assessed by comparing their respective EMAPS scores using nonparametric multivariate analysis (Burchett et al., 2017), both at 0 month and at 12 months post-CR program. We considered that the participants related to the identified clusters came from different multivariate distributions when the P value associated to the ANOVA Type statistic (F-approximation) was below or equal to 0.05. When there was an overall difference between the compared clusters, multiple comparisons were performed to determine for which EMAPS scores and combinations of EMAPS scores there were differences between the clusters, again using the ANOVA Type statistic (F-approximation) while maintaining the overall Type I error rate at 5%. The proportions of participants related to a given scenario of profile transition between 0 and 12 months post-CR program were computed along with their respective 95% Clopper and Pearson CIs.

(…)

Predictors of the change in 6MWT distance and IPAQ-SF MET-min/week

We finally explored the possibility to identify predictors of the change in 6MWT (0 – 12 months) distance and IPAQ-SF MET-min/week (6 – 12 months) using a latent class trajectory modelling approach (Proust-Lima et al., 2017). This approach consisted first of building an initial linear mixed model with the outcome of interest as response variable and the month of measurement as explanatory variable and a random intercept on the participants. Then, a series of models were derived from this initial model and tested to determine whether the change in the outcome of interest over the follow-up period could be categorized into different classes depending on the direction and the magnitude of the change. These new models were latent class mixed models as they included a term allowing the determination of a class-specific fixed effect (here the month of measurement) in the mixed model (Proust-Lima et al., 2017). Four groups of latent class linear mixed models were tested for the possibility to have 2 to 5 classes of change in the outcome of interest as previously proposed (Limpens et al., 2023). As these models needed initial values to allow the model building algorithm to converge, we implemented, as recommended (Proust-Lima et al., 2017), a grid search strategy. In the present analysis, this consisted of testing, for a given number of expected latent classes, 100 models respectively based on 100 random vectors of initial values obtained from the parameters defined with the initial linear mixed model (1 class). The best model for a given number of classes obtained from the grid search strategy was then retained for subsequently comparing the different models related to the different numbers of latent classes. For a given outcome of interest, the most appropriate latent class mixed model (i.e, the most appropriate number of classes) was chosen based on a combination of the Akaïke Information Criterion (AIC), the Bayesian Information Criterion (BIC), entropy, the numbers of study participants posteriorly assigned to a given class by the model considered (Proust-Lima et al., 2017), and also the possibility to have a model able to converge during the subsequent analysis of the predictors of the latent classes. The analysis of potential predictors of the assignment to a given class was performed using a multinomial regression model (with the class showing the best mean change as reference class) with the following potential predictors: six-minute walking distance, physical activity level and motivational profile at the end of the program; and the two main barriers to physical activity (unfavourable weather and lack of time). The inference technique related to this analysis was a 2-stage estimation of the joint likelihood of the primary (final) latent class mixed model and the secondary regression. Covariates in the latent class mixed models and the multinomial regression models were considered as statistically significant when the P values associated to the corresponding Wald tests were ≤ 0.05. (Proust-Lima et al., 2017)."

Please also see the results from these new analyses (cf. pp. 11-13 of the revised manuscript):

"We identified two motivational profiles both at 0 and 12 months after the CR program among the 76 participants with complete EMAPS scores data (Figure 3): a profile with a very high level of autonomous motivation and a high level of controlled motivation (introjected regulation), thereafter named the 'Very High AU-High C' profile); and a profile with a high level of autonomous motivation and a moderate level of controlled motivation (introjected regulation), thereafter named the 'High AU-Mod C' profile. Multivariate analysis suggested that the sets of the EMAPS scores from these two profiles were indeed different both at the end of the program and at 12 months post-program ($P < 0.001$), with significant differences for intrinsic motivation, integrated, identified and introjected regulations ($P \leq 0.05$). The 'High AU-Mod C' profile was more prevalent (57.9% of the participants) than the 'Very High AU-High C' profile at the end of the program and inversely at 12 months post-CR program (36.8% vs 63.2%). The proportions [95% CI] of participants related to a given scenario of cluster change were the followings: 57.9% [46.0%; 69.1%] of participants were associated to the same profile; 10.5% [4.7%; 19.7%] transited from the 'Very High AU-High C' profile to the 'High AU-Mod C' profile; and 31.6% [21.4%; 43.3%] transited from the 'High AU-Mod C' profile to the 'Very High AU-High C' profile (Figure 3B). Importantly, information available in Supplementary Material 8 suggest the good consistency between the actual individual changes in motivational profile and the data-driven categories of profile change assigned to the study participants.

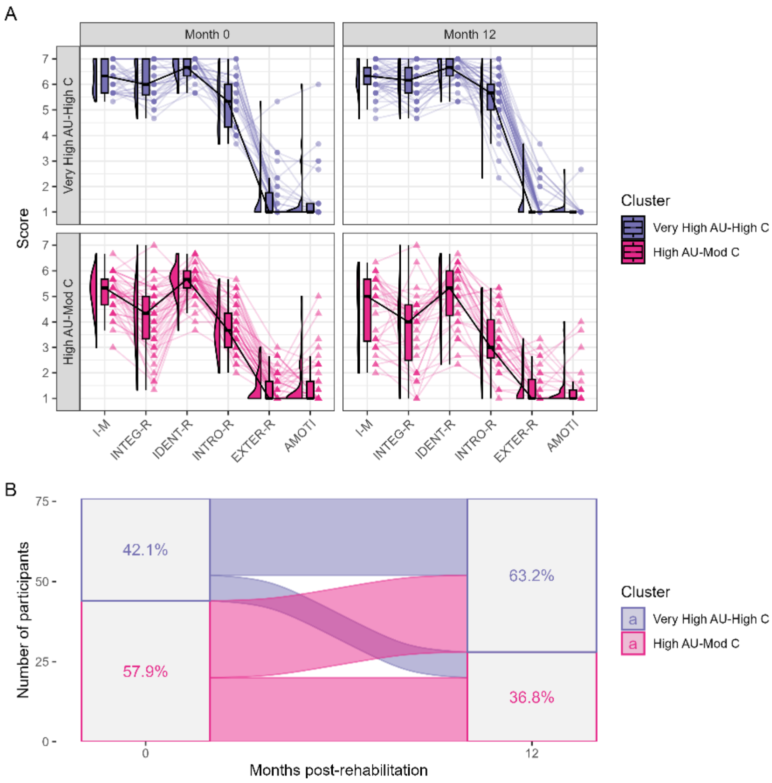


Figure 3 – Change in physical activity motivational profile between the end of the CR program and 12 months after the program. Panel A shows the distributions of the EMAPS scores for each of the two identified motivational profiles at the end of the CR program (Month 0) and at the end of the follow-up period (Month 12). The multivariate distributions related to the two motivational profiles were overall significantly different both at the end of the program and at 12 months post-program, with significant differences for intrinsic motivation and all the forms of regulations excepted external regulation. Panel B shows the transition from a motivational profile to the other one between the end of the program and the end of the 12-month follow-up period. AU = autonomous motivation; C = controlled motivation; I-M = intrinsic motivation; INTEG-R = integrated regulation; IDENT-R = identified regulation; INTRO-R = introjected regulation; EXTER-R = external regulation; AMOTI = amotivation.

(…)

Based on the latent class linear mixed model analysis (Figure 5 and Supplementary Material 9), it could be considered that the change in 6MWT distance could be categorized into 3 classes (Figure 5A) with the following class-specific effects of time (month) on 6MWT distance and related percentages of posterior classification of the participants: Class 1, significant decrease (-8.1 m/month, $P < 0.001$, $N = 2$ [2.7%]); Class 2, non-significant change (-0.7 m/month, $P = 0.118$, $N = 39$ [52.0%]); Class 3, significant increase (+3.6 m/month, $P < 0.001$, $N = 34$ [45.33%]). As shown in Figure 5A, the model seemed to be able to globally propose correct classifications of the study participants. Regarding the analysis of IPAQ-SF MET-min/week (Figure 5B), it was possible to get a categorization of the changes into 2 classes: Class 1, no significant change (-58.7 MET-min/week/month, $P = 0.381$, $N = 72$ [93.5%]); Class 2, significant increase (+1355.8 MET-min/week/month, $P < 0.001$, $N = 5$, [6.5%]). Contrary to the model for 6MWT distance, the model for IPAQ-SF MET-min/week seemed to have a poorer performance of classification of the study participants, as shown in Figure 5B (poor correspondance between the predictions of the model and the participant trajectories). None of the tested variables significantly predicted the assignment to a given class of change both for 6MWT distance and for IPAQ-SF MET-min/week.

