Patient Education and Counseling 94 (2014) 372–378

Contents lists available at ScienceDirect

Patient Education and Counseling

journal homepage: www.elsevier.com/locate/pateducou

Intervention

Motivational cues as real-time feedback for changing daily activity behavior of patients with COPD

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ARTICLE INFO

Article history:
Received 27 May 2013
Received in revised form 28 September 2013
Accepted 26 October 2013

Keywords:
COPD
Feedback
Motivational cues
Activity behavior
Telemedicine

ABSTRACT

Objective: To investigate how COPD patients respond to motivational cues that aim to improve activity behavior and how these responses are related to cue- and context characteristics. In addition, to explore whether activity can be increased and better distributed over the day by providing such cues.
Methods: Fifteen COPD patients participated. Patients used an activity sensor with a smartphone for four weeks, at least four days/week. Patients received motivational cues every 2 h with advice on how to improve their activity, on top of real-time visual feedback. The response was calculated by the amount of activity 30 min before and after a cue.
Results: In total, 1488 cues were generated. The amount of activity significantly decreased in the 30 min after a discouraging cue ($p < 0.001$) and significantly increased ($p < 0.05$) in the 10 min after an encouraging cue. The activity level increased with 13% in the intervention period compared to corrected baseline ($p = 0.008$). The activity was not more balanced over the day.
Conclusions: COPD patients significantly change their activity level in response to motivational cues, based on continuous ambulatory assessment of activity levels.
Practice implications: Motivational cues could be a valuable component of telemedicine interventions that aim to improve activity behavior.

1. Introduction

Globally, six percent of deaths are attributed to physical inactivity [1]. Regular physical activity is related to better health, reduced risk of (chronic) diseases [2,3], and can increase active life expectancy by limiting the development and progression of chronic disease and disabling conditions [4]. The promotion of a physically activity lifestyle plays an essential role in chronic disease management, such as Chronic Obstructive Pulmonary Disease (COPD) – a respiratory disease characterized by a progressive airflow limitation of the lungs. In patients with COPD, dyspnea (during exertion) is one of the major symptoms, which leads to lower physical activity levels. This is thought to be part of a vicious circle of symptom-induced inactivity, leading to a lack of fitness and a reduced quality of life [5]. In addition, a physically active lifestyle reduces the risk of hospital (re)admission [6–8], increases life expectancy [9], and slows lung function decline [10]. Previous studies demonstrated the inactive behavior of the COPD population [11–18] with a less equally distributed activity pattern [19] compared to healthy individuals. Increasing physical participation in everyday activities is among the key goals in the treatment of COPD [20].

Telemonitoring provides the possibility of measuring activity behavior in daily life in an objective manner. In telemedicine treatments the challenge is to replace some or all of the face-to-face contact with technology-provided coaching. Like the feedback from the professional, ambulant feedback should create awareness about patient's own functioning, motivate and stimulate patients to positively change their activity behavior, and eventually improve patient's functioning [21]. In contrast with the intramural setting of classical physical therapy, telemedicine can provide real-time, intensive feedback in the daily environment of the patient. We expect that feedback on the unobtrusive activity measurements can provide an intensive treatment with positive effects on daily activity behavior, by both increasing and balancing activity patterns. However, to our knowledge, such type of intervention that automatically provides real-time feedback based on objectively measured activity data has not been realized yet for COPD patients.

The Activity Coach – part of a telerehabilitation intervention [22] – consists of an activity sensor and smartphone that aims to

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http://dx.doi.org/10.1016/j.pec.2013.10.014

increase activity levels and to balance activities over the day. The Activity Coach visualizes the activity behavior of the individual patient, and provides real-time motivational cues in the form of text messages (e.g. "You have taken more rest, please go for a walk".) on top of continuous visual feedback i.e. a graph displaying the activity. These motivational cues have been successfully used in studies on chronic fatigue syndrome [23] and chronic low back pain [24], where 75% of chronic low back pain patients had a positive response to the motivational cues. We do not yet know how patients with COPD respond to the feedback and whether this kind of intervention can improve the activity behavior. In addition, we would like to know what determines the response to the motivational cues, so we can tailor future telemedicine treatments that aim to improve activity behavior.

