Depression severity correlated with remotely collected smartphone-, wearable-, and self-reported outcome data: a pilot study

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Introduction

Drug development for mood disorders can benefit from remotely monitored biomarkers that quantify treatment effects. Smartphones and wearable devices offer an opportunity for non-invasive and passive monitoring of real-time behavior. We used the CHDR Monitoring Remotely Platform (MORE™) to monitor and identify potential social, physical, and physiological clinical endpoints that might correlate with the Structured Interview Guide for the Hamilton Depression Rating Scale and Inventory of Depressive Symptomatology (SIGH-IDS), a depression severity rating scale often applied in drug trials.

Sensor	Feature Category	Features Extracted
Smartphone	Smartphone Use	98% acceleration magnitude
		number of times opening an app(per app category such as social Apps, gaming Apps)
		total duration of App use (per app category such as social Apps, gaming Apps)
	Location (GPS/Google places API)	total time spent at a location (per place category, such as home, social locations)
	Social Activity	% of time a voice is present; number of incoming, outgoing and missed calls; number of calls with known and unknown contacts; total and average call duration
Smartwatch	Physical activity	heart rate; steps; exercise duration
	Sleep	total sleep duration; number of times waking up during sleep
Blood Pressure Monitor & Scale	Biometric	blood pressure; weight

Table 1. *Features extracted from the CHDR MORE™ platform. In total 56 features were extracted.*

Methods

In this non-interventional pilot study, 30 male and female outpatients with major depressive disorder (MDD) without psychotic features or persistent depressive disorder (PDD), and 29 non-depressed, age and gender-matched controls were monitored for 3 weeks. Daily social, physical, and physiological activity was monitored using the CHDR MORE™ smartphone-based application (Table 1). Depression Anxiety Stress Scale-21 (DASS-21) and Positive and Negative Affect Schedule (PANAS) were remotely administered regularly, and the Structured Interview Guide for the Hamilton Depression Scale and Inventory of Depressive Symptomatology (SIGH-IDS) was administered weekly in-clinic. Given the longitudinal nature of the data, a cross-validated linear mixed-effects regression model was used to assess the correlations between daily activity, self-reported outcomes (DASS-21 and PANAS), and weekly SIGHD-IDS total scores.

Results

The SIGH-IDS total score regression model achieved a variance explained (R^2) of 0.8, and a Root Measure Square Error (RMSE) of ±15 points (Figure 1). Weekly DASS anxiety, depression, and stress subscales, and mean steps per minute were significantly positively correlated with the weekly SIGH-IDS total score, while the time spent travelling was negatively correlated with the weekly SIGH-IDS total score (Figure 2). The averaged weekly PANAS scores were not significantly correlated with the weekly SIGH-IDS total scores.

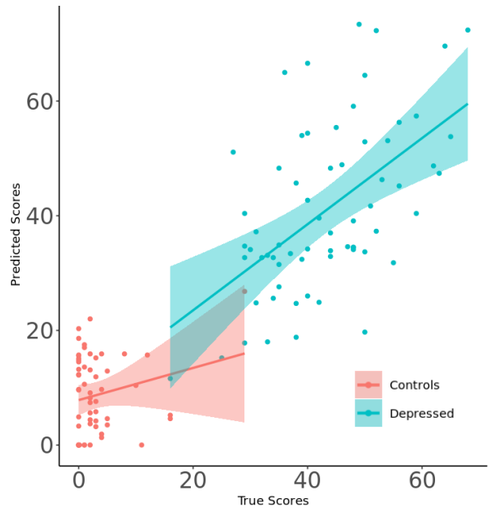

Figure 1. *Illustration of the linear relationship between the true and predicted SIGH-IDS total scores. The blue and red lines (with corresponding 95% confidence interval bands) represent the unipolar depressed outpatients and the healthy controls, respectively.*

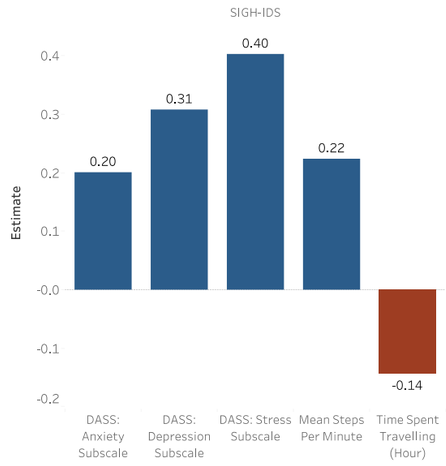

Figure 2. *Overview of all significant features ($p<0.05$) determined by the SIGH-IDS regression model. The bars represent the estimate for each of the significant features. The blue and red bars represent the positive and negative estimates, respectively.*

Conclusion

Remotely collected data related to physical activity correlated negatively, while self-reported anxiety, depression and stress correlated positively, with depression severity. Although remotely collected behavioural biomarkers arguably cannot replace in-clinic assessment for the quantification of treatment effects in MDD, measures such as physical activity, that are prone to depression related reporter-bias, can be objectively evaluated and therefore should be considered in the design of future MDD drug trials.

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