



UNIVERSITE DU DROIT ET DE LA SANTE - LILLE 2  
**FACULTE DE MEDECINE HENRI WAREMOB**

Année 2017

THESE POUR LE DIPLOME D'ETAT DE DOCTEUR EN MEDECINE

**Les objets connectés : un levier pour changer les comportements ?  
Résultats à un an de la campagne "10 000 pas, le défi pour la vie"**

Présentée et soutenue publiquement le Mercredi 20/12/2017 à 16h

Au Pôle Recherche

**Par Yu Jin JUNG**

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**JURY**

**Président :**

**Monsieur le Professeur Philippe AMOUYEL**

**Assesseurs :**

**Madame la Professeure Florence RICHARD**

**Monsieur le Docteur Luc DAUCHET**

**Directeur de Thèse :**

**Madame la Docteure Maël BARTHOULOT**

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Au Président du jury,

**Monsieur le Professeur Philippe AMOUYEL,**

Professeur des Universités - Praticien Hospitalier en Santé Publique,

Docteur en Médecine, Docteur en Sciences,

Chef de service de Santé Publique, Epidémiologie, Economie de la Santé et Prévention au CHRU de Lille,

Directeur de l'UMR1167 Inserm Université de Lille / Institut Pasteur de Lille « Facteurs de risques et déterminants moléculaires de maladie liées au vieillissement »,

Directeur du laboratoire d'excellence DISTALZ dédié à la maladie d'Alzheimer,

Ancien Directeur Général de l'Institut Pasteur de Lille,

Directeur Général de la Fondation Plan Alzheimer,

Chevalier de la Légion d'Honneur,

Je vous remercie de l'honneur que vous me faites de présider le jury de cette thèse et de la confiance que vous m'accordez.

**A Madame la Professeure Florence RICHARD,**

Professeure des Universités – Praticien Hospitalier en Santé Publique,

Service de Santé Publique, Epidémiologie, Economie de la Santé et Prévention au CHRU de Lille,

Pôle de Santé publique – CHRU de Lille,

INSERM U1167 – Institut Pasteur de Lille,

Vous me faites l'honneur d'accepter de faire partie du jury de cette thèse. Je vous remercie vivement pour votre enseignement durant cet internat.

**A Monsieur le Docteur Luc DAUCHET,**

Maitre de conférence des universités – Praticien hospitalier,

Service de Santé Publique, Epidémiologie, Economie de la Santé et Prévention au CHRU de Lille,

Pôle de Santé publique – CHRU de Lille,

INSERM U1167 – Institut Pasteur de Lille,

Vous me faites l'honneur d'accepter de juger cette thèse. Soyez assuré de mon profond respect et de ma reconnaissance.

A la directrice de cette thèse,

**Madame la Docteure Maël BARTHOULOT,**

Praticien hospitalier,

Service de Santé Publique, Epidémiologie, Economie de la Santé et Prévention au CHRU de Lille,

Pôle de Santé publique – CHRU de Lille,

Responsable Recherche, Epidémiologie au Centre Santé-Prévention-Longévité, Institut Pasteur de Lille / CHRU de Lille,

Je te remercie d'avoir accepté de diriger cette thèse et de m'avoir accordé ta confiance. Merci beaucoup pour ton accompagnement, tes conseils et ta patience durant ce travail.

## Remerciements

A ma famille, je vous remercie de votre soutien inconditionnel de près ou de loin.

A mes amis, je vous remercie de vos encouragements, de votre écoute et de ces moments de vie partagés.

A mes co-internes de Lille (et d'ailleurs) des promotions actuelles et anciennes, je vous remercie pour ces moments passés en votre compagnie, à rire, à braver la tempête et à débattre de tout et de rien. J'ai beaucoup appris avec vous.

A l'équipe d'enseignants de Lille (et à l'inconditionnelle Brigitte), je vous remercie de votre disponibilité, de vos encouragements et de votre implication active dans notre formation. Je suis honorée de bientôt pouvoir travailler sous votre aile.

A toutes les personnes que j'ai rencontrées en stage durant ces quatre ans et demi d'internat, je vous remercie de votre bonne humeur et de vos efforts pour m'intégrer dans vos équipes.

Enfin, je tiens à remercier chaleureusement mon co-interne Nicolas Depas, pour son immense contribution à ce travail de thèse, merci pour ta gentillesse, ta disponibilité et tes conseils précieux !

## Avant-propos

Le présent travail utilise les données 2016 – 2017 issues du projet « 10 000 pas : le défi pour la vie ». Les résultats sont rapportés au format d'un article scientifique en anglais dans sa première version.

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## Résumé

### Introduction

Le podomètre connecté est un dispositif simple, peu coûteux et fiable pour mesurer le nombre de pas journalier d'un individu et ainsi estimer son niveau d'activité physique. Il peut également être envisagé comme un outil motivationnel pour augmenter le niveau d'activité physique des individus. Cet outil est au cœur de la campagne de promotion de l'activité physique « 10 000 pas : le défi pour la vie » qui a été initiée en 2016 dans la région de Lille et qui cible les travailleurs. Son objectif principal était d'évaluer si l'utilisation du podomètre connecté pouvait agir comme un levier pour augmenter le niveau d'activité physique des individus et maintenir ce changement de comportement à long terme.

### Matériel et méthodes

Les participants ont été recrutés sur la base du volontariat de février à juin 2016 dans deux entreprises de la région de Lille et ont été suivis jusqu'au 30 juin 2017. Chaque participant a eu accès à un podomètre connecté (Vidonn X6) ainsi qu'à une application pour smartphone et un site internet spécialement conçus pour la campagne. Les caractéristiques des participants et leurs nombres de pas journaliers ont été recueillis. Le taux d'adhésion à la campagne a été monitoré et les participants ont été classés en deux groupes selon leur durée de participation (« dropouts » si moins de un an ou « completers » si au moins un an). Une analyse de survie a été réalisée afin d'identifier les déterminants de l'arrêt prématuré de leur engagement. Chez les completers un test apparié de Student a été utilisé pour comparer leur niveau d'activité physique moyen au début et à un an de la campagne.

### Résultats

Parmi les 635 individus engagés dans la campagne, 147 (23,1%) ont participé au-delà de un an. La durée moyenne de participation était de  $212,6 \pm 158,0$  jours. La moyenne d'âge était plus élevée dans le groupe des completers (43,6 ans vs 40,4 ans ;  $p = 0,0012$ ) ainsi que le nombre de pas journalier à l'inclusion (7163 pas/jour vs 6236 pas/jour ;  $p = 0,0001$ ). Un âge plus élevé ( $HR = 0,98 [0,97 ; 0,99]$ ), la pratique d'un sport ( $HR = 0,82 [0,68 ; 0,99]$ ) et un nombre de pas journalier à l'inclusion plus élevé ( $HR = 0,91 [0,87 ; 0,99]$ ) ont été identifiés comme facteurs protecteurs vis-à-vis de l'arrêt prématuré de la participation. Une adhésion plus élevée à l'utilisation du podomètre connecté a été identifiée comme facteur de risque de l'arrêt prématuré de la participation ( $HR = 1,05 [1,01 ; 1,09]$ ) en analyse de survie multivariée. Parmi le groupe des completers, une augmentation moyenne de +286 pas/jour a été observée après un an de suivi, comparée au nombre de pas journalier à l'inclusion. Néanmoins, cette différence n'était pas statistiquement significative ( $p = 0,2407$ ).

