The Reliability and Usability of Ecological Momentary Assessment Platform ReCoUPS to Monitor Concussion Symptoms and Psychological HRQoL

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INTRODUCTION

- Post-concussion symptoms may elicit negative emotions related to health and well-being, or psychological health-related quality of life (PHRQoL),[1,2] which is worse 3-10 days post-injury.[2] However, it is not known if PHRQoL changes, or fluctuates, throughout concussion recovery.
  - Psychological components of HRQoL include anxiety and depressive symptoms.[3]
- *Recovering Concussion Update on Progression of Symptoms* (ReCoUPS) is a novel, reliable and feasible ecological momentary assessment (EMA) platform which provides remote monitoring of concussion symptoms in real time.[4] However, ReCoUPS has yet to be used to monitor PHRQoL throughout concussion recovery.
- Despite the known possible impairments of PHRQoL post-concussion, there is a lack of reliable evidence supporting the measurement of these outcomes in real-time, specifically using EMA methodologies.

PURPOSE

- To investigate evidence of the psychometric properties of a post-concussion symptom checklist and PHRQoL inventories administered via novel, mobile EMA platform, ReCoUPS, in healthy individuals.

METHODS

- **Study Design.** A test-retest reliability study of healthy college aged individuals who currently participate or recently (i.e., within the past year) participated in sport (e.g., rec, club, varsity).
- **Materials.** Demographics, medical history information, and enrollment in the online ReCoUPS platform (facilitated through SMS text messaging) were completed at the initial visit.
  - A total of 30 survey questions from The Sport Concussion Assessment Tool-6 (SCAT6) Symptom Checklist (22 questions) and the Patient Reported Outcomes Measurement Information System Emotional Distress Short Forms Anxiety and Depression (PROMIS Anxiety and PROMIS Depression; 4 questions each) were completed via ReCoUPS daily text messages for 7 days to capture momentary (i.e., currently feeling) symptoms and PHRQoL.
    - SCAT6 symptoms were clustered for healthy individuals as affective (e.g., more emotional, nervous or anxious), cognitive-fatigue (e.g., feeling slowed down, fatigue/low energy), and migraine (e.g., sensitivity to light, sensitivity to noise).[5]
    - Participants selected a 6-hour time frame which they were most likely to respond to text messages (i.e., 9:00 am-3:00 pm, 12:00 pm-6:00 pm, or 3:00 pm-9:00 pm). Surveys were sent at random within these time frames.
  - ReCoUPS surveys were terminated, recalled (i.e., within the past 7 days) PROMIS inventories, and a brief user feedback survey were completed at the study closure visit (i.e., 8 days after the initial visit).
- **Agreement Coding.** Total momentary PHRQoL assessments ranged from 0-24 (i.e., Likert Scale of 0-6 for 4 questions; >0 indicates impairment present) to match SCAT6 Likert Scale (0-6), while total recalled PHRQoL ranged from 4-20 (i.e., Likert Scale of 1-5 for 4 questions; >4 indicates impairment present).
- **Statistical Analyses.** Response rates (%) for total surveys completed [(ReCoUPS Surveys Completed/Days Enrolled)*100] were calculated. Cronbach's alpha (α) determined the internal consistency of momentary PHRQoL (mPHRQoL). Intraclass correlation coefficients (ICC), 2-way mixed effects model (95% confidence intervals,[CI]) and Cohen's Kappa measured agreement between rHRQoL and mPHRQoL. Spearman's rho (rs) correlation coefficients determined linear relationships between mPHRQoL and SCAT6 symptom clusters. Descriptive statistics (frequencies) demonstrated participants' perceived usability of the ReCoUPS platform.

RESULTS

Table 1. Demographic characteristics of sample (n=79). Continuous variables presented as means (standard deviation), and categorical variables presented as frequencies (%).

Variable	Total Sample (n=79)
Age (years)	20.89 (2.25)
Days Enrolled	8.06 (0.33)
Sex	
Female	54 (68.4%)
Male	25 (31.6%)
Medical History	
Previous Concussion	23 (29.1%)
Depression/Anxiety	16 (20.3%)
ADD/ADHD	13 (16.5%)
Headache/Migraine Disorder	5 (6.3%)
Sport Participation	
Basketball	10 (12.7%)
Cross Country	5 (6.3%)
Soccer	9 (11.4%)
Volleyball	4 (5.1%)
Other[†]	30 (37.9%)
Recent (i.e., within the past year)	21 (26.6%)
Response Rates (% of daily surveys completed)	
100%	20 (25.3%)
85-95%	27 (34.2%)
70-80%	20 (25.3%)
50-69%	10 (12.7%)
<50%	2 (2.5%)

[†]Other sports include field hockey, football, gymnastics, softball, swimming, and tennis.