The objective of this study was to investigate how COPD patients respond to motivational cues and whether this response is related to cue- and context characteristics (e.g. time of motivational cue, weather influences). In addition, this study aims to explore whether the daily activity behavior can be altered by providing ambulant feedback enhanced with motivational cues via a smartphone on the activity level during the day. We hypothesize that the amount of activity will increase and that the distribution of activities throughout the day will be more balanced.

2. Methods

2.1. Design and participants

The intervention arm of a randomized controlled trial was studied that aimed to investigate the effect of a telerehabilitation intervention compared to usual care in patients with COPD. This study has been approved by the hospital's Medical Ethical Committee and registered in the Netherlands Clinical trial register (no. NTR2440). Thirty-four patients (22 male, 12 female) with a clinical diagnosis of COPD, were recruited from the department of pulmonary medicine of the *Medisch Spectrum Twente* hospital in Enschede, the Netherlands. The inclusion criteria were: a clinical diagnosis of COPD [20], no infection or exacerbation in the 4 weeks prior to start of the study, and a current or former smoker. Exclusion criteria were disorders or progressive disease seriously influencing daily activities or causing inability to use the smartphone application, other diseases influencing bronchial symptoms and/or lung function, need for regular oxygen therapy (>16 h per day or $pO_2 < 7.2$ kPa), history of asthma, and recently (<6 weeks) started training with a physiotherapist. Eligible patients were randomly assigned to either the intervention or control group according to a computer-generated randomization list. Sixteen patients participated in the control group (mean age: 68 years, male/female: 11/5, mean FEV_1%predicted: 56.4%). Patients in the control group received regular care, which could consist of e.g. medication and physiotherapy. The results of the randomized controlled trial are described separately [22]. Fifteen patients started with the intervention, but one patient was lost to follow up in the intervention group in the third week.

2.2. The activity coach intervention

The activity coach consisted of an activity sensor (MTx-W sensor, Xsens Technologies) and a smartphone (HTC P3600/3700). The activity sensor was a triaxial accelerometer, which measured 3D acceleration, expressed in counts per minute (cpm). The sensor connected wirelessly with the smartphone using Bluetooth. Both the sensor and smartphone were worn on the subject's belt. Patients used this system for four weeks from waking up until 22.00 in the evening, with a minimum of four days per week. The first week was a baseline measurement, followed by 3 weeks in which the patient received feedback to change activity behavior. This feedback consisted of (1) visual continuous feedback in the form of a graph and (2) text-based motivational cues. This feedback aimed to increase the activity level and distribute the activity level more equally over the day.

Fig. 1. Left: continuous feedback, right: text-based motivational cue. (Translation: "You took more rest. Please go for a walk around the block".)

2.2.1. Visual continuous feedback

The smartphone showed the measured activity cumulatively in a graph, together with the cumulative activity the patients should aim for: the reference activity line (Fig. 1, left). This reference line was developed based on a combination of social comparison (with healthy individuals) and temporal comparison (with oneself). The patient's baseline was compared to a social norm line (based on the data of 56 healthy controls) and the difference between both lines was calculated. To establish the reference line, the baseline of the patient was increased by 50% of this difference (Eq. (1)).

$$\text{Reference line} = \text{baseline patient} + 0.5 * (\text{social norm line} - \text{baseline patient}) \quad (1)$$

The reference line and the measured activity were displayed on the smartphone, so patients could continuously see their activity pattern in order to raise awareness. Patients were asked to try to approach the reference line as closely as possible during the day.