### Conclusion

Le podomètre connecté s'est avéré être un bon levier pour initier l'augmentation du niveau d'activité physique. Cependant, il n'était pas suffisant pour durablement maintenir le niveau d'activité physique atteint. Nos résultats soulignent l'importance d'utiliser des stratégies de rappel pour maintenir les effets positifs du podomètre connecté observés pendant les dix premières semaines.

## **Abstract**

### Introduction

E-pedometers are inexpensive and simple wearable devices for measuring daily step count in order to measure the level of daily physical activity and can serve as motivational tools to increase physical activity. Using the 10,000 steps/day goal setting coupled to the use of a connected e-pedometer, the “10,000 steps: a challenge for life” workplace-based program launched in 2016 in Lille area (France) and sought to determine if connected mobile Health (mHealth) devices could act as a lever to increase the levels of daily physical activity and to maintain the behavioral change over the long term.

### Methods

Participants were included voluntarily from February to June 2016 in two workplaces in Lille area and were followed up to June 30 2017. All participants were given a toolkit composed of an e-pedometer (Vidonn X6) and dedicated smartphone application and website. Individual characteristics and daily step count data were collected. Adherence to the e-pedometer use was monitored and the participants were classified in two groups according to their length of engagement (« dropouts » if length of engagement < one year; « completers » if length of engagement  $\geq$  one year). Survival analysis was performed to identify determinants of dropping out before one year, and step count increase after one year compared to baseline was assessed using Student’s paired t-test in completers group.

### Results

Among the 635 participants, 147 (23.1%) completed one-year follow-up. The mean length of engagement was  $212.6 \pm 158.0$  days. Compared to the dropouts group, completers group was older (43.6 years vs 40.4 years;  $p = 0.0012$ ) and had a higher numbers of daily steps at baseline (7163 steps/day vs 6236 steps/day;  $p = 0.0001$ ). Protective factors against dropping out before one year were higher age ( $HR = 0.98 [0.97 ; 0.99]$ ), sports practice ( $HR = 0.82 [0.68 ; 0.99]$ ) and higher physical activity at baseline ( $HR = 0.91 [0.87 ; 0.99]$ ). Higher adherence to the e-pedometer use was found to be a risk factor ( $HR = 1.05 [1.01 ; 1.09]$ ) for dropping out before one year in multivariate survival analysis. A mean increase of +286 steps/day was observed after one year compared to baseline step count in completers group, although this variation was not statistically significant ( $p = 0.2407$ ).

### Conclusion

The e-pedometer was found to be a good lever to introduce increase of physical activity in healthy workers. However it was not sufficient to sustain the increased level of physical activity. Our results show the importance of using additional « boosting » strategies to maintain the positive results of the first ten weeks.

## Abréviations

<b>BMI</b>	Body mass index
<b>CNIL</b>	Commission nationale de l'informatique et des libertés (French national data protection authority)
<b>eHealth</b>	Electronic health
<b>mHealth</b>	Mobile health
<b>WHO</b>	World health organization

## Contexte

### *La transition épidémiologique*

Enoncé pour la première fois en 1971, la notion de transition épidémiologique se résume par un changement qui s'opère dans l'épidémiologie des maladies au cours duquel les troubles dégénératifs et ceux liés aux comportements humains remplacent progressivement la pandémie de maladies infectieuses comme principales causes de morbi-mortalité au sein des communautés. Cette transition serait la résultante d'interactions complexes entre déterminants éco-biologiques, socio-économiques et des progrès réalisés en médecine et en santé publique. La transition épidémiologique aurait commencé au XIX<sup>ème</sup> siècle dans les pays industrialisés bénéficiant principalement de l'essor socio-économique de cette période (1). Les études du fardeau global des maladies (« Global burden of disease »), régulièrement mises à jour depuis 1993 confirment cette tendance avec une diminution de la mortalité globale, un allongement de l'espérance de vie et le déplacement progressif du fardeau global des maladies infectieuses, infantiles, maternelles et liées à la malnutrition vers les maladies non-transmissibles. En 2015, les cardiopathies ischémiques et les accidents vasculaires cérébraux occupaient les deux premières places au classement des maladies à l'échelle mondiale et le diabète occupait la 11<sup>ème</sup> place (2).

### *Le fardeau de l'inactivité physique*

En 2009, l'organisation mondiale de la santé (OMS) s'est intéressée aux principaux facteurs de risque associés à la mortalité et au fardeau des maladies dans le monde. L'inactivité physique représentait le 4<sup>ème</sup> facteur de risque le plus fréquent de décès après l'hypertension artérielle, le tabagisme et l'hyperglycémie. Six pourcents des décès survenus dans le monde en 2004, ou 3,2 millions en valeur absolue, étaient attribuables à l'inactivité physique. De nos jours ces facteurs de risque ne sont plus spécifiques aux pays industrialisés mais présents dans tous les pays quel

que soit leur niveau de revenus (3). Suite à ce constat, l'OMS a émis des recommandations en 2010 dans le but de promouvoir l'activité physique, dont les effets bénéfiques ont été démontrés scientifiquement. Les bénéfices apportés par l'activité physique sur la santé sont : l'amélioration de la santé cardio-respiratoire, la réduction du risque de diabète et de syndrome métabolique, la réduction du risque de fractures vertébrales et du bassin, la réduction du risque de cancer du sein et du cancer colorectal et une réduction de la mortalité toutes causes confondues (4). Une étude de fardeau global des maladies s'intéressant spécifiquement à l'inactivité physique vient renforcer ces arguments. Selon les résultats de l'étude, une diminution de l'inactivité physique de 10% pourrait prévenir 533 000 décès par an et une diminution de 25%, prévenir 1,3 millions de décès par an dans le monde. L'élimination totale de l'inactivité physique se traduirait par un gain de l'espérance de vie mondiale de 0,68 ans (5). En matière de coûts, l'inactivité physique aurait coûté 53,8 milliards de dollars aux systèmes de santé en 2013 et une perte de productivité de 13,7 milliards de dollars liée aux décès attribuables à l'inactivité physique (6).

### *L'état des lieux de l'activité physique en France*

En 2014, 52,3% des adultes déclaraient pratiquer une activité sportive au moins un jour par semaine en France. Cette proportion était légèrement plus élevée chez les hommes que chez les femmes et variait fortement selon le niveau d'étude et de revenus et de la catégorie socio-professionnelle. Seuls six à huit adultes sur dix rapportaient pratiquer une activité physique telle que recommandé par l'OMS. La moyenne journalière du temps passé devant l'écran était de 3h 30/jour en 2006 – 2007. Les niveaux observés d'activité physique semblaient insuffisants dans son ensemble (7).

## Introduction

### *Walking 10,000 steps/day*

Popularized in Japan in the 1960s, walking 10,000 steps/day became a commonly-admitted threshold to encourage people to increase their physical activity worldwide. This threshold is simple and easy to remember. Also it provides people with a concrete goal to attain which is an important element to be taken into consideration in physical activity promotion programs (8). Some evidence show that an increased number of steps/day could be associated with better health conditions such as a lower body mass index (BMI) (9). Based on currently available scientific data, the World Health Organization (WHO) recommends for adults aged 18 to 64 to do at least 150 minutes of moderate-intensity aerobic physical activity or 75 minutes of vigorous-intensity aerobic physical activity throughout the week (4). Although there is no direct evidence of improved health outcomes associated with an increased number of steps/day, the value of 10,000 steps/day seems to meet the WHO guidelines in terms of energy expenditure (8,10). Moreover, a goal set at 10,000 steps/day instead of simply reporting the daily step count was found to be associated with greater increase of physical activity within the participants of physical activity interventions (11,12). Several large-scale community-based interventions were designed with this specific goal-setting approach in Australia and Canada (13,14).