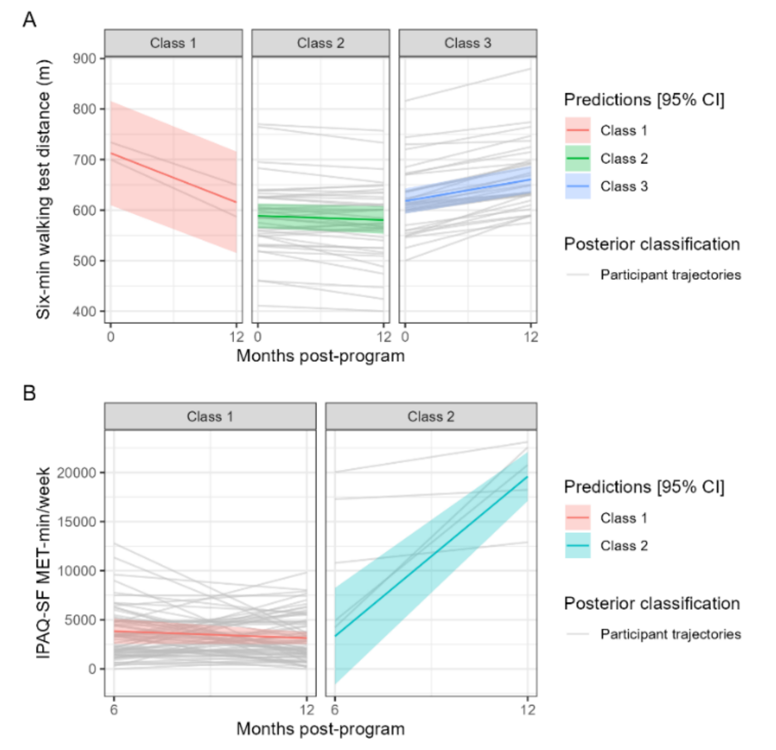


Figure 5. Predictions of the selected latent class linear mixed (trajectory) models along with the individual trajectories of the participants assigned to a given class of change for 6MWT distance (panel A) and IPAQ-SF MET-min/week.

”

In the Discussion, these results have been discussed in the following paragraph (cf. p15):

“We took the opportunity of having both functional (6MWT distance), behavioural (IPAQ-SF MET-min/week) and motivational (EMAPS-based clusters and barriers to physical activity) data to explore, via a latent class trajectory modelling analysis, the possibility to determine the predictors of particular classes of changes both in exercise capacity (6MWT distance) and physical activity (IPAQ-SF MET-min/week) over time. This analysis could add a value compared to the decile shift analysis we conducted by more clearly highlighting the different profiles of changes in the outcomes of interest, thus reinforcing the idea that patients may have different needs to get the best trajectory as possible for a given outcome after a CR program. A few previous studies had already identified different clusters of trajectories in physical activity outcomes over time after a CR program (Sweet et al., 2011; Blanchard et al., 2014; Limpens et al., 2023) but to our knowledge not for exercise capacity. Based on these studies, it could be expected that the baseline motivational profile (Sweet et al., 2011), exercise capacity and physical activity (Blanchard et al., 2014; Limpens et al., 2023) here measured at the end of the CR program in the present study, are identified as predictors at least of physical activity (here between 6 and 12 months post-CR program). Unfortunately, we were not able to identify any predictor that could allow clinicians to anticipate the trajectory a patient would be likely to have after a CR program depending on their profile. The relatively high level of 6MWT distance for all participants, the potentially high measurement error related to the IPAQ-SF and the relative lack of differences between the motivational profiles of our participants were clearly not in favour of their identification as potential predictors of a particular change in exercise capacity or physical activity after the CR program. Of note, our relatively low sample size to conduct such exploratory analyses imposed us important constraints in the definition of the structure of the models (e.g., impossibility to get models converging with several covariates when using random effects on slopes), which is line with the fact that such a kind of analyses generally require several hundreds of participants to ensure robust results (Sinha et al., 2021). For these reasons, the results from these analyses should be considered with great caution."

We have removed the following sentence from the Discussion when dealing with the non-uniformity in the shift of 6MWT distance: "with an attention given to the reasons that could explain such a pattern. Such studies could then help clinicians targeting the patients with the more pronounced needs to implement strategies that would allow them to maintain or improve their capacities over time." because the latent class analysis has attempted to answer this question.

For the same reason, we have also deleted the following sentence from the Discussion: "Further studies and analyses should be conducted to confirm a maintenance in physical activity level and motivation for physical activity over time (e.g., using equivalence testing procedures) and to describe the link between the changes in physical activity level and motivation for physical activity". It has been replaced in the revised manuscript by the following sentence (see text in bold below):

- "Further studies and analyses should be conducted to confirm **these results and to characterize the change in motivation for physical activity over time in more heterogeneous physical activity motivational profiles that could be identified at the end of a CR program**." (p. 15)

Why analysed change in mean AND distribution only for exercise capacity?

➢ Thank you for the opportunity to discuss this point. Initially, the analysis of the change in the mean of exercise capacity was considered to describe the evolution of the central tendency of the variable. When we looked at the physical activity and motivation variables, the distributions were very skewed, making the mean less appropriate than the median to represent the bulk of the distribution. As the decile analyses included comparisons of medians, no further computations were made to compare the central tendencies at the end of the program and at 12 months. To provide a more homogeneous view of the analyses, one could have suggested to remove the analysis of the change in the mean for exercise capacity. But this analysis was the basis on which the study was initially planned and the sample size determined, then preventing its removal. As the other reviewers did not point out this issue, we were not sure of the importance of providing further explanations about this in the revised manuscript. For now, we have made the choice to not add further explanations in the manuscript. Please let us know if you do require additional explanations in the manuscript regarding this point.

Specific comments

<u>Title and abstract:</u>

The title and the aim of the study is clear.

➢ Thank you for pointing this out.

7) The method is well summed and the results are clear but 2 or 3 sentences at the end of the abstract to help the reader to better understand the implication of these results could be of added value.

- Thank you for this remark. Based on your remark and the remark from another reviewer, we have substantially modified the abstract by adding both some results from the additional analyses we had to perform to comply with all the reviewers remarks and some sentences to present the implication of the results as well as a few words about the scientific context of the study. The new abstract is as follows:

  - "Exercise capacity (EC) and physical activity (PA) are relevant predictors of mortality in patients with coronary heart disease (CHD) but the CHD-specific long-term trajectories of these outcomes after a cardiac rehabilitation (CR) program are not well known. The main objective of this study was to determine the mean change in EC (six-minute walking test [6MWT] distance) in CHD patients at 12 months after a CR program compared to the end of the program. We also performed a series of exploratory analyses: (i) estimating the decile shifts and the typical (median) individual change for EC, PA (IPAQ-SF MET-min/week), and motivation for PA (EMAPS scores) over the 12-month follow-up period; (ii) characterizing the PA motivational profiles at the end of the program and 12 months after the program; (iii) characterizing the barriers to PA perceived at 12 months; and (iv) estimating the categories of changes in EC and PA over time and their potential predictors. Eighty-three patients (77 men; median (25th – 75th percentile) age: 59 (53 – 64) yr; 27.6 ± 4.0 kg/m2) were recruited at the end of a CR program. We found that, for an average patient, EC was trivially increased at 12 months (+12.56 m at the 6MWT; dav = 0.16; P = 0.005). However, the decile shifts analysis did not confirm that the positive shift of the distribution of the performances over time was uniform. In contrast, we observed a significant decrease in PA between the end of the program and 12 months post-program but not between 6 and 12 months post-program when considering both the group of patients as a whole and the typical individual change. The results regarding motivation for PA were mixed, with significant and non-uniform shifts of the deciles towards scores depicting degrees of autonomous and controlled motivations as well as amotivation that would be more in favour of PA, but with no significant typical individual changes except for introjected regulation. Two motivational profiles were identified both at the end of the program and 12 months after the program: one with a very high level of autonomous motivation and a high level of controlled motivation; and another one with a high level of autonomous motivation and a moderate level of controlled motivation. Unfavourable weather, lack of time, fatigue, and fear of injury were the main barriers to PA at 12 months post-program. The change in EC and PA could be categorized into different classes without the possibility to determine any potential predictor of the assignment to a given class. Overall, these results suggest that clinicians managing a CR program with CHD patients as the one implemented in the present study may expect slightly positive or at least steady trajectories in EC, PA (after 6 months), and motivation for PA during the year after the program when considering the bulks of the distributions of patient scores. However, these global trajectories are actually the results of heterogeneous individual changes with some profiles of patients who could need a particular attention but whose characteristics could not yet be predicted."

Introduction:

8) It could be clearly stated since the introduction that investigating the evolution between the beginning of the program and the end of the program is not the aim of the study (and then remove all reference of the measure performed before the CR program or explain why this measure is not

included, e.g., "The test performed at the end of the CR program actually was the second test experienced by the participants after the first one performed at the beginning of the CR program").

- ➢ We agree with the reviewer that the absence of consideration of the results at the entry in the program in the present study could be more explicitly stated in the Introduction section. Thus, we have modified the first sentence of the last paragraph of the Introduction section that was the following: "The main objective of the present study was to determine if there is a change in mean exercise capacity of CHD patients 12 months after completing a CR program compared to the end of the program.".

The new sentence in the revised manuscript is now the following:

- "The main objective of the present study was to determine if there is a change in mean exercise capacity of CHD patients 12 months after completing a CR program compared to the end of the program, with no consideration of the results at the entry in the program." (pp. 2-3)

Regarding the citation provided by the reviewer ("The test performed at the end of the CR program actually was the second test experienced by the participants after the first one performed at the beginning of the CR program"), it was provided to allow the reader to have some elements of context that could have influenced the results. As we think it is important information, we have slightly modified the following paragraph from the initial manuscript to be more explicit about the interest of that information:

- "The test performed at the end of the CR program actually was the second test experienced by the participants after the first one performed at the beginning of the CR program. Of note, in CHD patients, the 6MWT has a 2 to 8% test-retest mean change with an intraclass correlation coefficient (ICC) of 0.97, as well as a moderate correlation (around 0.5) with peak oxygen uptake (Bellet et al., 2012)." (p.3, initial version of the manuscript)."

The new paragraph in the revised version of the manuscript is as follows:

- "Of note, in CHD patients, the 6MWT has a 2 to 8% test-retest mean change with an intraclass correlation coefficient (ICC) of 0.97, as well as a moderate correlation (around 0.5) with peak oxygen uptake (Bellet et al., 2012). Because the test performed at the end of the CR program in the present study actually was the second test experienced by the participants after the first one performed at the beginning of the CR program, the potential learning effect may have been decreased for the follow-up measurements. (p.4, revised version of the manuscript)."

9) The authors could add the word "negatively associated" in "In CHD patients, mortality risk is associated with exercise capacity as assessed using cardiopulmonary (Ezzatvar et al., 2021) " to be more precise.

- ➢ Thank you for this suggestion. As this remark could also concern the association with physical activity level, we have updated the corresponding paragraph as follows (see added text in bold below):

- “In CHD patients, mortality risk is **negatively** associated with exercise capacity (i.e., cardiorespitarory fitness) as assessed (directly measured of estimated) using cardiopulmonary (Ezzatvar et al., 2021) and walking distance tests (Cacciatore et al., 2012) and is also **negatively** related to self-reported physical activity level (Bouisset et al., 2020). As a result, cardiac rehabilitation (CR) programs, which include exercise training and physical activity counselling as core components (Balady et al., 2007), are recommended for CHD patients with appropriate indications (Virani et al., 2023).”

10) There is at least one study about change in motivation for PA over time in cardiac patient after CR: Kim, Young Joo; Crane, Patricia A.; Houmard, Joseph A.; Swift, Damon L.; Wu, Qiang. Minor Improvement in Activity and Participation and Decline in Physical Activity Motivation After Cardiac Rehabilitation Discharge. https://doi.org/10.1097/HCR.0000000000000586

➢ We thank the reviewer for helping us to catch the most relevant studies in relation with our work. We have thus modified the following sentence from the initial version of the manuscript (Introduction section): “Moreover, to our knowledge, no studies analysed the change in motivation for physical activity over time in cardiac patients after a CR program.” (p. 2).

The new sentence in the revised manuscript is as follows:

- “Moreover, to our knowledge, very few studies analysed the natural change in motivation for physical activity over time in cardiac patients after a CR program, with the finding of a decline in the Physical Activity and Leisure Motivation Scale during the 9 months after the program (Kim, Crane, et al., 2021)).” (p. 2)

<u>Methods:</u>

11) The process of subject selection is quite clear (the word “a” could be replace by “the” in “has completed a CR program”)

➢ Thanks. We have made the modification.

12) Except for IPAQ-SF, the variables are measured and presented appropriately. For IPAQ-SF before seeing result it is not clear what was the measure chosen (MVPA? LPA? Min/week? Met-min/week?)

➢ Thank you for this remark. We have added this information at the end of the first sentence of the paragraph describing the IPAQ-SF in the Methods section, as follows (see added text in bold below):
  - “Physical activity level was assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF) **and was expressed in MET-min/week**.” (p. 4)

In the statistical analysis part the list of packages used could be in suppl. Material to ease the reading.

- We understand the reviewer's remark. However, we think it is important that all the authors of the main R packages we have used for our analyses are cited in the main manuscript in order to make easier the identification of their work by readers in recognition of the time they spent to help the scientific community. To comply with the reviewer remark, all the references to a package have been placed in a dedicated paragraph at the beginning of the section "Data, scripts, code, and supplementary information availability" as follows:

"The results of the study have been obtained thanks to several R packages:

- Initial tasks of the data analysis workflow (import, tidy, and transform data): {tidyverse} (Wickham et al., 2019); {tidyselect} (Henry & Wickham, 2024a).
- Figures: {ggplot2} (Wickham, 2016), {Hmisc} (Harrell, 2024), {patchwork} (Lin Pedersen, 2024), {ggbeeswarm} (Clarke et al., 2023), {ggrepel} (Slowikowski, 2023), {rlang} (Henry & Wickham, 2024b), {ragg} (Lin Pedersen & Shemanarev, 2024), {ggrain} (Allen et al., 2021), {ggalluvial}
- Interactive tables displayed in the supplementary materials: {reactable} (Lin, 2023).
- html format-based supplementary materials: {rmarkdown} (Xie et al., 2023).
- Descriptive statistics: {skimr} (Waring et al., 2022); {questionr} (Barnier et al., 2023).
- t-test, Pearson correlation coefficient, *P* value adjustement, and confidence intervals for proportions: {stats} (R Core Team, 2023).
- Decile differences analysis: {rogme} (Rousselet et al., 2017).
- Dataset scaling : {stats} (R Core Team, 2023).
- Multivariate outlier analysis: {performance} (Lüdecke et al., 2021; Thériault et al., 2024).
- Clustering analysis: {stats} (R Core Team, 2023), {factoextra} (Kassambara & Mundt, 2020), {cluster} (Maechler et al., 2023).
- Nonparametric multivariate analysis: {npmv} (Burchett et al., 2017).
- Latent class trajectory modelling: {lcmm} (Proust-Lima et al., 2017).
- Analytical pipeline implementation: {target} (Landau, 2021a), {tarchetypes} (Landau, 2021b)."