2.2.2. Motivational cues

During the intervention, the patients automatically received text-based motivational cues every two hours on the smartphone, in order to increase awareness and provide extra motivation. These cues were based on the difference between the measured activity and the reference line at the moment the cue was generated. Based on this deviation, the patient received advice to become more active, less active, or that they are doing well. The text message always consisted of (1) short summary of activity behavior of the past two hours and (2) an advice on how to improve the activity behavior (see Fig. 1, right). There were three types of motivational cues: encouraging cues (>10% deviation below reference line), discouraging cues (>10% deviation above reference line) and neutral cues (≤10% deviation with reference line). An encouraging cue could be for example: "you took more rest, we advise you to take a short walk" and a discouraging cue could be: "you have been

Table 1
Overview of the cue characteristics and context variables that were logged with the motivational cues.

Cue characteristic/context variable	
Hour of day	Hour of day in which the cue was provided (between 8.00 and 22.00)
Day part	Day part in which cue was provided (morning, afternoon, evening)
Day of the week	Day of the week in which cue was provided (Monday–Sunday)
Feedback day of usage	The number of days the Activity Coach was used in (the intervention period) in which cue was provided
Near full hour	Whether or not the message was read within 5 min after the full hour (time of generation by the system)
Delayed read of cue	The number of seconds between the time of message generation and the time of reading.
Distance from reference	The deviation from the reference line (in counts per minute)
Approaching reference	Was the patient approaching the reference line in the 30 min before the cue was provided? (yes/no)
Motivational cue	The motivational cue that was provided (17 options)
Cue: go outside	Was the cue suggesting to be more active by going outside? (yes/no)
Cue: question	Was the cue provided as a question? (yes/no)
Cue: suggest idle	Whether or not the message suggests to perform an activity (e.g. read) or to idle (e.g. 'please relax')
Temperature (min)	Minimum outside temperature of that day on which the cue was provided (in degrees Celsius)
Temperature (max)	Maximum outside temperature of that day on which the cue was provided (in degrees Celsius)
Temperature (mean)	Mean outside temperature of that day on which the cue was provided (in degrees Celsius)
Cloud scale	The cloud scale of that day on which the cue was provided (from 0: no clouds to 8: completely covered)
Precipitation sum	The total amount of precipitation of that day on which the cue was provided (in mm)
Precipitation duration	The total duration of precipitation of that day on which the cue was provided (in hours)

very active, take some time to read a magazine". Neutral cues were provided for extra motivation when the patient was doing well, such as: "you are doing well, keep up the good work!" The last generated motivational cue could be retrieved by pressing the advice button in the graph screen.

2.3. Measures

The objective daily activity was measured using the MTx-W sensor which measured 3D acceleration, as described previously [19]. The final output was expressed in activity counts per minute (cpm). In order to investigate the responses to the motivational cues, all the cues generated by the system were logged. The patient had to confirm reading a motivational cue by pushing a button, taking the patient back to the graph screen. This event was logged with the corresponding time stamp. In addition, cue characteristics and context variables were logged with the motivational cue retrospectively, like the outside temperature (see Table 1). General patient characteristics (age, gender, work status) were retrieved before start of the intervention.

2.4. Data analysis

The mean activity for each patient was calculated for the baseline- and intervention period. Only those days were included

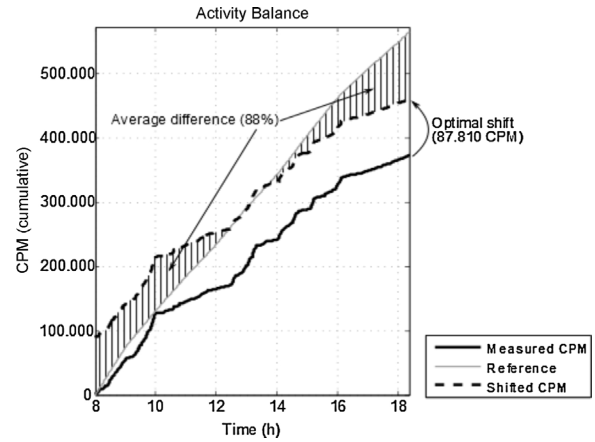

Fig. 2. Illustration on how the activity balance was calculated. The absolute difference between the reference line and measured activity line for each data point was calculated. Subsequently, the line was vertically translated with a constant *c* to obtain the smallest difference. This mean smallest cumulative deviation from the reference line is divided by the mean cumulative activity value of the reference line and expressed as a percentage.