### *Using the pedometer as a motivational tool*

Pedometers are usually inexpensive simple wearable devices that not only measure step counts but can also serve as motivational tools in physical activity interventions because they provide the participants with the possibility of self-monitoring and give out instant feedback (15,16). Several meta-analyses were carried out to assess the effect of using pedometers in physical activity interventions. The results were rather encouraging, all Bravata et al., Richardson et al. and Kang et al. observed an average increase of at least 2,000 steps/day in pedometer-using groups (11,12,17). Moreover, the use of pedometers was associated with clinically relevant

reductions in weight and blood pressure (11,17). However, the studies included in the analyses presented relatively small sample sizes and mostly reported results for relatively short time periods. Also, the interventions often used multiple components such as setting daily step count goals, keeping diaries or counseling so the independent contribution of the pedometer in increasing physical activity was difficult to isolate. The effect of using pedometers to increase physical activity over the long term is therefore not well established (18).

#### *Using mobile health (mHealth) devices as health promotion tools*

In recent years, an important number of electronic and mobile technology solutions were developed in health field. These solutions seem to have a particularly great potential in low- and middle-income countries as a means of facilitating access to healthcare at a lower cost (19). In high-income setting, mHealth seems to be involved mostly in managing chronic diseases (asthma, hypertension, type 2 diabetes, cardiovascular diseases, psychiatric disorders) or chronic health conditions (obesity, tobacco smoking). Some of the reported uses of mHealth are: informational and educational purpose, appointment reminding, drug intake reminding, therapy adjustment and motivational support for behavioral changes (20). Besides, diverse kinds of activity trackers, usually coupled with smartphone applications, became very popular lately, mostly because of the possibility of self-monitoring a health behavior. People usually report that wearing a tracker make them adopt healthier behaviors but there is insufficient data to confirm this (21). Moreover, these connected devices present the added benefit of facilitating data collection for health researchers (22).

#### *Workplace-based physical activity interventions*

Modern lifestyle seems to push people to inactivity since physical activity decreases continuously in all life environments including at work (23). Yet, the workplace has been recognized as an appropriate place for promoting health, and a joint initiative was launched by WHO and the World

economic forum in 2007. Focusing on the prevention of non-communicable diseases through healthy diet and physical activity, existing evidence on workplace-based interventions were summarized and guidelines for successful future interventions were stated. Some of the key elements were: establishing clear goals and objectives, effective communication and creating supportive environments (24). Some evidence showed that the effectiveness of workplace interventions to increase physical activity seemed controversial. These results were possibly attributable to sub-optimal study designs and reporting (25,26). More recently, a meta-analysis of workplace-based physical activity interventions with the use of pedometers published in 2013 also led to the conclusion that data were insufficient to determine the effectiveness of these interventions (27).

#### *« 10,000 steps: a challenge for life »*

Launched in 2016 by the Public health department of Lille university hospital the objective of the program was to promote and encourage physical activity within employees from different workplaces by using e-pedometers to achieve the goal of walking 10,000 steps/day over the long term (28). The program first started in Lille area, in the Northern part of France, a region which presents poor health indicators (7).

#### *Objectives*

« 10,000 steps: a challenge for life » program sought to determine if connected mHealth devices could act as a lever to bring behavioral changes over the long term. Using the data from the program after one year of follow-up, we aimed to identify independent factors associated with adherence to the program and to assess the impact of the e-pedometer use on behavioral changes in the long term.

## Methods

### *Program toolkit*

A toolkit composed of an e-pedometer (Vidonn X6), a smartphone application and a dedicated website was at the disposal of the participants to the « 10,000 steps: a challenge for life » program. They were encouraged to challenge each other individually or via team-based workplace challenges using the smartphone application and website. The application allowed to store the data from the e-pedometer so they could be monitored by the user and was designed to provide personalized advice to the user on a weekly basis according to collected personal characteristics and step count data processed by automatic algorithms. The website not only provided detailed information on the program but also updated tips for healthy eating and physical activity regularly. The contents were written and reviewed by health professionals.

### *Ethics, data protection and confidentiality*

Account creation for the smartphone application was possible only after an informed consent was provided. The study informed the Commission nationale de l'informatique et des libertés (CNIL – French national data protection authority) of its data collection and stored the data on a secure server. All collected data were anonymized for statistical analyses.

### *Study population and inclusion criteria*

Purchasing the e-pedometers for the employees was required for any company, community or institution willing to participate to the program. Each company was then free to promote the challenge using the means that seemed appropriate to its own organizational structure. The employees enrolled voluntarily. Participants had to be aged at least 18 years old and own a smartphone to enroll in the program. No other inclusion criteria nor exclusion criteria were set.

### *Study settings*

The program started out in two workplaces in Lille area in February 2016. The inclusion period went from February 17 to June 30 2016.

### *Data collection*

The two different categories of collected data were: (i) individual characteristics of the participant entered at the moment of application account creation: gender, age, weight, height and practice of a sport at least once a week and (ii) the number of walked steps per hour received from the e-pedometers after synchronization. In fact, the e-pedometer used in the program, which was chosen for its simplicity and ergonomic design, contained enough memory to store up to seven days of step count data. Participants were required to synchronize their pedometer with their smartphone at least once a week, to wear the pedometer during waking hours, to continue with their typical activities and to remove the pedometer only while bathing, showering, or swimming.

### *Statistical analysis*

The definitions of the variables we used for data management and statistical analysis are shown in Figure 1. The end-of-study date was fixed at June 30 2017 so the follow-up period could reach at least 365 days for each participant. Physical activity at baseline was defined as the mean step count recorded during week 1 of participation. The end-of-study physical activity was defined as the mean step count recorded during week 52 for the completers group, and the mean step count recorded during their last week of participation for the dropouts group. The cut-off values used to define the physical activity level based on the step count data at baseline were from Tudor-Locke et al (8). For a given participant, his/her step count data were considered valid if they were available at baseline and during his/her last week of participation.

Two datasets were used. Descriptive and survival analysis were based on the total valid population ( $n = 635$ ). Long term behavioral change analysis was performed on completer population ( $n = 147$ ). Missing days were excluded from the computation.

Quantitative variables were expressed as mean  $\pm$  standard deviation, or median (first quartile and third quartile); qualitative variables were expressed as percentage. The completers vs dropouts groups were compared using  $X^2$  or Fisher's exact test for qualitative variables and Student's t-test for quantitative variables. Univariate and multivariate survival analyses were performed. The time variable was the length of engagement in the program (days). The event variable was coded as 1 for dropouts group and 0 for completers group. Kaplan-Meier survival curves showing the proportion of participants surviving over time and survival time were estimated by age categories, gender, BMI categories and sports practice. A log-rank test was used to compare the survival curves between groups. Predictors of dropping out before one year were examined by univariate and multivariate Cox proportional hazard regression. The variation of mean step count during week 1 compared to the mean step count during week 52 was evaluated using Student's paired t-test in completers group. All statistical analyses were performed using R 3.3.2.

## Results

### *Study population*

A total of 769 accounts were created from February to June 2016 and 635 accounts qualified as valid. The number of completers after one-year follow-up was 147, representing 23.1% of the valid population (vs 488 dropouts; 76.6%).