13) The authors stated the only participants who had data at both the time point were considered. Is there differences between those who complete both measure and the others?

- After analysis, we did not observe a specific pattern in the characteristics of the participants who had missing data at follow-up compared with participants who had no missing data. To make this clear to the reader, we have added the following details in the revised version of the manuscript (Results, section), supported by analyses placed in supplemental materials (SM7.html). The added details are as follows:

    - "Finally, details related to analyses of the participants with missing data at follow-up are provided in Supplementary Material 7, showing that no specific pattern was detected in their physical characteristics, exercise capacity, physical activity and motivation for physical activity compared to the remaining part of the initial sample of participants." (pp. 8-9)

14) It is not clear at this point why the measurement of the IPAQ at the end of the program could not be used in the analysis alike for the other variables. The explanation gave in the discussion section could be presented in this part.

Nevertheless, the decrease of PA between the end of the program and the follow up is what happen in general, and could be an interesting result to analyse to better understand the evolution of the PA.

- To comply with the reviewer remarks, we have performed for the comparison 0/12 months the same analysis as initially performed for the 6/12 months comparison. Thus, we have modified the following paragraph from the initial version of the manuscript:
    - "Then, for the 6MWT distance, the IPAQ-SF MET-min/week and the EMAPS scores, we exploratory analysed (i) the change in the distribution of the scores (no consideration of the individual trajectories) and (ii) the distribution of the participant changes (consideration of the individual trajectories) between the two time points of interest (0 and 12 months for 6MWT and EMAPS, and 6 months and 12 months for IPAQ-SF to consider free-living physical activity behaviour only), respectively using (i) a shift function and (ii) the median of the changes and a difference asymmetry function." (p. 5)

The modified version in the revised manuscript is as follows:

- "Then, for the 6MWT distance, the IPAQ-SF MET-min/week and the EMAPS scores, we exploratory analysed (i) the change in the distribution of the scores (no consideration of the individual trajectories) and (ii) the distribution of the participant changes (consideration of the individual trajectories) between the two time points of interest (0 and 12 months for 6MWT, IPAQ-SF and EMAPS; and 6 months and 12 months for IPAQ-SF only to also consider the change in "true" free-living physical activity behaviour as the measurement at 0 month for the IPAQ-SF was not related to a week after patient discharge and thus did not reflect the participant natural behaviour; thus, the change between 6 and 12 months in IPAQ-SF MET-min/week was the main analysis of physical activity in the present study). These analyses were conducted (…)" (p. 6)

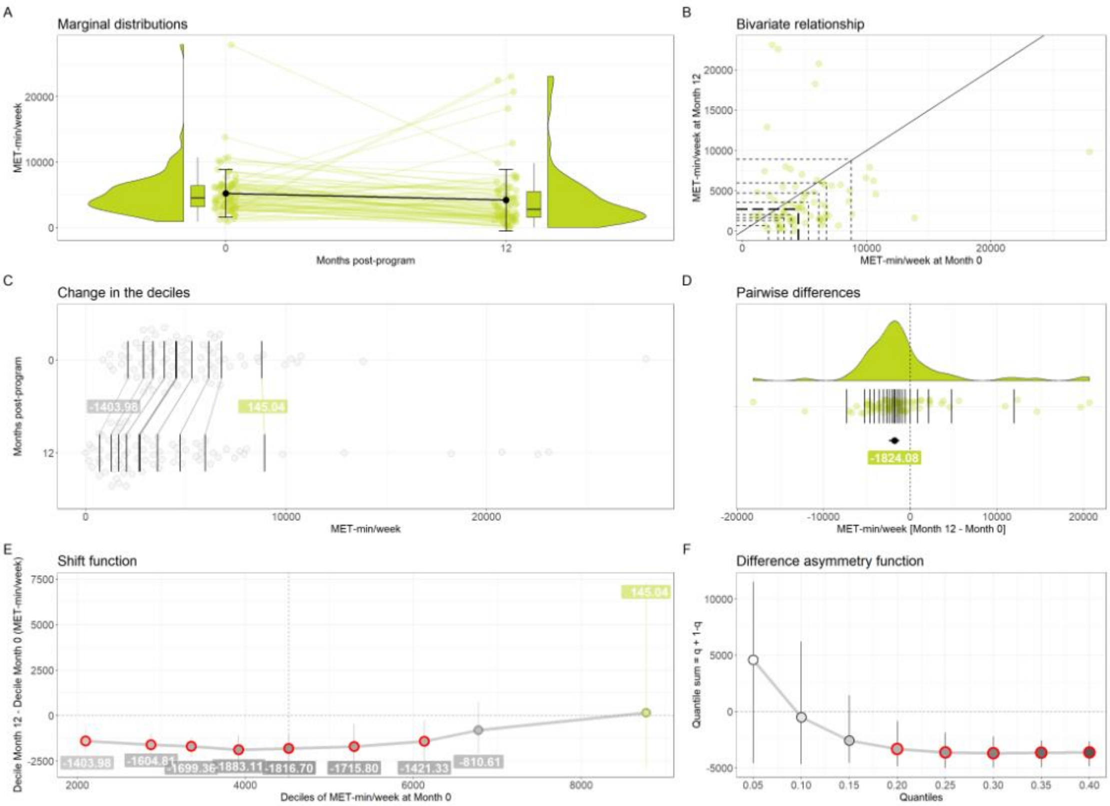
The results of the new analysis have been put in a supplementary material (#5) and are shown below. As shown, physical activity level was significantly decreased for most of the deciles and the typical (median) individual change was negative. We have added the description of the results in the revised manuscript (Results section) as follows:

- "When analysing the change between 0 and 12 months (Supplementary Material 5), we could observe a significant decrease in MET-min/week when comparing the first seven deciles of the distributions and a typical negative change (-1824.08 [-2460.44; -1251.77] MET-min/week)." (p. 10)

We have also modified a sentence at the beginning of the Results section to indicate where are shown the results, as follows (see added text in bold below):

- "Data and results regarding the change in 6MWT distance **(0-12 months)**, IPAQ-SF MET-min/week **(6-12 months)** and EMAPS scores **(0-12 months)** are respectively shown in Figure 1, Figure 2, and Supplementary Material 4. **Results regarding the change in IPAQ-SF MET-min/week between 0 and 12 months are shown in Supplementary Material 5.** Statistical details related to the shift and difference asymmetry functions are provided in Supplementary Material 6." (p.8)

Below the figure related to these new results:



Results:

15) Results are presented for specialists : the results are presented but their meaning in not clear.

We agree that the presentation of some results may be quite technical and may need some clarifications, in particular regarding the decile analyses. To comply with the reviewer remark, we have added short and simplified summaries of the results at the end of each paragraph related to the analyses of the changes in variables over time, as follows (see added text in bold below):

- "Regarding 6MWT distance, the 75 participants with complete data at both 0 and 12 months had a mean ± SD 6MWT distance of 605.44 ± 71.96 m at the end of the CR program. When analysing the change in 6MWT distance at 12 months post-program at the group level using the mean, we found a significant and trivial improvement compared to the end of the program (+12.56 m; $r = 0.88$; $t(74) = 2.8614$; $d_{av} = 0.16$; $P = 0.005$; Figure 1A). However, our exploratory analyses failed to demonstrate that the change in 6MWT distance was uniform, with a significantly positive shift only for the 5th (+17.42 m, $P < 0.001$), 6th (+19.53 m, $P < 0.001$) and 7th deciles (+19.61 m, $P < 0.001$) as shown in Figure 1E. The typical individual change as assessed using the median [95% CI] of the differences (Figure 1D) was also significantly positive (+13.25 [1.54; 25.08] m), while the difference asymmetry function (Figure 1F), with most of the quantile sums being significantly positive ($P < 0.001$) except the first one, revealed that the positive individual changes were larger than the negative ones except when comparing the most extreme quantiles. **In other words, this series of results show that, at 12 months post-CR program, clinicians could expect having a slightly fitter group of patients when considering the average walking performance, but not when considering the lowest and highest fractions of the performances of the group. They also could expect a slightly better walking performance in a randomly chosen patient, as well as**

positive changes in the group that would be of greater magnitude than the negative changes.” (p. 9)