in the analysis for which at least 6 h per day were available. To investigate the response to the motivational cues, we compared the amount of activity (in cpm) 30 min before (act_{before}) the cue was seen by the patient with a time interval after the cue was seen (act_{after}). The time intervals are: 5-, 10-, 15-, 20-, 25-, and 30 min. The magnitude of the response was expressed as a percentage of change (Eq. (2)).

$$\text{Response}\,(\%) = \frac{act_{after} - act_{before}}{act_{before}} \times 100 \quad (2)$$

The response of an individual cue was only calculated if 90% of the data points per time interval was available. For discouraging cues we expected a decrease in activity level and for encouraging cues we expected an increase of activity. For neutral cues we expected no significant response. To investigate how the responses are related to cue- and context characteristics the time interval (between 10 and 30 min) was used where the largest response was found. To investigate whether the distribution of activities throughout the day would be more balanced, we calculated the absolute difference between the reference line and measured activity line for each data point (every minute). Subsequently, the line was vertically translated with a constant *c* to obtain the smallest difference and thus to rule out the influence of the activity level. This mean smallest cumulative deviation from the reference line was divided by the mean cumulative activity value of the reference line and expressed as a percentage (Fig. 2). In other words, when the patient's activity line follows the exact same pattern as the reference line, the percentage would be 100%.

To investigate whether the patient increased the activity level, we calculated the mean activity level during baseline and during intervention. In our study, which was part of a telerehabilitation intervention [22], patients wore a pedometer in addition to the activity sensor. They recorded their steps/day during the whole study period in a paper diary. Literature shows that recording your steps in a diary already causes a substantial increase in activity level in the first measurement week compared to a blinded baseline activity measurement [25]. As such, Clemes and Parker advised the first three days of a baseline measurement to be treated as a familiarization period. These results were confirmed by our pedometer findings from the RCT [22]. Therefore, we corrected for this effect by a lowering of the entire baseline period by 13.21% based on the results found by Clemes and Parker [25].

Table 2
Patient characteristics, expressed as means (standard deviations) or counts.

	COPD patients ($n = 15$)
Age (years)	66 ± 9.2
Gender (male/female)	9/6
FEV_1% predicted	47.7 ± 16.6
GOLD stage (II/III/IV)	5/8/2
BMI (kg/m^2)	28.1 ± 7.5
Current smoker (yes/no)	1/14
Work status (employed/unemployed)	4/11

COPD, chronic obstructive pulmonary disease; FEV_1% predicted, forced expiratory volume in 1 s percent predicted; GOLD, Global Initiative for Chronic Obstructive Lung Disease; BMI, Body Mass Index.

Both the original and the corrected data were displayed in the results.

2.5. Statistical analysis

The results were described in terms of mean (SD), counts or percentage. The Statistical Package for the Social Sciences (SPSS, 19.0) was used for statistical analyses, and the alpha was set at 0.05. p values ≤ 0.20 were shown; p values > 0.20 were shown as non significant (ns). The analyses were performed separately for encouraging, discouraging and when applicable, neutral cues.

The response to the motivational cues was tested using a paired t-test, comparing the 30 min activity interval before the cue, with the activity level after the cue in increasing time intervals, to be able to observe the possible difference between a faster or slower response. All cues were used for calculating the overall response on a group level. Similarly, the change in amount of activity and balance was tested using a paired t-test, comparing the baseline period with the feedback period.