Baseline characteristics overall and according to completer or dropout status are shown in Table 1. Female participants were predominant (73.1%). Most participants had a normal range BMI (18.5 – 24.9 kg.m<sup>-2</sup>). Sixty-five point five percent of participants reported practicing at least one sport at least once a week. Seventy-two point three percent of participants entered less than 7,500 steps/day in their seven first days after logging day.

Completers and dropouts groups differed significantly by their mean age, completers being older than dropouts (43.6 years vs 40.4 years; p = 0.0012) and by the mean number of daily steps at baseline (7163 steps/day for completers vs 6236 steps/day for dropouts; p = 0.0001). No significant differences were observed between the two groups in terms of gender, BMI and sports practice.

### *Adherence to e-pedometer use*

The mean length of engagement was  $212.6 \pm 158.0$  days. The median was 161 days ([79 ; 348]). The mean ratio of logging days to the length of engagement (adherence) was  $0.68 \pm 0.23$  with a median at 0.73 ([0.53 ; 0.88]). In average,  $12.0 \pm 2.62$  hours/day were recorded. The median was 12.1 hours/day ([10.3 ; 14.0]).

### *Step count data*

The mean daily step count over the total length of engagement was  $6624 \pm 2135$  steps/day overall. The mean daily step count for the completers group was  $7390 \pm 2011$  steps/day and  $6393 \pm 2011$

steps/day for the dropouts group. The completers group recorded a mean daily step count of 7449  $\pm$  3118 steps/day during week 52 and the dropouts group 6297  $\pm$  2719 steps/day during their last week of participation.

### *Survival analysis*

Survival curves are shown in Figure 2. The number of participants synchronizing their daily step count decreased constantly and progressively over the study period. The results of univariate and multivariate survival analyses are shown in Table 2. In univariate analysis, older age category, sports practice, higher level of physical activity at baseline were found to be protective against the risk of dropping out of the program before one year. Older age, sports practice and higher level of physical activity at baseline remained significant as protective factors against dropping out before one year in multivariate survival analysis. Higher adherence to the e-pedometer use was found to be a risk factor for dropping out before one year in multivariate analysis.

### *Long-term behavioral change*

The evolution of step count variation compared to baseline over the total length of engagement among completers population is shown in Figure 2. A mean increase of +286 steps/day was observed at week 52 compared to baseline step count in completers population although this variation was not statistically significant ( $p = 0.2407$ ). A peak was observed at week 10 (mean increase of +843 steps/day) and progressively decreased until week 52.

## Discussion

To our knowledge, this is the first study to report the results of a workplace-based physical activity promotion program over the long term in France. The number of participants was consistent ( $n = 647$ ). Participants were included irrespectively of their age, BMI and baseline level of physical activity, including people regarded as sedentary according to their baseline daily step count. Indeed, 30.6% of the participants could be classified as sedentary at baseline (< 5000 steps/day), an additional 41.9% of the participants could be classified as low active (5000 – 7499 steps/day). This is an important point to be highlighted given that it is relatively well established that workplace interventions tend to attract people who are already active and may contribute to minimize the measured impact of such interventions (11,25,26,29). However, given the fact that only volunteers enrolled in the program, it is still possible that the selected participants were likely to be more health-conscious and motivated to increase their physical activity compared to those who did not enroll. One of the limitations of using the pedometer to measure physical activity was that certain types of physical activity (mostly non ambulatory activities such as swimming, cycling and weight training) could not be recorded (18) even if they were proved to have positive impacts on health outcomes. Some participants might have been wrongly classified as being inactive because only the step count data were used to assess the level of physical activity. Nevertheless, focusing on a simple and unique goal of 10,000 steps/day for everyone by using the e-pedometer and ensuring that each participant could keep up with his/her personal regimen of physical activity were important elements to increase adherence to the program (18). Female participants were predominant in our study (73.1%). This is a well described determinant to participating to health promotion programs (18,30).

In the present study, 142 participants out of 647 (21.9%) kept synchronizing their daily step count data after one-year follow-up. The median engagement length was 161 days. Retention rate is a frequently reported concern in health promotion interventions (30). Iwane et al. reported a

retention rate of 11.4% after 12 weeks of follow-up in a workplace-based 10,000 steps/day walking program (31). This could be explained by the fact that most health promotion programs' do not present a critical issue to the participants over the short-term as opposed to what a drug trial could represent. Additionally, low retention rate seems to be particularly recurrent in interventions involving the use of information and communication technology because it is easier for the participants to discontinue the assignments in these kinds of interventions (32). Low retention rate was firstly reported in web-based (eHealth) health interventions. Etter et al. reported a retention rate of 30 – 40% after 2-month follow-up in a web-based smoking cessation program (33). Spittaels et al. reported a similar retention rate after 6-month follow-up in a web-based physical activity intervention (34). Those studies were published in 2005. More recently, researchers assessed the possibility of improving retention rate by combining eHealth and mHealth devices. Analyzing the data extracted in 2013 – 2014 from 10,000 steps Australia program, Guertler et al. found that app-only users had longer duration of physical activity logging compared to web-only users. Web-and-app users had a longer duration of activity logging compared to web-only and app-only users overall and in workplace challenges, they also reported higher daily step counts. Nonetheless, the authors found that half of the participants stopped logging their activity after 30 days of follow-up in 2013 – 2014 (35). Most recently, Hermsen et al. reported, in an observational-study aiming to explore the use of a connected activity tracker in 4 urban areas in France, that 16.0% of the participants who were given an activity tracker still logged their activity after 320 days (21). Based on these data, the retention rate of our study seems to be acceptable after one-year follow-up.

In our study, the factors found to be associated with completing one-year follow-up were: older age, practicing at least one sport once a week and higher level of physical activity at baseline. Higher adherence was unexpectedly found to be a risk factor for dropping out of the program before one year. Some of these factors were already reported as predictors of early dropping-out

of health interventions. In a meta-analysis of web-based smoking cessation programs, Geraghty et al. found that younger age was a predictor of being lost to follow-up (36). Hermsen et al. also found that older age was a predictor of more sustained use of activity tracker (21). The reason why remains unclear and needs further investigations. Sports practice and higher level of physical activity at baseline could reflect the interest and motivation of participants regarding physical activity, factors that are likely to increase adherence to a program (15). Concerning higher adherence to the e-pedometer use being a risk factor for dropping-out before one year, it is possible that participants who logged their step count for a higher number of days at the beginning became rapidly weary of the practice and eventually dropped out. Other determinants of adherence to a sustained use of the tracker that were reported are related to its technical features such as battery duration (21). This should be taken into consideration in the conception of interventions including connected wearable devices.

An observational design was used in our study without a control group. Therefore it is not possible to directly conclude on the effectiveness of using an e-pedometer to bring and maintain behavioral changes over the long-term. The impact of the e-pedometer was evaluated in completers population and was not statistically significant, although a mean increase of +286 steps/day was reported after one-year follow-up compared to baseline. Another weakness of our study is that health outcomes were only assessed through daily step count data. However, this is a common issue in community-based or workplace-based health interventions dealing mostly with healthy people. To our knowledge, many physical activity promotion interventions used the daily step count as a proxy for health outcomes or measured indirect short- to middle- term health outcomes such as blood pressure or BMI (13–15,31,37). In an ideal design of physical activity intervention, indicators such as mortality and the incidence of diseases related to physical inactivity (ischemic heart disease, type 2 diabetes, breast and colon cancer) should be measured. It is reasonable to think that this kind of study would be very costly in time, logistics and financial means.

Nevertheless, using and matching already existing data via hospital, occupational or administration data bases to the data collected from the intervention could be an interesting track to measure more accurate health outcomes.