- “Regarding IPAQ-SF scores, the 77 participants with complete IPAQ-SF data at both 6 and 12 months had a median (25th – 75th) IPAQ-SF score of 3318 (1680 – 4914) MET-min/week at 6 months after the end of the program. Our exploratory analyses did not reveal any change in physical activity level at the group level, with no statistically significant decile shift (Figure 2E). Similarly, the typical individual change as assessed using the median [95% CI] of the differences (Figure 2D) was not statistically significant (62.54 [457.28; 424.54] MET-min/week), and the difference asymmetry function (Figure 1F), showing no statistically significant quantile sums (Figure 2F), did not reveal any imbalance between the magnitude of the negative and the positive individual changes at any level of the distribution of the individual changes. When analyzing the change between 0 and 12 months (Supplementary Material 5), we could observe a significant decrease in MET-min/week for the first seven deciles and a typical negative change (-1824.08 [-2460.44; -1251.77] MET-min/week). **For clinicians, this series of results means that when using the IPAQ-SF (MET-min/week), we have no evidence to expect any change in the group as a whole and in a randomly chosen patient bewteen 6 and 12 months post-CR program. However, clinicians could expect a group of patients or a randomly chosen patient to perform less physical activity at 12 months compared to when completing the last week of the CR program.”** (p. 10)
- “Concerning EMAPS scores, the 76 participants with complete EMAPS results at both 0 and 12 months had a median (25th – 75th) of 5.67 (5.00 – 6.00) for intrinsic motivation, 5.33 (4.00 – 6.00) for integrated regulation, 6.00 (5.67– 6.67) for identified regulation, 4.17 (3.58 – 5.33) for introjected regulation, 1.00 (1.00 –1.67) for external regulation and 1.00 (1.00 – 1.33) for amotivation at the end of the CR program. When considering the change in EMAPS scores at the group level, our exploratory analyses globally showed beneficial but possibly non-uniform changes in the different forms of motivation for physical activity, with significant decile shifts that were generally inferior to 1 point and only regarding the 5th (+0.31, $P = 0.045$) and 6th (+0.28, $P < 0.001$) deciles for intrinsic motivation, the 6th (+0.55, $P < 0.001$) and 7th (+0.49, $P = 0.045$) deciles for integrated regulation, the 5th (+0.89), 6th (+0.87), 7th (+0.61) and 8th (+0.37) deciles ($P < 0.001$) for introjected regulation, the 5th (-0.04, $P = 0.030$) and 6th (-0.31, $P < 0.001$) deciles for external regulation, and the 6th (-0.02), 7th (0.24), 8th (-0.85) and 9th (-1.39) deciles ($P < 0.001$) for amotivation. However, when looking at the typical individual change as assessed using the median [95% CI] of the individual changes, it was not significant for intrinsic motivation (0.04 [-0.1; 0.29]), for integrated regulation (+0.31 [-0.01; 0.67]), for identified regulation (+0.11 [-0.08; 0.32]), for external regulation (0 [-0.08; 0]) and for amotivation (0 [0; 0]). It was significant only for introjected regulation (+0.29 [0.01; 0.69]) while remaining of little practical interest (less than 0.5 point on the 7-point EMAPS scale). Only quantile sums from the difference asymmetry function related to amotivation were significant, revealing a marked left-skewed distribution of the individual changes, with negative changes being larger than the positive ones, depicting a trend towards less amotivation. **In summary, this series of results implies that clinicians could expect, after 12 months post-CR program, a beneficial change in the different forms of motivation when looking at the bulks of the distributions of patient scores but not when looking at the worst and best fractions of the distributions. It also means that they could expect a positive change in a randomly chosen patient only regarding introjected regulation and that the negative changes (decreases) would actually be larger than the positive changes (increases) in a group of patients only for amotivation.** (p. 11)

16) Table 1 could be improved by replacing “descriptive statistics” by “ mean and SD”

- We thank the reviewer for this suggestion. However, this does not seem appropriate here since the statistics shown in the table are not all means and standard deviations.

and "surgery history" could be removed or add a space before "angioplasty" and bypass"

- The new table, based on the present reviewer and Reviewer #1 remarks, is now as follows in the revised manuscript (p. 8):

Participant characteristic	Descriptive statistics
Sex (W / M)	6 / 77 (7% / 93%)
Age (yr)	59 (53 – 64)
Height (cm)	173 ± 7
Weight (kg)	82.5 ± 13.6
Body mass index (kg/m^2)	27.6 ± 4.0
Surgery history	
Angioplasty	66 (79.5%)
Bypass	21 (25.3%)

Note: W = women; M = men. Statistics are counts (%) for categorical variables and mean ± SD or median (25th – 75th percentiles) for numeric variables.

Discussion:

17) In the discussion the authors emphasized that they did not used the same measurement tools as previous studies. It could be stated only once in the "limits part". The tools used in the present study could have been used in similar pathological contexts (even if it is not in CHD). This could help to discuss the results.

- Thank you for this suggestion. To comply with the reviewer remark we have performed the following actions:
    - We have replaced the following sentence: "The comparison of 6MWT results with previous works cannot be straightforward because studies did not use both the same follow-up duration and the same exercise test. Indeed, studies compared (…)" (p. 9, Discussion section, initial manuscript) by only: "Previous studies compared (…)" (p. 14, Discussion section, revised manuscript).

As suggested, comparisons with other populations have been performed, here for the 6MWT. This has been performed while responding to the remark n°6 from Baraa Al-Khazraji. The added text is the following:

- "The small positive change we found in 6MWT distance actually could be considered as an encouraging result regarding the interest of the CR program to allow a given group of CHD patients to maintain the highest walking capacity as possible over time, in particular when considering the possible trajectory of 6MWT distance observed in other studies, including those with other clinical populations or older adults. Indeed, Oerkild et al. (2011) observed in cardiac patients (≥65 years), who had followed a program in centers and at home, a decrease respectively of -27 m (baseline: 376 m) and -45 m (baseline: 346 m) in mean 6MWT distance between 3 and 12 months after the end of the program. In older adults, Manning et al. (2024) observed at 12 months a mean increase in 6MWT distance of about 40 m in active older adults (N = 318; 72.5 yr on average; exercise 3 days/week; baseline 6MWT distance: 457 m) and a mean decrease of about 76 m in sedentary older adults (N = 146; 74.4 yr on average, no moderate exercise in the past 5 yrs; baseline 6MWT distance: 421 m). Finally, in chronic obstructive pulmonary disease (COPD) patients, Frei et al (2022) observed at 12 months, in the control group (N = 51; routine care; baseline 6MWT distance: 417 m) of a randomized trial, a mean decrease of -24 m in 6MWT distance. While the results of the CR program we implemented compare well with several studies that reported changes in 6MWT distance at 1 yr, especially considering the relatively high 6MWT distances of our participants who were de facto more prone to a decrease at 1 yr, it seems possible for a cohort of patients to have a maintained 6MWT distance at 1 yr without having followed a rehabilitation program, as previously observed in COPD patients (n = 294; baseline: 388 m; median age: 66 yr) (Casanova et al., 2007). (pp. 14-15, 3'd paragraph of the Discussion section).

We have also deleted the following sentences from the Discussion section:

- "Unfortunately, we are not aware of any study that reported on the change in EMAPS scores in CHD patients to allow meaningful comparisons with the literature about our EMAPS results" (initial manuscript, p. 10, Discussion section).
- "Since previous studies used a different method from the present study to assess barriers to physical activity (Brown, 1999; Fleury et al., 2004), comparisons are difficult. Nonetheless, the" (initial manuscript, p. 10, Discussion section).