To investigate the relation of the response to the motivational cues, the following tests were performed. When comparing two categories the independent Student's t-test was used, and when comparing more than two categories analysis of variance (ANOVA) with the Bonferroni post hoc test was used. The Pearson product-moment correlation coefficient (r) or Spearman's rank correlation coefficient (r_s) was calculated to evaluate the relationships of the response with continuous variables, as appropriate.

3. Results

3.1. Characteristics

Fifteen patients were included in the intervention. Table 2 shows the patients' characteristics.

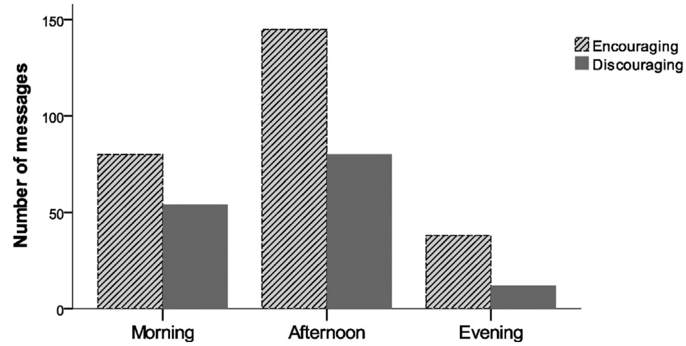

Fig. 3. Number of motivational cues per day part, subdivided into encouraging cues and discouraging cues.

3.2. Response to motivational cues

In total, 1488 motivational cues were generated. One patient did not have sufficient sensor data and was excluded from analysis. One patient was lost to follow up in the third week, but the results are included in the analysis of the response to motivational cues. For the analysis ($n = 14$), 809 motivational cues were used of which 250 (31%) encouraging, 421 (52%) neutral, and 138 (17%) discouraging cues. Others were excluded because either they did not have 90% of the data points available in all time intervals, either due to a gap in the sensor data, or due to partly overlapping responses when 2 cues were viewed in too rapid succession. Fig. 3 shows the distribution of encouraging and discouraging cues per day part. The patients received a different set of motivational cues: 5 patients received mostly encouraging cues, 7 patients mostly neutral cues, 1 patient mostly discouraging cues and 1 patient received encouraging and neutral cues equally. Of this group, there were 3 patients that did not receive any discouraging cues.

Table 3 shows the response to the motivational cues on a group level. Patients respond significantly to discouraging cues for all time intervals, with the largest response for the 30 min interval. Patients also significantly respond to encouraging cues, although mainly in the first 5–10 min. There was no significant response found for the neutral cues, which corresponds to our expectancies. Due to these findings, the rest of our analysis of discouraging cues will employ the 30 min interval after the cue, and for encouraging cues the 10 min interval is used.

3.3. Relation with response to motivational cues

The relationships between the response to motivational cues and cue characteristics are shown in Table 4. For encouraging

Table 3
Response to the motivational cues ($n = 809$). The table shows the total number of motivational cues, subdivided into encouraging, neutral and discouraging cues and the response to these cues. The response is shown for different time intervals, to be able to observe the possible difference between a faster or slower response.

Cue type	N	$t = 5$	$t = 10$	$t = 15$	$t = 20$	$t = 25$	$t = 30$
Discouraging	138	−25% $p < 0.001$***	−25% $p < 0.001$***	−25% $p < 0.001$***	−26% $p < 0.001$***	−27% $p < 0.001$***	−29% $p < 0.001$***
Encouraging	250	+23% $p = 0.005$**	+15% $p = 0.017$*	+11% $p = 0.076$	+10% $p = 0.100$	+11% $p = 0.090$	+10% $p = 0.115$
Neutral	421	−3% *ns*	−6% $p = 0.109$	−6% $p = 0.137$	−5% $p = 0.158$	−6% *ns*	−5% $p = 0.116$

* $p \leq 0.05$.
** $p \leq 0.01$.
*** $p \leq 0.001$.

Table 4
Relations with the response to the motivational cues, and cue characteristics and context variables. The correlations are shown separately for encouraging and discouraging motivational cues.

