Efficacy of a Smart Textile Shirt: Developing a Sleep Health Screening Tool for Military Populations

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OBJECTIVES
Development of a high-throughput sleep health screening tool

- Sleep disruption, in general, is pervasive in military populations and has myriad health and readiness implications.
- Between 2001 and 2012, there was a 25-fold increase in the number of veterans and military retirees receiving compensation for sleep apnea.
- Current standards require expensive overnight studies using polysomnography (PSG). While actigraphy is cost-effective, convenient, and thus widely-used as an alternative to PSG, it is limited both in its relative accuracy and in dimensionality.
- There is a need for a cost-effective and multi-dimensional sleep health screening tool that can be employed in the field.

METHODS
A quick, dry, breathable, smart textile shirt with heart rate, activity, and respiration sensors was evaluated in active-duty U.S. Navy service members via:

- An in-lab overnight study with polysomnography (PSG; n=7).
- An in-home 3-5 day study with actigraphy (ACT; n=8).
- A 10-item questionnaire that assessed shirt comfort and ease of use (n=12).

In-lab data analyses

- PSG data – one rest interval (lights off/on), scored for sleep manually according to R&K 1968 classification (Compumedics USA, Inc.)
- STS data – one rest interval (lights off/on), scored for sleep utilizing the manufacturer’s algorithm (Carré Technologies, Inc.).

In-home data analyses

- Actigraphy data – two rest intervals (diary-based, and ACT-generated), each scored for sleep utilizing the manufacturer’s algorithm (Phillips-Respironics).
- STS data – two rest intervals (diary-based, and STS-generated), each scored for sleep utilizing the manufacturer’s algorithm (Carré Technologies, Inc.).

Data were then averaged to yield one value for each metric per individual. As a preliminary analysis for both experiments, differences in derived sleep parameters were evaluated across devices with paired t-tests.

RESULTS

Smart Textile Shirt (STS) comfort and ease of use:

- 100% of subjects from both experiments reported the shirt was somewhat (50.0%) or very (50.0%) comfortable.
- 83% were able to don & doff the shirt off independently in <1 minute (versus ~90 min with tech for PSG).

<table>
<thead>
<tr>
<th>COMFORT</th>
<th>During sleep</th>
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<tbody>
<tr>
<td>Very comfortable</td>
<td>50.0%</td>
</tr>
<tr>
<td>Somewhat comfortable</td>
<td>50.0%</td>
</tr>
<tr>
<td>Somewhat uncomfortable</td>
<td>0%</td>
</tr>
<tr>
<td>Very uncomfortable</td>
<td>0%</td>
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</tbody>
</table>

Preliminary analysis of total sleep time (TST) and sleep efficiency (SE):

- No difference between the STS and PSG on either sleep metric (p>0.05).
- Sleep efficiency was significantly higher for STS than actigraphy (p<0.05).

<table>
<thead>
<tr>
<th>EASE OF USE</th>
<th>Putting it on</th>
<th>Taking it off</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30 sec</td>
<td>58.3%</td>
<td>83.3%</td>
</tr>
<tr>
<td>30-60 sec</td>
<td>25.0%</td>
<td>16.7%</td>
</tr>
<tr>
<td>60-120 sec</td>
<td>8.3%</td>
<td>0%</td>
</tr>
<tr>
<td>&gt;120 sec</td>
<td>8.3%</td>
<td>0%</td>
</tr>
</tbody>
</table>

FUTURE DIRECTIONS

The smart textile shirt shows promise as an alternative for sleep health assessment compared with standard polysomnography and/or actigraphy. However, indications are that the commercially-available algorithm for the STS likely over-estimates both sleep metrics that are provided to consumers. Further investigations, including epoch-by-epoch analyses and development of independent algorithms, are currently underway.

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