We have added the following sentences to the paragraph of the revised manuscript initially dealing with physical activity:

- "To our knowledge, one study investigated the evolution of motivation for physical activity over time in cardiac patients after a CR program (Kim, Crane, et al., 2021). Contrary to the overall positive shift of the motivation scores found in the present study, Kim et al. (2021) have found a decrease in motivation for physical activity at 9 months post-program as assessed using the Physical Activity and Leisure Motivation Scale. Thus, from this perspective, the general positive shift as well as the close-to-zero medians of the individual changes for the different motivation variables, combined with the fact that the participants stayed in a motivational profile that was highly to very highly self-determined, could be considered as encouraging outcomes of the CR program implemented in the present study since autonomous motivation for physical activity is a powerful driver of long-term exercise behaviour in CHD patients (Slovinec D'Angelo et al., 2014)." (p. 15, Discussion section).

As suggested, we have added in the limitations the following sentence:

- "Sixth, precise comparisons with similar works conducted in CHD patients are difficult since we used different tools to assess the outcomes of interest, in particular physical activity, motivation for physical activity and barriers to physical activity." (p. 17, Discussion section).

18) If not tested or referenced the sentence "The absence of statistically significant changes in physical activity in the present study might have parallels with the absence of significant individual changes in most of the forms of motivation for physical activity (EMAPS scores), but this link remains for now highly speculative" could be remove because as said it is only speculative.

- Based on the reviewer's remark, we have removed the following sentence from the revised manuscript: "The absence of statistically significant changes in physical activity in the present study might have parallels with the absence of significant individual changes in most of the forms of motivation for physical activity (EMAPS scores), but this link remains for now highly speculative."

19) In the paragraph before the strengths paragraph the authors used the words "positive responses" It is not clear what positive response mean in this case.

- Thank you for this remark. The wording was not clear enough. We have modified the following paragraph: "Moreover, the relatively high percentages of positive responses for several intrapersonal barriers to physical activity (i.e., lack of time, the fact to be too tired, and the fear of injury) compared to interpersonal barriers (i.e., social isolation / weak social network) or to organizational barriers (…)" (pp. 10-11) as follows:
  - "Moreover, the relatively high **proportions** of **participants acknowledging** intrapersonal barriers to physical activity (i.e., lack of time, the fact to be too tired, and the fear of injury) compared to interpersonal barriers (i.e., social isolation / weak social network) or to organizational barriers (…)" (p. 15)

In my opinion, the fact that environmental factors do not have the same importance when comparing studies led in different town, city, country or continent is not so surprising.

- We agree with the reviewer and thus we have removed the sentence "The fact that an environmental factor was the most reported barrier to physical activity in the present study may be, however, surprising in comparison with the Fleury et al. (2004) results." from the Discussion section in the revised manuscript.

Some references that could be useful:

Intensity matters: protocol for a randomized controlled trial exercise intervention for individuals with chronic stroke. https://doi.org/10.1186/s13063-02

Physical activity and sedentary behaviour changes during and after cardiac rehabilitation: Can patients be clustered? https://doi.org/10.2340/jrm.v55.4343

We thank the reviewer for these two references that have been really helpful to respond to the reviewers' remarks.

Response to reviewer 1

Thank you for the opportunity to review this manuscript that investigates the change in exercise capacity, physical activity, and motivation for physical activity by examining individual and group trajectories in patients following completion of a cardiac rehabilitation program. Overall, the manuscript is well written. It's a nice demonstration of the idiosyncrasy of people's journeys, although more is needed to clarify the interpretation of the results so that the message is not only clear to those who know the methodological approach. Please see below my comments and suggested revisions.

➢ We appreciate the overall positive feedback from the reviewer. We also thank the reviewer for their comments and hope our responses will be satisfactory.

Abstract:

1. **The aims, methods, and results of the study are well covered in the abstract. However, the abstract could benefit from a sentence or two that provides the background/rationale for the study, along with concluding sentences that summarise the implications of the study findings.**

➢ Thank you for this remark. We have pasted here the answer we have made to another reviewer about this point: Based on your remark and the remark from another reviewer, we have substantially modified the abstract by adding both some results from the additional analyses we had to perform to comply with all the reviewers remarks and some sentences to present the implication of the results as well as a few words about the scientific context of the study. The new abstract is as follows:

- "Exercise capacity (EC) and physical activity (PA) are relevant predictors of mortality in patients with coronary heart disease (CHD) but the CHD-specific long-term trajectories of these outcomes after a cardiac rehabilitation (CR) program are not well known. The main objective of this study was to determine the mean change in EC (six-minute walking test [6MWT] distance) in CHD patients at 12 months after a CR program compared to the end of the program. We also performed a series of exploratory analyses: (i) estimating the decile shifts and the typical (median) individual change for EC, PA (IPAQ-SF MET-min/week), and motivation for PA (EMAPS scores) over the 12-month follow-up period; (ii) characterizing the PA motivational profiles at the end of the program and 12 months after the program; (iii) characterizing the barriers to PA perceived at 12 months; and (iv) estimating the categories of changes in EC and PA over time and their potential predictors. Eighty-three patients (77 men; median (25th – 75th percentile) age: 59 (53 – 64) yr; 27.6 ± 4.0 kg/m2) were recruited at the end of a CR program. We found that, for an average patient, EC was trivially increased at 12 months (+12.56 m at the 6MWT; dav = 0.16; P = 0.005). However, the decile shifts analysis did not confirm that the positive shift of the distribution of the performances over time was uniform. In contrast, we observed a significant decrease in PA between the end of the program and 12 months post-program but not between 6 and 12 months post-program when considering both the group of patients as a whole and the typical individual change. The results regarding motivation for PA were mixed, with significant and non-uniform shifts of the deciles towards scores depicting degrees of autonomous and controlled motivations as well as amotivation that would be more in favour of PA, but with no significant typical individual changes except for introjected regulation. Two motivational profiles were identified both at the end of the program and 12 months after the program: one with a very high level of autonomous motivation and a high level of controlled motivation; and another one with a high level of autonomous motivation and a moderate level of controlled motivation. Unfavourable weather, lack of time, fatigue, and fear of injury were the main barriers to PA at 12 months post-program. The change in EC and PA could be categorized into different classes without the possibility to determine any potential predictor of the assignment to a given class. Overall, these results suggest that clinicians managing a CR program with CHD patients as the one implemented in the present study may expect slightly positive or at least steady trajectories in EC, PA (after 6 months), and motivation for PA during the year after the program when considering the bulks of the distributions of patient scores. However, these global trajectories are actually the results of heterogeneous individual changes with some profiles of patients who could need a particular attention but whose characteristics could not yet be predicted."

Introduction:

1. **It is stated that cardiac rehabilitation programs which include exercise training and physical activity counselling are recommended for CHD patients with appropriate indications. However, it is not clear what these indications are. Some examples would be useful to provide context**.

➢ Thank you for this remark. The expression "appropriate indication" is employed by the AHA (Virani et al., 2023). We have slightly modified the initial text including the expression and have added details about this in the introduction as follows (see modified/added text in bold below):

- "As a result, cardiac rehabilitation (CR) programs, which include exercise training and physical activity counselling as core components (Balady et al., 2007), are recommended (Virani et al., 2023) **for CHD patients with appropriate indications (i.e., recent myocardial infarction, percutaneous coronary intervention, or coronary artery bypass grafting; stable angina or recent heart transplant; recent spontaneous coronary artery dissection event).**" (revised manuscript, Introduction section, p. 2).

2. **Clear rationale is provided for investigating the change in exercise capacity and physical activity over time in the introduction. However, the rationale for analysing the change in motivation for physical activity over time is less clear. Please include more about the concepts of the self-determination theory and its components and some expectations based on past findings about how it may or may not change across rehabilitation programs.**

To comply with the reviewer remark, we have modified the second paragraph of the introduction by adding the following sentences:

"Such an investigation could also be coupled with the characterization of the individual determinants (e.g., motivations, self-efficacy, exercise history, skills, and other health behaviours) and environmental determinants (e.g., access, cost, and time barriers and social and cultural supports) of physical activity behaviour (Sherwood & Jeffery, 2000). This could help to understand the reasons of a possible change in physical activity and hence exercise capacity over time in cardiac patients. In particular, analysing motivation for physical activity could be here an appropriate approach supported by the well-established self-determination theory framework stating that the adoption and maintenance of physical activity behaviour is dependent on the form of motivation (autonomous vs. controlled) and regulation (integrated, identified, introjected, external) related to physical activity, with a particular positive influence of autonomous (identified and intrinsic) regulations (Teixeira et al., 2012). This statement is based on both cross-sectional and longitudinal (observational and experimental) studies (Teixeira et al., 2012), including studies conducted in cardiac patients after a CR program (Russell & Bray, 2009)."