	Encouraging	Discouraging
Hour of day	*ns*	$r = 0.168$, $p = 0.043$ [*]
Day part	*ns*	*ns*
Day of the week	*ns*	*ns*
Feedback day of usage	$r = 0.097$, $p = 0.118$	$r = -0.109$, $p = 0.189$
Near full hour	*ns*	*ns*
Delayed read of cue	*ns*	*ns*
Distance from reference	*ns*	*ns*
Approaching reference (yes/no)	$p < 0.001$ [***] (CI: −279, −130)	$p = 0.014$ [**] (CI: 7.4, 65.5)
Motivational cue (17 options)	$p = 0.021$ [*,a]	*ns*
Cue: go outside (yes/no)	$p = 0.102$ (CI: −198, 17.9)	n/a
Cue: question (yes/no)	*ns*	*ns*
Cue: suggest idle (yes/no)	n/a	*ns*
Temperature (min)	*ns*	$r = 0.159$, $p = 0.055$
Temperature (max)	*ns*	*ns*
Temperature (mean)	*ns*	$r = 0.126$, $p = 0.131$
Cloud scale (1–8)	*ns*	*ns*
Precipitation sum	*ns*	$r = 0.232$, $p = 0.005$ [**]
Precipitation duration	*ns*	$r = 0.156$, $p = 0.060$

[a] Bonferroni post hoc test, mean response (%) is −14 (75) and 271 (404), for respectively 'Do you need something out of town?' and 'Is there something to clean in your house?' ($p = 0.045$).
[*] $p \leq 0.05$.
[**] $p \leq 0.01$.
[***] $p \leq 0.001$.

cues, a significant relation was found for the 'approaching reference' parameter. When a person was approaching the reference line in the half hour before the cue, the mean response to the cue was $-10 \pm 66\%$, while when a person was not approaching the reference line, the response was $194 \pm 410\%$. For discouraging cues this was respectively $+10 \pm 90\%$ and $-27 \pm 84\%$. In other words, when patients are not already improving their activity behavior the 30 min before the cue, they respond better to the cue. In addition, patients respond significantly different to the different encouraging cues. The highest responses were found for: 'Is there something to clean in your house?' and 'Go for a nice walk!', while a negative response was found for 'Do you need something out of town?' After this cue, patients became less active. The response to discouraging cues significantly related to the hour of day and the amount of precipitation, and showed a trend with the minimum temperature.

3.4. Activity behavior

In total, there were 254 measurement days of which 186 feedback days with >6 h measured. One patient dropped out due to technical problems in the third week and three patients were excluded from the data analysis because of insufficient data in the baseline period. Therefore, 11 COPD patients were included in the data analysis.

Table 5 shows the measured activity levels at baseline and at the intervention period, per patient and for the total group. In addition, this table shows whether the patients increase and balance their activity level. On a group level, no significant changes were found in activity level or balance. The table also shows the activity data corrected for reactivity (based on [25]). After this correction, the activity level significantly improved on a group level. The response to the encouraging motivational cues was significantly related to the percentage change in activity level ($r_s = 0.66$, $p = 0.026$), but not to balance. The response to discouraging motivational cues showed no significant relationships with activity level or balance.

Table 5
Original activity data and balance data, and the corrected activity, per patient and for the group ($n = 11$). We corrected for the reactivity effect by a lowering of the baseline period by 13.21%.