Long-term behavioral change is a difficult issue to deal with for health promotion specialists. To these days, no strategies were clearly identified as being effective over the long-term. Most physical activity interventions typically show promising results in the short-term but fail to maintain the participants' positive results over the long term. Tudor-Locke et al. highlighted the importance of « booster sessions » multiple times (15,18). More recently, the « TRIPPA » trial assessed the effectiveness of trackers with or without financial incentives to increase physical activity (38). It was a four-arm randomized control trial carried out within employees in Singapore. The four-arms were: control, activity tracker, activity tracker + charity incentives, activity tracker + cash incentives. The incentive period went up to 6 months during which the cash incentives group recorded the highest increase of step count. However, after cessation of incentives these results were not sustained. Multiple and more innovative strategies should be investigated given the recent proliferation of technical devices and increasing awareness of wellness (39).

## Perspectives

L'analyse des données 2016 – 2017 du projet « 10 000 pas, le défi pour la vie » a permis d'apporter des éléments de réponse quant à la possibilité d'utiliser un objet connecté pour promouvoir l'activité physique auprès d'une population de travailleurs en bonne santé. Le podomètre connecté s'est avéré être un bon levier pour initier le changement de comportement, notamment car il permettait aux participants de pouvoir suivre leur performance presque en temps réel et les stimulait à atteindre des nombres de pas progressivement plus élevés grâce aux algorithmes automatiques générant des objectifs personnalisés. Les données de notre étude montrent cependant que l'effet de l'utilisation du podomètre connecté atteint son maximum à environ 10 semaines de son utilisation et qu'il décroît progressivement. Le podomètre connecté seul, n'était ainsi pas suffisant pour maintenir un niveau d'activité physique accrue à long terme au sein de la population d'étude. Toutefois, il est possible que cet infléchissement soit en partie dû à l'arrêt ou à la diminution des fréquences de la synchronisation du podomètre au fur et à mesure du suivi sans qu'il ne soit le reflet exact du niveau d'activité physique des participants. Les modalités d'utilisation du podomètre connecté par les participants devront être évaluées pour les sujets prochainement inclus dans le programme.

L'interprétation des résultats de l'étude et leur confrontation avec des données déjà existantes ont permis d'identifier des pistes d'amélioration pour le programme. En effet, il a été démontré qu'un suivi actif avec des phases de rappel permettait d'aboutir à de meilleurs résultats. Cette stratégie devra être évaluée pour les prochaines inclusions, notamment aux alentours de la période critique des 10 semaines. Il serait également intéressant d'encourager les participants à combiner les différents outils proposés (application smartphone et site internet).

En France, la promotion de l'activité physique est considérée comme une priorité de santé publique depuis maintenant deux décennies. Le Programme national nutrition santé (PNNS) a été inauguré en 2001 et est mis à jour tous les 5 ans. De nombreuses initiatives à l'échelle nationale, découlant notamment du PNNS (40), et à l'échelle locale comme le sport sur ordonnance (dispositif généralisé au pays entier suite à la parution d'un récent décret (41)) ont vu le jour pour promouvoir l'activité physique auprès des personnes en situation de prévention secondaire et tertiaire, aussi bien qu'en population générale en bonne santé. Il existe également des initiatives venant de la part du secteur privé, notamment pilotées par les caisses d'assurance-maladie et les mutuelles de santé. Par ailleurs, le rapport Toussaint datant de 2008 recommandait déjà d'intégrer la pratique de l'activité physique ou sportive en entreprise (42).

Cependant nous constatons à ce jour qu'en France, très peu de données existent sur ces interventions en termes d'amélioration de l'état de santé des bénéficiaires malgré le rappel récurrent de l'importance d'évaluer les interventions dans les rapports et les programmes officiels. En ce qui concerne les interventions conduites sur le lieu du travail, il n'existe actuellement aucune donnée publiée. Or il existe un réel besoin d'accroître le niveau de connaissances dans le domaine de la promotion de l'activité physique afin de pouvoir conduire des interventions efficaces d'autant plus qu'il a été montré que les deux premières causes du fardeau des maladies en France étaient les lombalgies/cervicalgies et les cardiopathies ischémiques (2), deux causes dont l'impact pourrait être abaissé par une augmentation de l'activité physique.

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**Annexe 3.** Figure 2. Survival curves.

**Annexe 4.** Table 2. Univariate and multivariate survival analyses.

**Annexe 5.** Figure 3. Evolution of step count increase over the total length of engagement.

## Annexe 1. Figure 1. Definitions used for data management and statistical analysis.

<b>Daily step count</b>	Sum of the number of total steps performed by a participant on a given day
<b>Logging day</b>	A study day for which the daily step count is well recorded (e-pedometer worn $\geq$ 6 hours/day; daily step count $\geq$ 500 steps/day)
<b>Missing day</b>	A study day for which the daily step count is not well recorded (e-pedometer worn $<$ 6 hours/day; daily step count $<$ 500 steps/day)
<b>Repeated values</b>	Identical numbers of step/hour (above 1,000 steps/hour) and occurrence of more than 5 times on a given day. Resulting from e-pedometer defect. Repeated values were replaced by zero and the daily step count was recalculated.
<b>Registration date</b>	Date of creation of the participant's application account
<b>Study initiation date</b>	First logging day of a participant
<b>Length of engagement</b>	Number of days between the study initiation date and the end-of-study date for each participant
<b>Completer</b>	A participant who logged step count up to week 52
<b>Dropout</b>	A participant who definitely stopped logging step count before week 52
<b>Active</b>	Daily step count $>$ 10,000 steps/day

**Annexe 2. Table 1. Characteristics of the study population overall and according to dropout or completer status.**

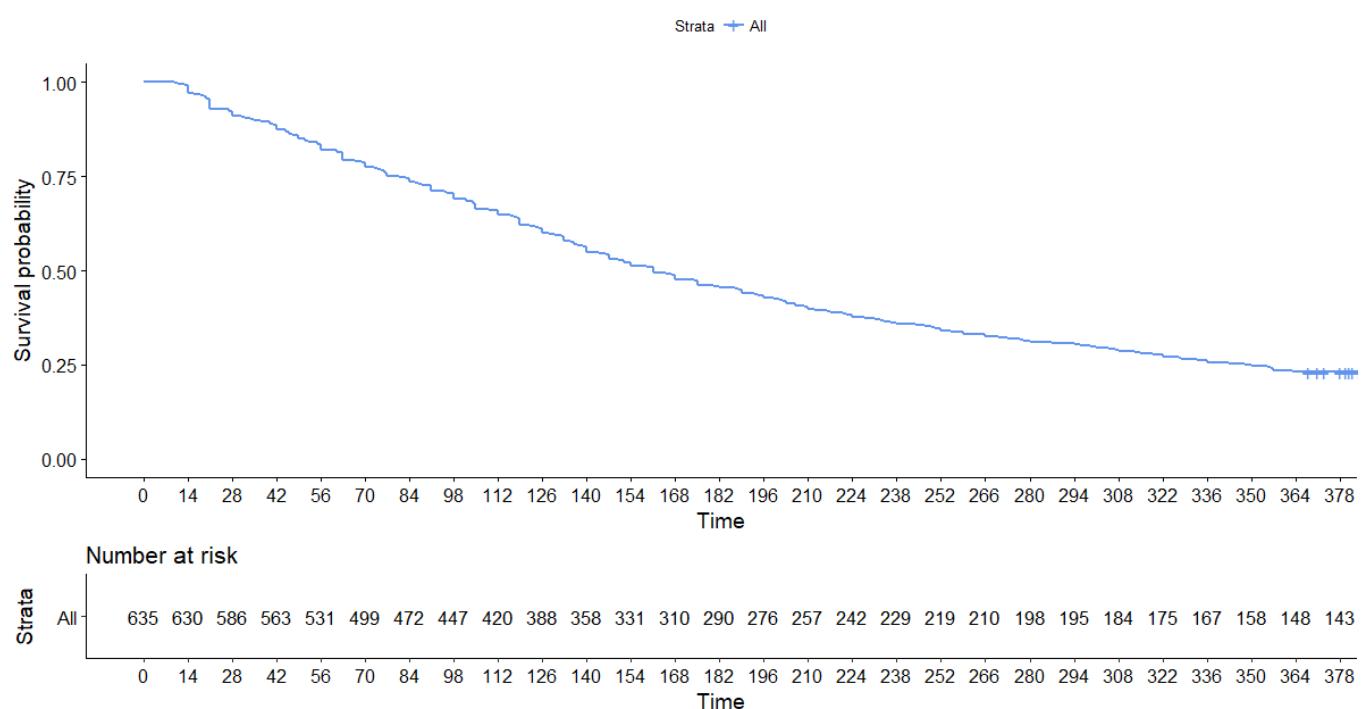
**Table 1. Characteristics of the study population overall and according to dropout or completer status.**