Regarding the end of the reviewer's remark suggesting the addition of "some expectations based on past findings about how it may or may not change across rehabilitation programs.", we have not added information about to what extent a rehabilitation program can increase motivation for physical activity, as the aim of our study was to investigate how motivation evolves after the rehabilitation program only. However, based on a reference provided by one of the reviewers, we have added some information about previous findings regarding the evolution of motivation after a program:

- "Moreover, to our knowledge, very few studies analysed the natural change in motivation for physical activity over time in cardiac patients after a CR program, with the finding of a decline in the Physical Activity and Leisure Motivation Scale during the 9 months after the program (Kim, Crane, et al., 2021). (p. 2)

Methods:

1. **Please specify the sampling method used to recruit participants.**

➢ To add details about this point, we have modified the first paragraph of the Method section (Study overview) as follows (see text in bold below):

- "We conducted a prospective, monocentric, and observational study **coupled with a convenience sampling method**. This study has been approved by the relevant regulatory authorities and institutional ethics committee ("APA&Co" project; CPP Ile de France X, France; ClinicalTrials.gov ID: NCT04732923). The recruitment of the participants was conducted at the hospital center of Cholet (France). **It consisted of orally presenting, by the same person (a teacher of adapted physical activity), the study at the beginning of the last week of the CR program (week 4) to the wave of patients currenty enrolled in the CR program and who fulfilled the following criteria** (…)."

We have also added, in the Results section, the rate of acceptance for the participants to the study, as follows:

- "A total of 83 participants were included in the study, with 10 out of 93 patients (11%) who refused to participate." (first sentence of the Results section of the revised manuscript, p.8).

2. **The rehabilitation program seems like a much more intensive dosage than is common (although maybe that's country specific). If I understand it correctly, it seems they had 10**

or more sessions per week? This dosage will have a different impact on outcomes than others like once per week. More on that in the discussion would be good.

➢ The program included approximately up to 15 sessions of physical activity per week (but only up to 7 sessions were structured endurance (x4) or resistance training (x2-3) sessions). This program followed the guidelines from the French Society of Cardiology in terms of recommended types of physical activities but was above in terms of the minimal dose of physical activity recommended.
We agree with the idea that such a dose of physical activity may lead to different results at the end of the program compared to other programs that would propose a different physical activity dose. However, we were not sure if the reviewer wanted to deal with the outcomes at the end of the program, or at the end of the follow-up period. In the first case, we think this may be a minor limitation for the present study as we were not interested in the effect of the program on outcomes at the end of the program. Instead, we were interested in the evolution of the outcomes during the follow-up period. That being said, it might be possible that the physical activity dose experienced during the program influence future physical activity behaviour. Indeed, some studies have shown that a given amount of structured exercise in a cardiac rehabilitation program leads to an increase in self-efficacy for various physical activities. This is important since self-efficacy could mediate the relationship between motivation and physical activity. In other words, the large amount of physical activity experienced by the patients in our study could have played an important role (in comparison with programs including less exercises) in the rise of self-efficacy and then in turn on the positive influence of motivation on physical activity.
To comply with the reviewer remark, we have elaborated on this in the Discussion section of the revised manuscript as follows:

- “As a general note, the possible influence of the relatively high physical activity dose experienced by the participants during the CR program on the outcomes of the present study should be considered in the comparisons with past and future studies. Our CR program included approximately up to 15 sessions of physical activity per week, including the structured endurance exercise sessions (4 per week) and resistance exercise sessions (2-3 per week) recommended by the French Society of Cardiology (Pavy, Illiou, et al., 2011). Such a dose of physical activity could have had a particular influence on future physical activity behaviour compared to programs with less physical activity sessions since a given amount of structured exercises in a CR program leads to an increase in self-efficacy for various physical activities (Cheng & Boey, 2002) and self-efficacy mediates the relationship between motivation and physical activity behaviour (Klompstra et al., 2018).” (p. 16)

Please include the wording used for the measures. Were patients asked to focus exclusively on physical activity done in the rehab setting, outside the rehab setting or all inclusive?

➢ Thank you for this suggestion. We have added precisions as follows:

  - “For the first assessment, participants were asked to consider physical activity performed both at the hospital center where the CR program was completed and outside the hospital.” (Methods section, “Physical activity level subsection”, second line, p. 4).

The description of the scoring of the exercise capacity and motivation measures is a bit unclear. Please clarify.

- We were not sure to what the reviewer wanted to refer when using the term "scoring" for exercise capacity. Exercise capacity was described using the distance performed during the six-minute walking test. We have added this precision at the beginning of the description of the test, as follows (seed added text in bold below):

  - "Exercise capacity was studied throughout the use **of the distance performed during** the six-minute walking test (6MWT)" (p. 4).

Regarding the scoring procedure for motivation, the previous description was as follows:

- "Each item is associated with a 7-point Likert scale (1 = "Does not correspond at all"; 7 = "Corresponds very strongly"). A score is obtained for each of the motivational constructs by averaging the scores related to the 3 corresponding items. For one patient, a score related to one item was lacking. The average was then computed from the two remaining items." (p. 4)

We have modified these sentences to be more explicit in the revised manuscript, as follows:

- "Each item was **scored using** a 7-point Likert scale (1 = "Does not correspond at all"; 7 = "Corresponds very strongly"). **Then**, a **final** score for each of the motivational constructs **was obtained** by averaging the scores related to the 3 corresponding items. For one patient, a score related to one item was lacking. The average was then computed from the two remaining items." (p. 5)

3. **I appreciate the description of the analytic method and approach. There are a few different ways to test the research questions, but the one elected is acceptable. I personally don't see the added value of the bivariate plots and description as it seems to be a bit redundant with the trajectory analyses, but if the authors can clarify the added interpretation and practical significance of it, that would be suitable.**

   - Thank you for this remark. We agree with the reviewer that the bivariate plot and the plot allowing trajectory analyses from the same figure provide some similar statistical information. However, we think that the bivariate plot provides much more visually clear information (thanks to the identity line) about which patient actually has a negative or a positive change over time depending on their outcome decile at the end of the CR program. Such information seems more difficult to catch with the plot containing the individual trajectories. An example of the potential interest of the bivariate plots may be the case of the 6MWT. We could observe a non-significant negative decile shift when comparing the first decile (i.e., the poorest walking performances) at 12 months with the first decile at 0 month, but the decile shift does not tell us which patients are responsible of this decile shift. When we look at the bivariate plot, we can easily see that all the patients with the lowest performances at the end of the program had a decrease of their performance at 1 yr, explaining the negative shift of the first decile. It is true that we did not highlight this kind of reflection in the Results section, mainly because the decile shift was not significant and thus did not deserve too much attention. Because bivariate plots allow the reader to have better insights on the trajectories of the patients, we thought they deserve to be kept in the paper.

Results:

1. **Please clarify how descriptive statistics are presented in the footnote of table 1 (e.g., mean±SD) so that the table can be understood without having to read the main text.**

Thank you for this remark. We have modified the table as follows:

Participant characteristic	Descriptive statistics
Sex (W / M)	6 / 77 (7% / 93%)
Age (yr)	59 (53 – 64)
Height (cm)	173 ± 7
Weight (kg)	82.5 ± 13.6
Body mass index (kg/m^2)	27.6 ± 4.0
Angioplasty	66 (79.5%)
Bypass	21 (25.3%)

Note: W = women; M = men. Statistics are counts (%) for categorical variables and mean ± SD or median (25th – 75th percentiles) for numeric variables.