No.	*T*	Activity (cpm)	Balance (%)	Corr. activity (cpm)
1	Baseline	851 ± 117	94.7 ± 1.2	738 ± 101
	Intervention	928 ± 135	93.3 ± 2.4	914 ± 125
	Difference	+9%, *ns*	−1%, *ns*	+24%, $p = 0.051$
2	Baseline	1072 ± 178	93.0 ± 2.2	930 ± 155
	Intervention	1104 ± 187	92.9 ± 5.6	1104 ± 187
	Difference	+3%, *ns*	−0%, *ns*	+19%, $p = 0.134$
3	Baseline	556 ± 106	85.7 ± 7.6	483 ± 92
	Intervention	549 ± 80	87.9 ± 5.9	549 ± 80
	Difference	−1%, *ns*	+3%, *ns*	+14%, *ns*
4	Baseline	990 ± 203	91.8 ± 2.2	859 ± 176
	Intervention	1008 ± 196	91.5 ± 3.6	1008 ± 196
	Difference	+2%, *ns*	−0%, *ns*	+17%, *ns*
5	Baseline	1047 ± 142	86.6 ± 6.3	908 ± 123
	Intervention	1006 ± 78	94.3 ± 2.3	1006 ± 78
	Difference	−4%, *ns*	+9%, $p = 0.003$ [**]	+11%, $p = 0.074$
6	Baseline	1102 ± 154	92.8 ± 1.3	957 ± 134
	Intervention	849 ± 139	90.2 ± 4.0	849 ± 139
	Difference	−23%, $p = 0.005$ [**]	−3%, $p = 0.174$	−11%, $p = 0.165$
7	Baseline	763 ± 106	89.6 ± 9.6	663 ± 92
	Intervention	681 ± 169	85.4 ± 9.0	681 ± 169
	Difference	−11%, *ns*	−5%, *ns*	+3%, *ns*
8	Baseline	875 ± 126	94.8 ± 2.5	759 ± 110
	Intervention	917 ± 53	95.8 ± 1.0	917 ± 53
	Difference	+5%, *ns*	+1%, *ns*	+21%, $p = 0.002$ [**]
9	Baseline	945 ± 61	94.0 ± 2.4	820 ± 53
	Intervention	829 ± 41	92.8 ± 2.1	829 ± 41
	Difference	−12%, $p = 0.020$ [*]	−1%, *ns*	+1%, *ns*
10	Baseline	332 ± 48	78.0 ± 4.8	288 ± 42
	Intervention	573 ± 153	90.4 ± 7.3	569 ± 158
	Difference	+73%, $p = 0.003$ [**]	+16%, $p = 0.003$ [**]	+98%, $p = 0.001$ [**]
11	Baseline	1593 ± 616	88.6 ± 9.3	1382 ± 535
	Intervention	1507 ± 460	88.0 ± 8.5	1507 ± 460
	Difference	−5%, *ns*	−1%, *ns*	+9%, *ns*
T	Baseline	920 ± 323	89.9 ± 5.1	799 ± 280
O	Intervention	904 ± 268	91.1 ± 3.1	903 ± 269
T	Difference	−2%, *ns*	+1%, *ns*	+13%, $p = 0.008$ [**]

[*] $p \leq 0.05$.
[**] $p \leq 0.01$.

4. Discussion and conclusion

4.1. Discussion

This study aimed to investigate how COPD patients respond to motivational cues, whether this response is related to cue- and context characteristics and in addition, to explore whether the daily activity can be altered by providing these cues. This study showed that COPD patients significantly change their activity level on a short-term notice in response to motivational cues on a smartphone. On a group level, the activity level increased with 13% in the intervention period compared to corrected baseline, but was not more balanced.

Patients responded significantly to discouraging cues, with the largest response for the 30 min interval. In response to the encouraging cues, people became increasingly active for at least 10 min. This corresponds to the ACSM guidelines, which indicate that the recommended amount of physical activity can be reached by engaging in several short periods of activity lasting at least 10 min to accumulate the desired amount of daily activity. Patients with COPD often show sedentary activity behavior, and in this group, also accumulation of shorter sessions of physical activity (<10 min) may result in fitness and health benefits as long as the total energy expended is similar [26]. When sedentary activities are broken up by short periods of physical activity or standing, this can decrease the damaging effects of sedentary behavior [27]. Therefore, text-based motivational cues provided on a smartphone seem feasible to use for activity interventions in COPD. Nguyen et al. used weekly reinforcement text messages in a cell-phone based exercise intervention for COPD, but did not find a significant contribution of these messages to the end results of their exploratory study [28]. This could very likely be caused by the low frequency of the messages provided. Text messaging on mobile devices are shown to be an effective manner for influencing physical activity behavior in several user groups [29]. Although the results were positive, these interventions neither provided messages automatically, nor in real-time. Dekker-van Weering et al. did provide time-based text messages to patients with chronic low back pain, and found significant responses to both encouraging and discouraging messages [24].

