Salivary Alpha-Amylase (sAA) Concentration Related to Fatigue Biomarkers in Palm Oil Office Workers in Jambi Province: Preliminary Study

David Kusmawan (✉ david.kusmawan@unja.ac.id)
FKIK Universitas Jambi

Research Article

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Abstract

Background

The use of Salivary alpha-amylase (sAA) has the potential as a biological sign of work-related fatigue caused by stress and mental workload. This study aimed to determine the levels of sAA and the factors that influence it.

Methods

This study used a cross-sectional design with a sample of 40 office staff respondents at PT XYZ (Persero). Measurements were made to determine work-related fatigue, mental workload, and sleep quality. Meanwhile, the measurement of basic sAA levels was carried out using the sandwich ELISA method using the Bioenzy® Kit Assay.

Results

Results of the descriptive analysis showed that workers were dominated by men by 75% with high education level and marital status of 72.5%. Mental Workload Scoring with NASA-TLX shows an average score of 70.91 which is categorized as high workload. Analysis with Pearson correlation showed that the variables of work-related fatigue and sleep quality were significantly correlated with sAA concentration. The final model showed that the work-related fatigue variable indicated that for each one-unit increase in work-related fatigue, the sAA (U/mL) concentration will increase by 15.901 (U/mL). While the sleep quality variable showed the result that for every unit increase in sleep quality, the sAA concentration will decrease by 13.38 (U/mL).

Conclusion

sAA concentration can be used as a potential candidate for biological markers related to sleep quality and work-related fatigue

Introduction

Work-related fatigue (fatigue) is one of the risk factors that have a major contribution to the occurrence of occupational accidents that can cause death. The nominal claim by BPJS-TK due to occupational accidents has reached IDR 1.2 trillion/year with a total of 173,105 cases. Fatigue conditions are very dangerous and encourage workers to be in a state of at risk behavior. Workers who experience fatigue will make a negative contribution to safety performance, a decrease in productivity levels, low quality of work, an increased risk of occupational accidents, and even death.
Fatigue is multifactorial such as poor sleep quality, increased mental activity and load, and prolonged physical activity. Sustained physical activity fatigue is correlated with loss of strength in peripheral muscles as well as the perception of fatigue mediated by signaling pathways in the central nervous system (CNS) [1].

Salivary α-amylase (sAA) activity, which is an enzyme present in the oral cavity, can be measured as a stress marker. In humans and animals, there are 2 main systems in the body that are involved in the stress response process, namely the Autonomic Nervous System (ANS) and the Hypothalamus-Pituitary-Adrenal (HPA) axis. Measurement of sAA concentration is a useful technique for monitoring ANS reactivity under stress conditions [2]. Salivary Alpha-Amylase (sAA) is a digestive enzyme involved in the breakdown of starch. The sAA is synthesized in acinar cells and stored in granules and released into saliva in response to neuronal stimulation [2]. During stressful conditions, the sympathetic nervous system will be stimulated which will result in increased secretion of sAA by the salivary glands. Salivary alpha amylase has been widely used as a biological marker of stress conditions [3, 4].

Biomarkers using saliva are increasingly popular in the stress-related studies because saliva is easy to produce, non-invasive in the collection process, not limited by geographic distance, and not using a lot of equipment in the collection process. Several salivary fluid biomarkers have been used as markers in stress studies such as cortisol, amylase, and immunoglobulin [5]. The use of salivary biomarkers has had many positive impacts on the measurement of fatigue. The development of the Fatigue Biomarker Index has taken stress and fatigue study to a new level with the ability to measure fatigue more objectively. Fatigue can alter small-molecular weight (sMW) salivary proteome composition during a 10-hour session of moderate physical activity [5, 4].

The sAA showed a higher level of sensitivity to changes in stress levels, including psychological stress such as during medical procedures, and physical stress such as during exercise. During exercise, there is an increase in sympathetic activity which will cause adrenergic activity in the salivary glands and result in an increase in the concentration of sAA in saliva after exercise [2]. While saliva samples are easy to collect, researchers often overlook important properties of saliva such as the diurnal nature of saliva secretion, and individual variations (age, gender, possibly ethnicity, and oral or systemic health). Microorganisms in saliva and oral cavity, oral hygiene (including hygiene habits and other oral conditions), diet and medications, and physical activity or exercise [6, 7, 8]. Therefore, it is highly important to standardize the protocol in saliva collection including careful selection of subjects, abstaining from oral hygiene protocols, the timing of collection, ideal collection method of unstimulated whole saliva, rapid processing eg using centrifugation at 4 °C to remove debris. More importantly, because saliva is affected by individual variations, it is important to have a baseline sample to compare changes in biomarkers.

In fact, the relationship between mental workload, sleep quality, and fatigue level with salivary alpha-amylase concentrations is still not clear. Moreover, investigations related to sAA concentration in the oil palm plantation workers in Jambi Province have not been studied clearly. This study aimed to find a baseline for salivary alpha-amylase concentration in oil palm plantation workers and the factors that
influence it and to determine their potential as non-invasive biological markers of stress and work-related fatigue.

**Material And Methods**

2.1. Study Design, Instrument, and Population

This study obtained ethical review approval from the Research Ethics Committee, Faculty of Medicine and Health Sciences, Jambi University with Number: 736/Lolos Etik 2021. Informed consent was given to respondents during filling out questionnaires and collecting saliva samples.