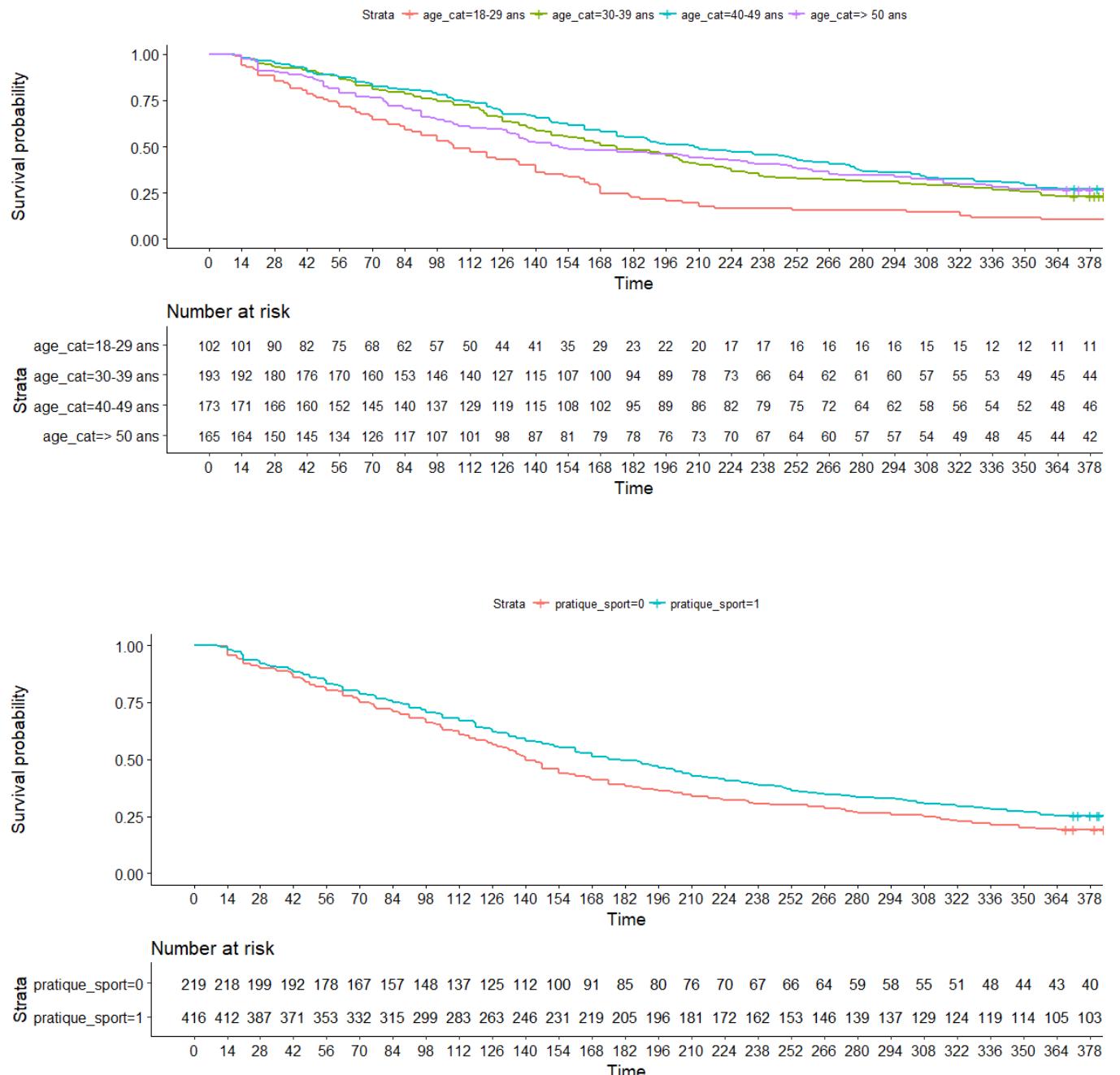
Variable	Overall population (n = 635)	Completers (n = 147)	Dropouts (n = 488)	p*
Age category, n (%)				<b>0.008</b>
18 - 29	104 (16.4)	11 (7.5)	93 (19.1)	
30 - 39	193 (30.4)	45 (30.6)	148 (30.3)	
40 - 49	173 (27.2)	47 (32.0)	126 (25.8)	
>= 50	165 (26.0)	44 (29.9)	121 (24.8)	
Female, n (%)	464 (73.1)	103 (70.1)	361 (74.0)	0.406
Body mass index (BMI), n(%)				0.832
< 18.5 kg·m <sup>-2</sup> (underweight)	19 (3.0)	3 (2.0)	16 (3.3)	
18.5 - 24.9 kg·m <sup>-2</sup> (normal weight)	376 (59.2)	88 (59.9)	288 (59.0)	
25 - 29.9 kg·m <sup>-2</sup> (overweight)	169 (26.6)	41 (27.9)	128 (26.2)	
>= 30 kg·m <sup>-2</sup> (obese)	71 (11.2)	15 (10.2)	56 (11.5)	
Sports practice, n(%)	416 (65.5)	105 (71.4)	311 (63.7)	0.085
Pedometer-determined physical activity level at baseline				<b>0.001</b>
< 5000 steps/day (sedentary)	149 (23.5)	31 (21.1)	161 (33.0)	
5000 - 7499 steps/day (low active)	299 (47.1)	58 (39.5)	209 (42.8)	
7500 - 9999 steps/day (somewhat active)	141 (22.2)	37 (25.2)	86 (17.6)	
10,000 - 12,499 steps/day (active)	35 (5.5)	14 (9.5)	24 (4.9)	
>= 12,500 steps/day (highly active)	11 (1.7)	7 (4.8)	8 (1.6)	