Patients received a mixture of encouraging, discouraging and neutral cues, whose distribution differed considerably between patients. Most encouraging cues were provided in the afternoon, which could be expected as the activity pattern of COPD patients show a decrease in activity level in the afternoon [19]. The responses to the motivational cues, especially to encouraging cues, were not clearly related to the cue- or context variables. Only when a patient was approaching the reference line in the 30 min before the cue was provided, the response was lower than when the patient was not approaching the reference line. Other variables, like the influence of the time and weather were only weakly related to the response. From our study results, we can therefore not provide a general recommendation for the motivational cues – describing the best type of cue, under what kind of conditions they should be provided or at what moment – applicable to the general COPD population. COPD is a systemic disease, influenced by comorbidities, and patients exhibit great variation in their degree of activity behavior [30]. Together with the different responses found among the patients to the motivational cues, this suggests that the response and compliance would be better when the system would be able to adapt to its individual user, which underlines the recommendation toward more personalized medicine and tailor-made treatments in COPD [30,31]. Such a personalized system should be able to learn to predict the optimum content and timing by analyzing the responses on previously given cues and learning when a patient is likely to respond well to a given cue by relating relevant context factors to patient compliance and content [32]. In addition, investigating the influence of patient characteristics and behavioral parameters, such as the stages of change [33], on the response to motivational cues would be an additional potential improvement to gain more insight in these relationships.

This study showed that the activity level significantly increased compared to corrected baseline, but was not more balanced, which partly confirmed our hypothesis. This increase in activity level was significantly related to the response to the encouraging motivational cues. In other words, the motivational cues seem to contribute to an improvement in activity level. Clinical guidelines indicate that self-monitoring – using e.g. activity sensors – has been the behavior modification strategy that has produced the most consistent effects in increasing participation in physical activities in daily life [34]. However, providing an activity sensor could be an intervention on its own, and an important factor for baseline measurements or monitoring studies [25]. In the present study, we corrected for this effect by lowering the measured values of the entire baseline period. For future studies, a blinded activity sensor is recommended, and a longer baseline period, to obtain the least influence of reactivity. The activity level was not more balanced over the day, and motivational cues had no direct influence on the activity balance. A balanced daily activity pattern is often assumed to be beneficial in regular care to improve patient's well-being, as the energy is more efficiently spread over the day. This is not directly mentioned in the guidelines and more research is needed, on how we can improve this balance and whether this can indeed improve patient's quality of life. A potential limitation of the current study is that we applied personal feedback within a telerehabilitation program of four weeks, which is very short to establish changes in behavior. More research is needed to investigate the effects of the Activity Coach and whether it can motivate patients in the long term to establish sustainable behavior change.

4.2. Conclusion

This study was to our knowledge the first intervention that provides motivational cues as real-time feedback to promote a change in activity behavior in COPD. It shows that using motivational cues provided on a smartphone seems feasible and can positively change activity behavior. More research into optimization of the feedback strategy and a more adaptive generation of feedback may result in an innovative approach to promote an active healthy behavior, which is beneficial for patients with COPD.

4.3. Practice implications

This first study shows that motivational cues could be a valuable component of telemedicine interventions that aim to improve activity behavior. Providing feedback to the patient about the physical activity behavior is important to stimulate self-management. The Activity Coach could support patients in enabling a more active and healthy lifestyle through active participation in their healthcare.

Conflict of interest

None declared.

Acknowledgement

This study was supported by a research grant from The Netherlands Organization for Health Research and Development (ZonMW).

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