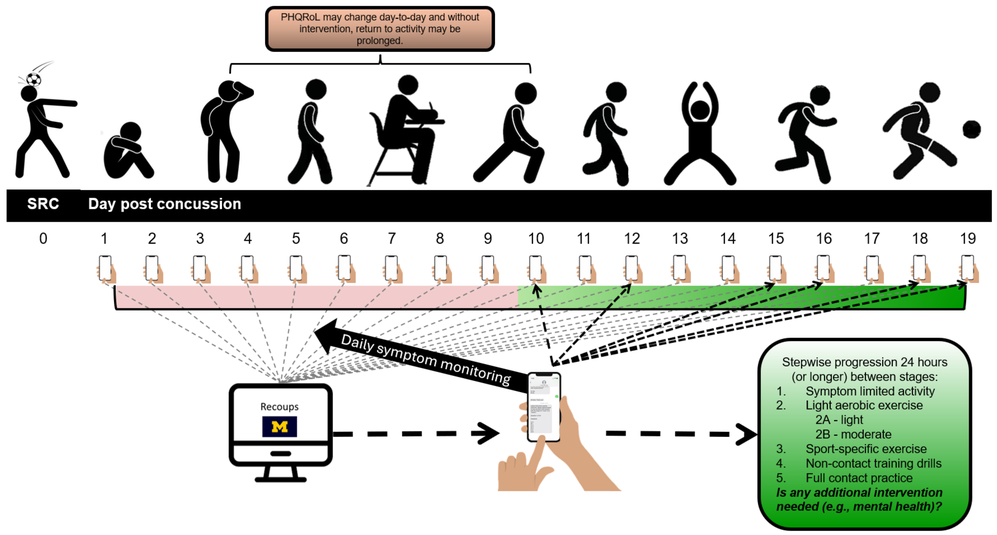
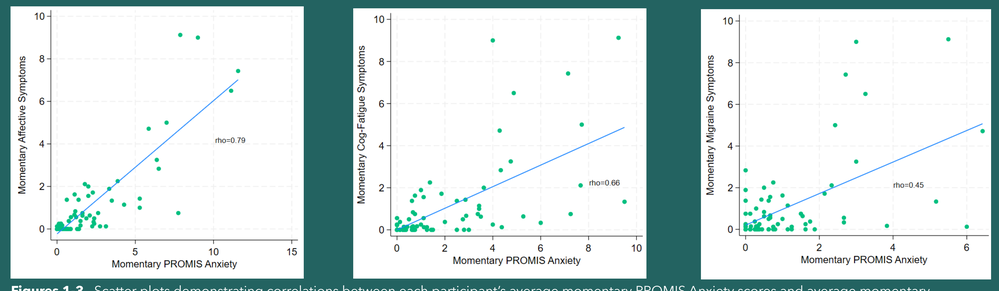


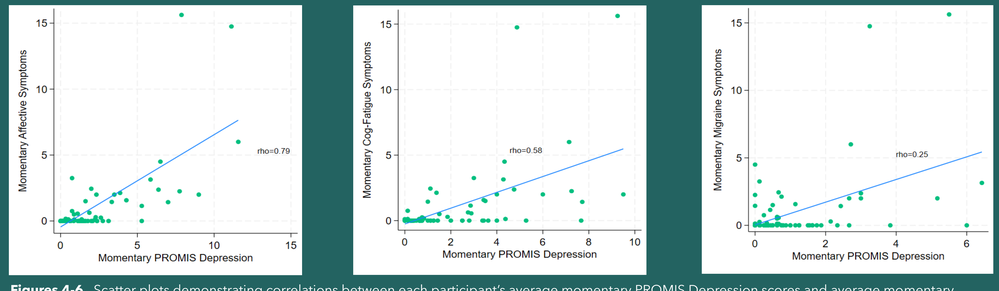
Figure 1. Demonstration of utilizing the ReCoUPS text message surveys and online platform to monitor symptoms and PHRQoL throughout concussion recovery. As symptoms resolve, clinicians can continue to progress athletes through the stepwise return to activity protocols. However, if PHQoL is diminished and proper intervention is not prescribed, the athlete may be at risk for prolonged impairments and recovery.

Momentary assessments of the PROMIS-SF Anxiety, PROMIS-SF Depression, and SCAT6 Symptom Checklist **demonstrate evidence of reliability and validity** when collected via **ReCoUPS** in healthy participants.