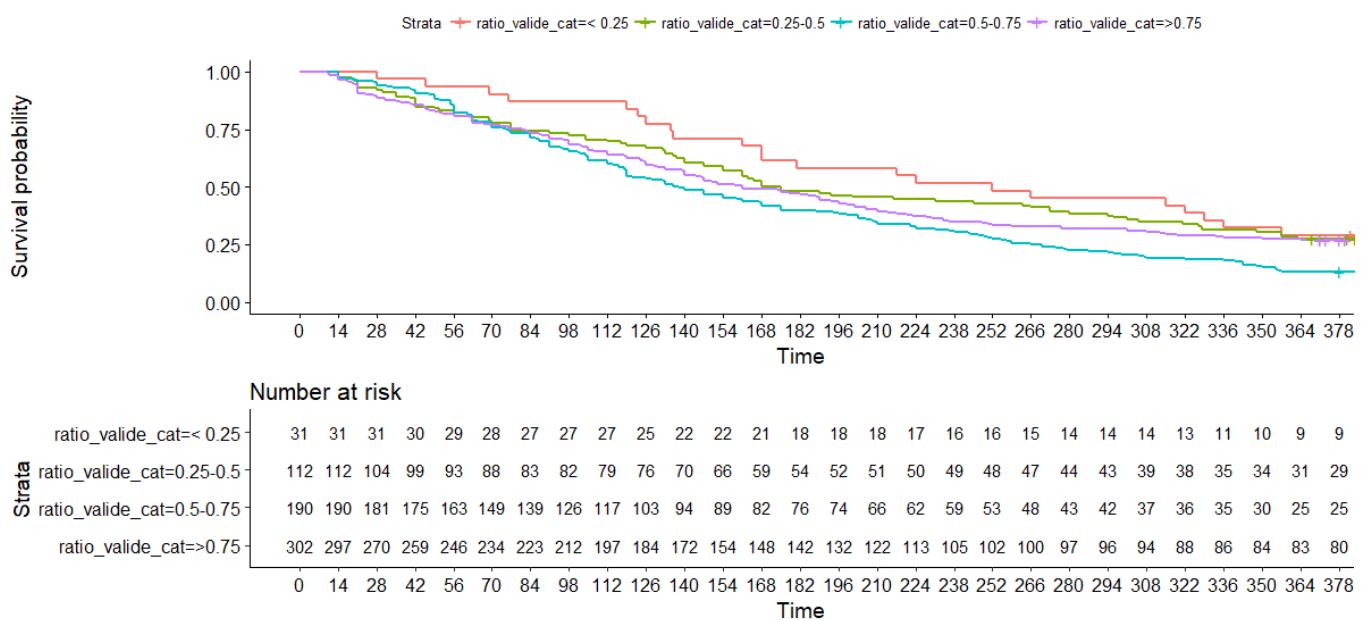
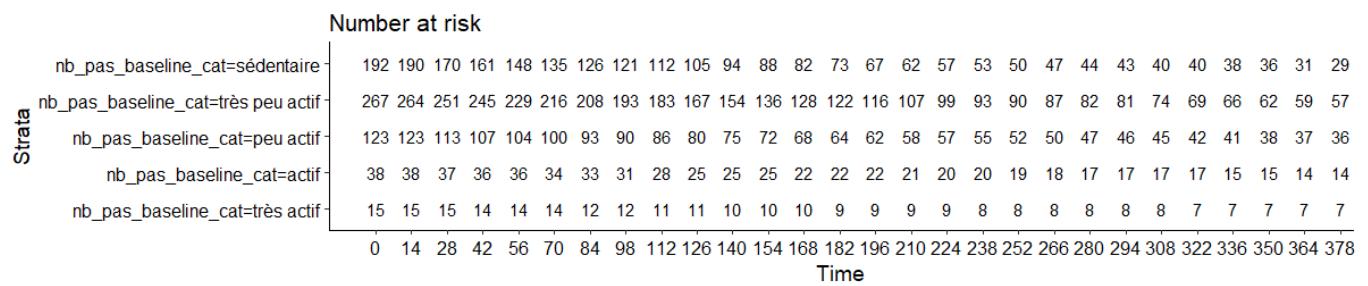
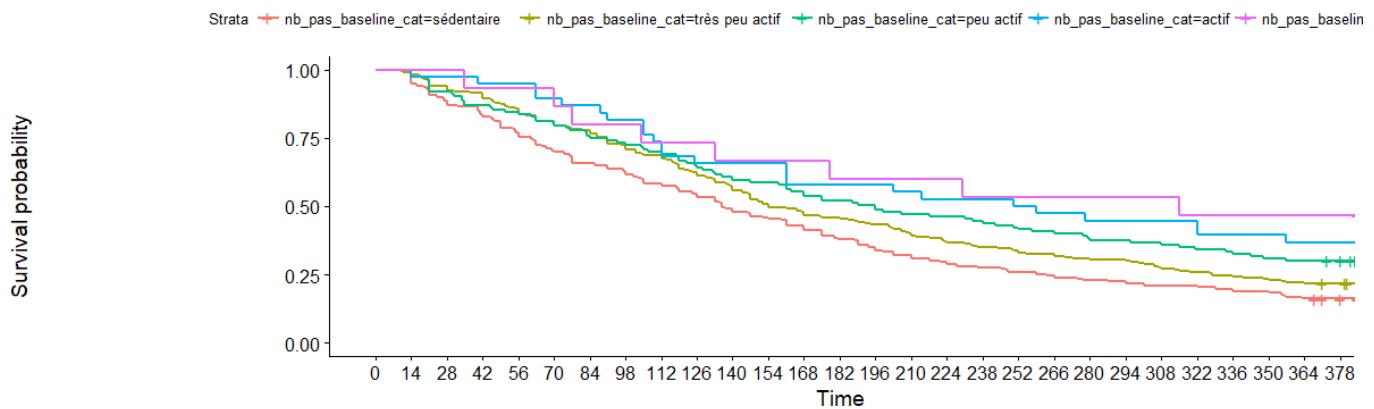
n: number

\*: completers were compared to dropouts.