2. **Given the rare application of this analytic approach for the field, it would be valuable to include a few sentences in the results that provide a clearer 'lay person' interpretation of the findngs. Eg., "This means that of the 75 people whose data were analysed for this, X amount experienced a change of Y units…"**

Another reviewer provided a similar remark (please see above Géraldine Escriva-Boulley's comments, Results section). As explained to the other reviewer, to comply with this remark, we have added short and simplified summaries of the results at the end of each paragraph related to the analyses of the changes in the variables over time, as follows (see added text in bold below):

- "Regarding 6MWT distance, the 75 participants with complete data at both 0 and 12 months had a mean ± SD 6MWT distance of 605.44 ± 71.96 m at the end of the CR program. When analysing the change in 6MWT distance at 12 months post-program at the group level using the mean, we found a significant and trivial improvement compared to the end of the program (+12.56 m; $r = 0.88$; $t(74) = 2.8614$; $d_{av} = 0.16$; $P = 0.005$; Figure 1A). However, our exploratory analyses failed to demonstrate that the change in 6MWT distance was uniform, with a significantly positive shift only for the 5th (+17.42 m, $P < 0.001$), 6th (+19.53 m, $P < 0.001$) and 7th deciles (+19.61 m, $P < 0.001$) as shown in Figure 1E. The typical individual change as assessed using the median [95% CI] of the differences (Figure 1D) was also significantly positive (+13.25 [1.54; 25.08] m), while the difference asymmetry function (Figure 1F), with most of the quantile sums being significantly positive ($P < 0.001$) except the first one, revealed that the positive individual changes were larger than the negative ones except when comparing the most extreme quantiles. **In other words, this series of results show that, at**

12 months post-CR program, clinicians could expect having a slightly fitter group of patients when considering the average walking performance, but not when considering the lowest and highest fractions of the performances of the group. They also could expect a slightly better walking performance in a randomly chosen patient, as well as positive changes in the group that would be of greater magnitude than the negative changes." (p. 9)

- "Regarding IPAQ-SF scores, the 77 participants with complete IPAQ-SF data at both 6 and 12 months had a median (25th – 75th) IPAQ-SF score of 3318 (1680 – 4914) MET-min/week at 6 months after the end of the program. Our exploratory analyses did not reveal any change in physical activity level at the group level, with no statistically significant decile shift (Figure 2E). Similarly, the typical individual change as assessed using the median [95% CI] of the differences (Figure 2D) was not statistically significant (62.54 [457.28; 424.54] MET-min/week), and the difference asymmetry function (Figure 1F), showing no statistically significant quantile sums (Figure 2F), did not reveal any imbalance between the magnitude of the negative and the positive individual changes at any level of the distribution of the individual changes. When analyzing the change between 0 and 12 months (Supplementary Material 5), we could observe a significant decrease in MET-min/week for the first seven deciles and a typical negative change (-1824.08 [-2460.44; -1251.77] MET-min/week). **For clinicians, this series of results means that when using the IPAQ-SF (MET-min/week), we have no evidence to expect any change in the group as a whole and in a randomly chosen patient bewteen 6 and 12 months post-CR program. However, clinicians could expect a group of patients or a randomly chosen patient to perform less physical activity at 12 months compared to when completing the last week of the CR program."** (p. 10)
- "Concerning EMAPS scores, the 76 participants with complete EMAPS results at both 0 and 12 months had a median (25th – 75th) of 5.67 (5.00 – 6.00) for intrinsic motivation, 5.33 (4.00 – 6.00) for integrated regulation, 6.00 (5.67– 6.67) for identified regulation, 4.17 (3.58 – 5.33) for introjected regulation, 1.00 (1.00 –1.67) for external regulation and 1.00 (1.00 – 1.33) for amotivation at the end of the CR program. When considering the change in EMAPS scores at the group level, our exploratory analyses globally showed beneficial but possibly non-uniform changes in the different forms of motivation for physical activity, with significant decile shifts that were generally inferior to 1 point and only regarding the 5th (+0.31, P = 0.045) and 6th (+0.28, P < 0.001) deciles for intrinsic motivation, the 6th (+0.55, P < 0.001) and 7th (+0.49, P = 0.045) deciles for integrated regulation, the 5th (+0.89), 6th (+0.87), 7th (+0.61) and 8th (+0.37) deciles (P < 0.001) for introjected regulation, the 5th (-0.04, P = 0.030) and 6th (-0.31, P < 0.001) deciles for external regulation, and the 6th (-0.02), 7th (0.24), 8th (-0.85) and 9th (-1.39) deciles (P < 0.001) for amotivation. However, when looking at the typical individual change as assessed using the median [95% CI] of the individual changes, it was not significant for intrinsic motivation (0.04 [-0.1; 0.29]), for integrated regulation (+0.31 [-0.01; 0.67]), for identified regulation (+0.11 [-0.08; 0.32]), for external regulation (0 [-0.08; 0]) and for amotivation (0 [0; 0]). It was significant only for introjected regulation (+0.29 [0.01; 0.69]) while remaining of little practical interest (less than 0.5 point on the 7-point EMAPS scale). Only quantile sums from the difference asymmetry function related to amotivation were significant, revealing a marked left-skewed distribution of the individual changes, with negative changes being larger than the positive ones, depicting a trend towards less amotivation. **In summary, this series of results implies that clinicians could expect, after 12 months post-CR program, a beneficial change in the different forms of motivation when looking at the bulks of the distributions of patient scores but not when looking at the worst and best fractions of the distributions. It also means that they could expect a positive change in a randomly chosen patient only regarding introjected regulation and that the negative changes (decreases) would actually be larger than the positive changes (increases) in a group of patients only for amotivation.** (p. 11)

Discussion:

1. **Further discussion about the self-determination theory is needed. Specifically, how these findings align or contrast with other similar studies and what the implications are about patients' motivation throughout this process.**

➢ We agree with the reviewer remark. We have deleted the sentence related to EMAPS in the Discussion section from the initial version of the manuscript and then added the following paragraph in the revised version of the manuscript.

- "To our knowledge, one study investigated the evolution of motivation for physical activity over time in cardiac patients after a CR program (Kim, Crane, et al., 2021). Contrary to the overall positive shift of the motivation scores found in the present study, Kim et al. (2021) have found a decrease in motivation for physical activity at 9 months post-program as assessed using the Physical Activity and Leisure Motivation Scale. Thus, from this perspective, the general positive shift as well as the close-to-zero medians of the individual changes for the different motivation variables, combined with the fact that the participants stayed in a motivational profile that was highly to very highly self-determined, could be considered as encouraging outcomes of the CR program implemented in the present study since autonomous motivation for physical activity is a powerful driver of long-term exercise behaviour in CHD patients (Slovinec D'Angelo et al., 2014)." (p. 15, Discussion section).

2. **It would be interesting to consider a bit about how motivation may be expected to shift from focusing on rehab adherence to focusing more on sustained lifestyle physical activity.**

➢ Thank you for this remark. We have added the following paragraph in the Discussion section of the revised manuscript to elaborate on this point:

- "The EMAPS scores we have obtained were in line with previous results obtained in persons recruited in health centres providing physical activity rehabilitation, including people of various ages or having a chronic condition (Boiché et al., 2019). When analysed throughout a clustering approach, these scores depicted motivational profiles with high to very high levels of autonomous forms of motivation in combination with moderate to high levels of introjected regulation both at the end of the CR program and 12 months after the program. These profiles compare very well with the most self-determined motivational profiles that have been previously identified in the work domain (Gillet et al., 2010), the sport domain (Gillet et al., 2009) and the public health domain (Friederichs et al., 2015). Several procedures were implemented during our CR program so that patients develop autonomous forms of motivation for physical activity during the program. In particular, the number of lifestyle counselling sessions, as well as the discovery of various physical activities during the program so that patients may find enjoyable activities that could fit their preferences, might have played a role in the relatively good scores the patients obtained. Moreover, since a focus was made on future lifestyle and not particularly on exercise adherence during the CR program, it could be expected that autonomous motivation for physical activity at the end of the program would be at least maintained over time.**"** (p. 15)