Figures 1-3. Scatter plots demonstrating correlations between each participant's average momentary PROMIS Anxiety scores and average momentary symptom cluster scores.

- Momentary PROMIS Anxiety scores were significantly correlated with the affective (rho=0.79, $p<0.001$), cognitive-fatigue (rho=0.66, $p<0.001$), and migraine (rho=0.45, $p<0.001$) symptom clusters.



Figures 4-6. Scatter plots demonstrating correlations between each participant's average momentary PROMIS Depression scores and average momentary symptom cluster scores.

- Momentary PROMIS Depression scores were significantly correlated with the anxiety (rho=0.79, $p<0.001$), cognitive-fatigue (rho=0.58, $p<0.001$), and migraine symptom clusters (rho=0.25, $p<0.001$).

Scan to view the SCAT6, PROMIS SFs, and User Feedback Survey

RESULTS

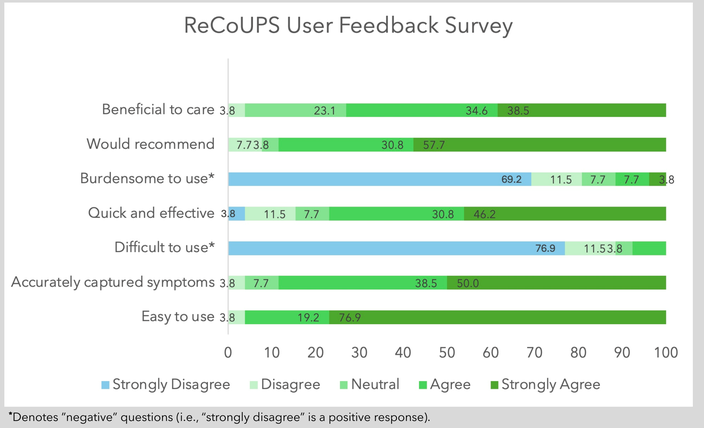
Table 2. Characteristics of momentary PROMIS Anxiety, PROMIS Depression, and SCAT6 symptoms clusters and recalled assessments of PROMIS Anxiety and PROMIS Depression [Mean (SD)] for the entire sample. Agreement between momentary and recalled PROMIS measures [ICC (95% CI)].

	Anxiety	Depression	Affective Symptoms	Cognitive-Fatigue Symptoms	Migraine Symptoms
Momentary Assessment	1.00 (1.92)	0.93 (2.57)	1.97 (2.61)	1.96 (2.36)	1.06 (1.43)
Recalled Assessment	5.49 (2.44)[†]	6.10 (2.89)[†]	--	--	--
Agreement	0.99 (0.98-0.99)	0.99 (0.99-0.99)	--	--	--

[†]**Agreement coding** indicates that a score of 0 on momentary assessments will be equivalent to a score of 4 on recalled assessments.

- Prior to agreement coding, momentary measures of both PROMIS Anxiety and PROMIS Depression demonstrated excellent agreement with their recalled measures.
- Following agreement coding, momentary PROMIS Anxiety demonstrated moderate agreement with the recalled measure (Kappa=0.51; Expected: 50.76%, Actual: 75.95%, p<0.001). Additionally, momentary PROMIS Depression demonstrated substantial agreement with the recalled measure (Kappa=0.66; Expected: 51.85%, Actual: 83.54%, p<0.001).

RESULTS: ReCoUPS USER FEEDBACK



*Denotes "negative" questions (i.e., "strongly disagree" is a positive response).

Figure 2. Distribution of percent of responses to the ReCoUPS User Feedback Survey. Twenty-six participants completed the survey at their study closure visit.

- Participants were asked to respond to 7 questions related to the usability and effectiveness of the ReCoUPS platform on a 5-point Likert Scale (i.e., Strongly Disagree-Strongly Agree). Two follow-up qualitative questions were asked regarding (1) why participants responded to the number of surveys they did and (2) in their opinion, how could the daily surveys be improved? *Please refer to supplemental materials for qualitative responses.*
- Of the participants who completed the user feedback survey, 73.1% indicated that they completed all the daily surveys while 26.9% indicated that they complete most of the daily surveys.

DISCUSSION

- This study provides preliminary evidence to support the reliability and validity of administering "momentary" versions of the PROMIS-SF Anxiety and PROMIS-SF Depression to monitor psychological HRQoL in real time using a novel, mobile EMA platform, ReCoUPS.
- These findings ensure the robustness, usability, and generalizability of utilizing ReCoUPS to monitor post-concussion symptoms and psychological HRQoL in real time in healthy college-aged individuals. This sets the necessary foundation for future implementation research to monitor these outcomes throughout concussion recovery.

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