## Annexe 3. Figure 2. Survival curves.







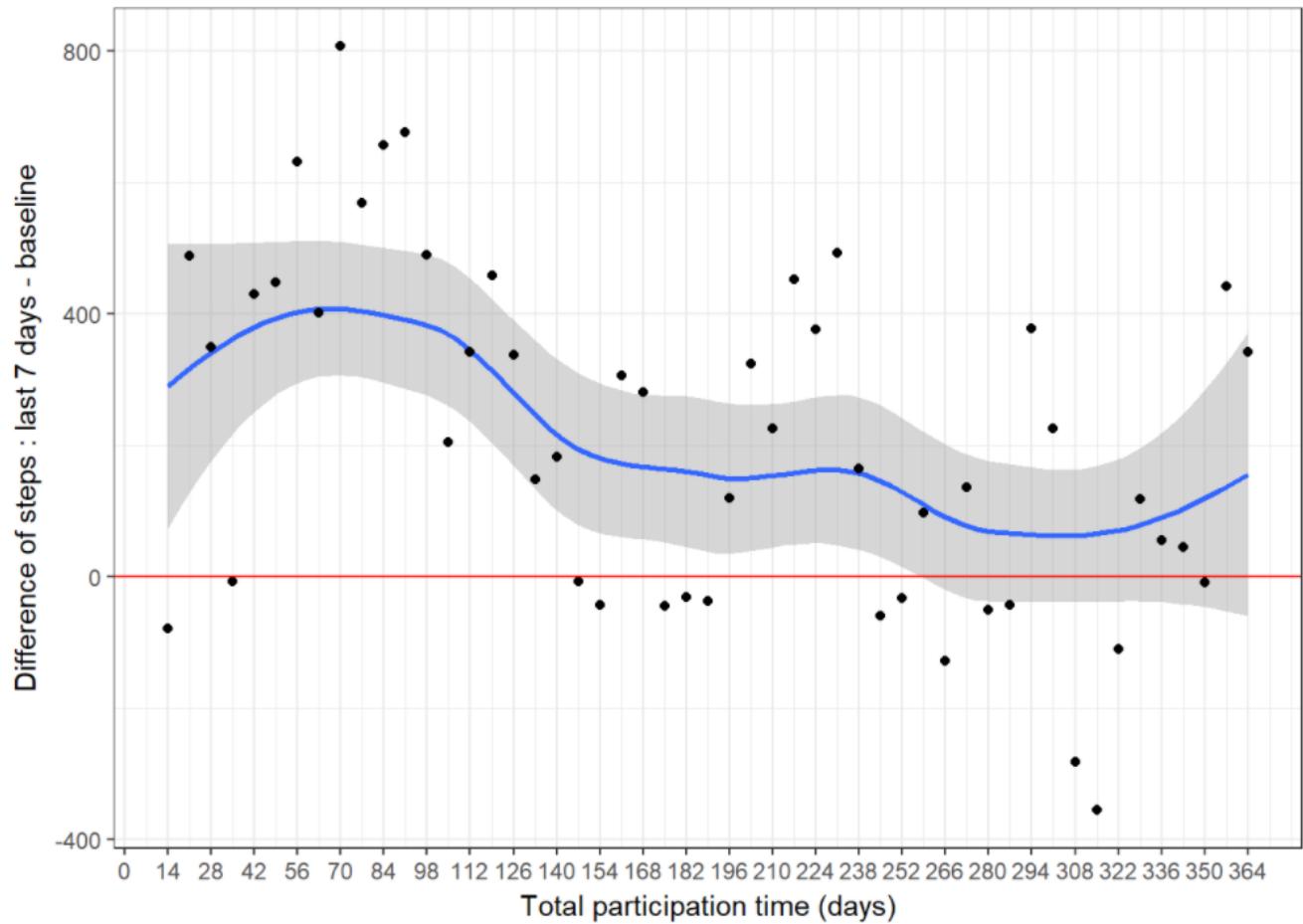
**Annexe 4. Table 2. Univariate and multivariate survival analyses.**

**Table 2. Univariate and multivariate survival analyses.**

Variable	Univariate HR	95% CI	p	Multivariate HR	95% CI	p
Age	0.98	[0.97 ; 0.99]	<b>7.5 * 10-5</b>	0.98	[0.97 ; 0.99]	<b>4.2 * 10-5</b>
Gender (male)	0.94	[0.77 ; 1.15]	0.560	0.96	[0.78 ; 1.18]	0.687
Body mass index (BMI)	0.99	[0.97 ; 1.01]	0.324	0.98	[0.96 ; 1.00]	0.052
Sports practice	0.81	[0.68 ; 0.98]	<b>0.029</b>	0.82	[0.68 ; 0.99]	<b>0.038</b>
Daily step count at baseline (per 1000 steps)	0.92	[0.89 ; 0.96]	<b>3.2 * 10-5</b>	0.91	[0.87 ; 0.95]	<b>3.1 * 10-6</b>
Adherence (ratio logging days/total length of engagement)	1.02	[0.98 ; 1.06]	0.365	1.05	[1.01 ; 1.09]	<b>0.023</b>

95% CI: 95% confidence interval; BMI: body mass index.

**Annexe 5. Figure 3. Evolution of step count increase over the total length of engagement.**



AUTEUR :	NOM : JUNG	Prénom : Yu Jin
<b>Date de Soutenance :</b> 20/12/2017		
<b>Titre de la Thèse :</b>		
Les objets connectés : un levier pour changer les comportements ?		
Résultats à un an de la campagne "10 000 pas, le défi pour la vie"		
<b>Thèse - Médecine - Lille 2017</b>		
<b>Cadre de classement :</b> Médecine		
<b>DES + spécialité :</b> DES de santé publique et médecine sociale		
<b>Mots-clés :</b> activité physique, objet connecté, promotion de la santé		
<p><b>Résumé :</b> <i>Introduction</i> : Le podomètre connecté est un dispositif simple, peu coûteux et fiable pour mesurer le nombre de pas journalier d'un individu et ainsi estimer son niveau d'activité physique. Il peut également être envisagé comme un outil motivationnel pour augmenter le niveau d'activité physique des individus. Cet outil est au cœur de la campagne de promotion de l'activité physique « 10 000 pas : le défi pour la vie » qui a été initiée en 2016 dans la région de Lille et qui cible les travailleurs. Son objectif principal était d'évaluer si l'utilisation du podomètre connecté pouvait agir comme un levier pour augmenter le niveau d'activité physique des individus et maintenir ce changement de comportement à long terme. <i>Matériel et méthodes</i> : Les participants ont été recrutés sur la base du volontariat de février à juin 2016 dans deux entreprises de la région de Lille et ont été suivis jusqu'au 30 juin 2017. Chaque participant a eu accès à un podomètre connecté (Vidonn X6) ainsi qu'à une application pour smartphone et un site internet spécialement conçus pour la campagne. Les caractéristiques des participants et leurs nombres de pas journaliers ont été recueillis. Le taux d'adhésion à la campagne a été monitoré et les participants ont été classés en deux groupes selon leur durée de participation (« dropouts » si moins de un an ou « completers » si au moins un an). Une analyse de survie a été réalisée afin d'identifier les déterminants de l'arrêt prématuré de leur engagement. Chez les completers un test apparié de Student a été utilisé pour comparer leur niveau d'activité physique moyen au début et à un an de la campagne. <i>Résultats</i> : Parmi les 635 individus engagés dans la campagne, 147 (23,1%) ont participé au-delà de un an. La durée moyenne de participation était de <math>212,6 \pm 158,0</math> jours. La moyenne d'âge était plus élevée dans le groupe des completers (43,6 ans vs 40,4 ans ; <math>p = 0,0012</math>) ainsi que le nombre de pas journalier à l'inclusion (7163 pas/jour vs 6236 pas/jour ; <math>p = 0,0001</math>). Un âge plus élevé (<math>HR = 0,98 [0,97 ; 0,99]</math>), la pratique d'un sport (<math>HR = 0,82 [0,68 ; 0,99]</math>) et un nombre de pas journalier à l'inclusion plus élevé (<math>HR = 0,91 [0,87 ; 0,99]</math>) ont été identifiés comme facteurs protecteurs vis-à-vis de l'arrêt prématuré de la participation. Une adhésion plus élevée à l'utilisation du podomètre connecté a été identifiée comme facteur de risque de l'arrêt prématuré de la participation (<math>HR = 1,05 [1,01 ; 1,09]</math>) en analyse de survie multivariée. Parmi le groupe des completers, une augmentation moyenne de +286 pas/jour a été observée après un an de suivi, comparée au nombre de pas journalier à l'inclusion. Néanmoins, cette différence n'était pas statistiquement significative (<math>p = 0,2407</math>). <i>Conclusion</i> : Le podomètre connecté s'est avéré être un bon levier pour initier l'augmentation du niveau d'activité physique. Cependant, il n'était pas suffisant pour durablement maintenir le niveau d'activité physique atteint. Nos résultats soulignent l'importance d'utiliser des stratégies de rappel pour maintenir les effets positifs du podomètre connecté observés pendant les dix premières semaines.</p>		
<b>Composition du Jury :</b>		
<b>Président :</b>	Monsieur le Professeur Philippe AMOUYEL	
<b>Assesseurs :</b>	Madame la Professeure Florence RICHARD	
	Monsieur le Docteur Luc DAUCHET	
<b>Directeur de Thèse :</b>	Madame la Docteure Maël BARTHOULOT	