Previous near-infrared spectroscopy (NIRS) studies using a verbal fluency task (VFT) have consistently reported that adults with attention-deficit hyperactivity disorder (ADHD) showed significantly smaller oxygenated-hemoglobin (oxy-Hb) activations in the prefrontal cortex (PFC) relative to those in healthy controls (HC). Despite this consistent evidence of brain dysfunction in ADHD, ADHD is currently diagnosed based only on subjective clinical and scoring measures, which are often unreliable. Hence, it is necessary to establish objective neuroimaging biomarkers for ADHD. While most NIRS studies have utilized averaged [oxy-Hb] values during the whole task period for group comparisons, we used a cluster-based nonparametric randomization test to compare the [oxy-Hb] time-course changes with a 0.1-s time resolution between drug-naïve adults with ADHD and HC, which may provide us with more details regarding abnormal prefrontal activation patterns in ADHD. A total of 101 participants, consisting of 63 drug-naïve adult individuals with ADHD and 38 HC, were included in this study. We identified that adults with ADHD showed significantly smaller [oxy-Hb] activations than those in HC at spatially and temporally connected clusters located in the bilateral PFC (more prominent on the left) and temporal brain region (more prominent on the left). We further found that aberrant [oxy-Hb] activation differs according to the time period during the task or to brain location. Our findings indicate more detailed aberrant prefrontal and temporal activation patterns of ADHD compared with those in previous studies, possibly representing a biological marker for ADHD.