The Use of Disposable EEG Caps Compared to Standard 10-20 Electrode Application

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Introduction

The benchmark for all quality EEG recordings starts with the 10-20 system of measurement. Today the number of qualified EEG technologists who can measure and place electrodes continues to fall short of demand for EEG studies. Reducing the time and complexity for electrode application without compromising quality may help in meeting the demand.

Methods

We evaluated electrode setup and placement using a disposable adult EEG electrode cap (Flex-Cap, manufactured by Greentek) compared to the standard electrode 10-20 application performed by the same registered EEG technologist experienced in both methods. Tape, gauze, or headwrap was not used to secure the standard electrodes. The study included a variety of head and hair phenotypes across eight different subjects. We determined the time required to position the cap or to measure and mark by the standard method and then in each instance to apply the electrodes to achieve impedances less than 10Kohms. We also appraised the displacement of each cap electrode relative to its measured 10-20 position. The measured 10-20 positions were verified before the comparison was made.

Statistical methods: Times and displacements were not normally distributed. A two-way ANOVA was used to determine significant differences in times 1. to measure for standard electrode placement / position the cap, 2. to apply standard / cap electrodes, and 3. to complete standard / cap EEG 10-20 setup. A Bonferroni correction was applied for the three hypothesis tests that were performed, with a $p < 0.017$ threshold for significance. Median displacements were used to determine accuracy of cap electrode positions.

Results

There were a variety of head and hair phenotypes in this study. Of the 8 subjects included, head circumferences ranged from 53 cm – 57 cm with a median of 55 cm. Hair length measured from Cz ranged from 0 cm - 46 cm with median length of 17 cm. Figure 1 graphically represents the phenotype, hair length, and head circumference of the subjects.

The time required to measure for standard electrode placement or to position the cap was significantly different ($p<0.0001$) with medians of 5.8 minutes and 0.19 minutes, respectively. There was no statistical difference in times to apply electrodes between the standard method and cap. The total time required for standard EEG 10-20 setup ranged from 12.5 minutes to 21.3 minutes with a median of 19.1 minutes, which was significantly different ($p<0.001$) from the total time for cap setup, ranging from 5.4 minutes to 20.6 minutes with a median of 9.6 minutes (Figure 1).

Displacement of electrodes using the cap was generally negligible, with measured and marked positions almost always beneath the cap electrode (2 cm in diameter). Of the 152 measured electrodes (19 electrodes, 8 subjects) applied with the cap, only five exhibited a displacement from the closest edge of the electrode to the standard 10-20 position between 0.7 cm and 1 cm. The only non-zero median displacements were for T5 and P3 at 0.2 cm and 0.1 cm respectively (Figure 2). The Ref, GND, A1, and A2 were applied for each application; however, they do not fall into the measured electrode category.

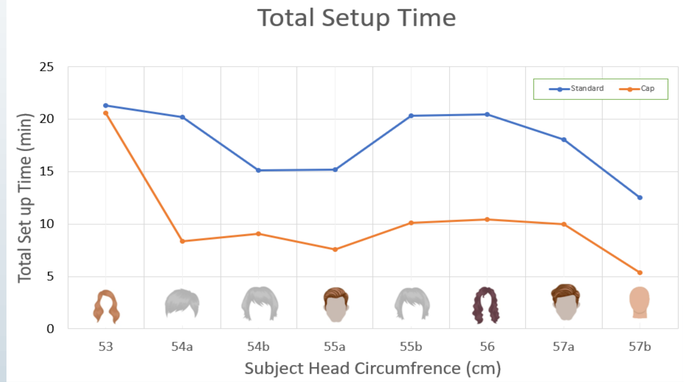

Figure 1
This graph displays the total time required to perform the Flex-cap and standard 10-20 set up over 8 subjects with a variety of head circumferences and hair phenotypes.

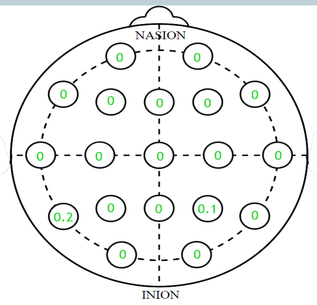

Figure 2
The number within each of the 10-20 electrodes displayed here represents the median distance in centimeters between the closest edge of the cap electrode to the standard 10-20 position among 8 subjects

Conclusion

The benchmark for EEG will always be the 10-20 system performed by registered technologists. However, when unavailable, the disposable EEG Flex-Cap provides quick and accurate EEG electrode setup relative to the standard EEG method for most head and hair phenotypes.

Higher follicle density, in combination with longer hair length of one subject in this study, may have compromised the ease / efficiency of cap setup but overwhelmingly outperform the standard 10-20 setup.

Quick EEG application can be critical in rapid diagnosis of nonconvulsive status epilepticus (McKay, 2019) and can reduce staffing costs (Kolls, 2014).

We conclude that the disposable EEG electrode cap will produce statistically indistinguishable 10-20 electrode placements by a registered EEG technologist in significantly less time.

A single registered EEG technologist with experience in both standard EEG and cap setup was both a strength and limitation of this study. On the one hand, this was one less variable to consider. On the other hand, our results may not reflect variance in efficiency and accuracy of electrode placement with different registered/ unregistered technologists.

Future Directions

We will repeat these studies with more registered/ unregistered EEG technologists to examine accuracy / precision and efficiency of electrode placement by non-experts. Ease of proficient use by unregistered technologists, nurses, or other allied health professionals will address the present and persistent shortage of expert personnel. The quality of the EEG recording over time using standard 10-20 EEG placement vs. the Flex-cap is being evaluated and will also be reported in future studies.

References

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