This study used a cross-sectional study design by taking as many as 40 office staff respondents of PT XYZ (Persero) using inclusion criteria. The study was conducted from September to March 2022. The study instrument used was the IFRC work-related fatigue measurement instrument, mental workload (NASA-TLX), and sleep quality (PSQI). Bioenzy® ELISA kit for measurement of salivary alpha-amylase levels. The data obtained were then analyzed using univariate analysis and multiple linear regression to determine the factors that affect the concentration of salivary alpha-amylase. The inclusion criteria used were oil palm sector workers, workers who did not smoke, and were not currently infected with SARS-CoV-2 based on the results of the rapid swab antigen.

2.2. Saliva sample collection

The saliva collection process was carried out at PT X’s office using equipment such as saliva collection tubes, alcohol, and tissue. Before their saliva was collected, the respondents were asked to fill out informed consent and questionnaires related to self-reported work-related fatigue (IFRC) and sleep quality of workers (PSQI).

After the saliva sample was obtained, the sample was temporarily stored in a cooler with a temperature of 4–10 °C and then sent to the Oral Biology Laboratory, Faculty of Dentistry, University of Indonesia to check the alpha-amylase concentration. The method used was the sandwich ELISA method with an ELISA kit (Bioenzy®) Alpha-amylase.

Collected saliva samples in a centrifuge tube then frozen at -70 °C for 1 hour. After the sample was thawed on ice, and centrifuged at 1000x speed for 20 minutes, then the supernatant was collected for use. Alpha-amylase assay was carried out at a wavelength of 405 nm. Measurement of salivary total protein concentration by Bradford assay. The examination was carried out 2 times at the 1st minute and the 3rd minute.

2.3. ELISA Protocol (Bioenzy®)

Using the Enzyme-Linked Immunosorbent Assay (ELISA) Kit. The plates were pre-coated with Human AMS antibody. The AMS present in the sample was added and bound to the coated antibody on the well. Then the biotinylated Human AMS Antibodies were added and bound to the AMS in the samples. Followed by the addition of Streptavidin-HRP which was then bound to the biotinylated AMS antibody. After incubation,
the unbound Streptavidin-HRP was washed during the washing step. The substrate solution was then
added, and color developed in proportion to the amount of Human AMS. The reaction was terminated by
the addition of an acid-stopping solution and the absorbance was measured at a wavelength of 450 nm.

2.4. Reagent Preparation

All reagents should be stored at room temperature before use. Standard Reconstitute 120 µl of standard
(8000U/L) with 120 µl of standard diluent to produce a standard stock solution of 4000 U/L. The standard
was placed for 15 minutes with gentle stirring before making the dilution. Duplicate standard points were
prepared by serially diluting standard stock solution (4000 U/L) 1:2 with standard diluent to produce 2000
U/L, 1000 U/L, 500 U/L, and 250 U/L solutions. The standard diluent serves as the zero standards (0
ng/ml). Any remaining solution should be frozen at -20°C and used within one month.

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Standard No.</th>
<th>Dilution Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000 U/L</td>
<td>No. 5</td>
<td>120 microL Standard + 120 microL standard diluent</td>
</tr>
<tr>
<td>2000 U/L</td>
<td>No. 4</td>
<td>120 microL Standard No.5 + 120 microL standard diluent</td>
</tr>
<tr>
<td>1000 U/L</td>
<td>No. 3</td>
<td>120 microL Standard No.4 + 120 microL standard diluent</td>
</tr>
<tr>
<td>500 U/L</td>
<td>No. 3</td>
<td>120 microL Standard No.3 + 120 microL standard diluent</td>
</tr>
<tr>
<td>250 U/L</td>
<td>No. 1</td>
<td>120 microL Standard No.2 + 120 microL standard diluent</td>
</tr>
</tbody>
</table>

2.5 Pittsburg Sleep Quality Index (PSQI)

The PSQI questionnaire measured sleep quality in the last 1-month interval and consisted of 19 questions
that measure 7 assessment components, namely subjective sleep quality, sleep latency, sleep duration,
habitual sleep efficiency, sleep disturbance, sleeping medication, and daytime dysfunction.

2.6. Industrial Fatigue Research Committee (IFRC)

IFRC was used to measure symptoms of work-related fatigue. The Industrial Fatigue Research Committee
(IFRC) includes the Subjective Self Rating Test (SSRT). This questionnaire was used to get the value of
work-related fatigue through subjective fatigue symptoms felt by workers. There were 3 sections that are
asked of respondents, each section had 30 questions. The first part contained 10 questions about
indications of weakened activity, the second part contained 10 questions about indications of weakened
motivation, and the third part contained 10 questions about symptoms of physical fatigue.

2.7. Statistic analysis

The data obtained in the form of sociodemographic variables, sAA concentration data, sleep quality, work-
related fatigue, working, marital status, and the mental workload was then analyzed univariately,
bivariately with Pearson correlation analysis and multivariate with multiple linear regression analysis using
IBM SPSS statistical software version. 21.

Results And Discussion
### 3.1 Table of Sociodemographic Overview of Respondents

<table>
<thead>
<tr>
<th>No.</th>
<th>Variable</th>
<th>Frequency</th>
<th>Percentage (%)</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Male</td>
<td>30</td>
<td>75.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Female</td>
<td>10</td>
<td>25.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Level of Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. High</td>
<td>29</td>
<td>72.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Moderate</td>
<td>11</td>
<td>27.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Marital Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Married</td>
<td>29</td>
<td>72.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Unmarried</td>
<td>11</td>
<td>27.5</td>
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<td></td>
</tr>
<tr>
<td>4.</td>
<td>Respondent Age</td>
<td></td>
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<td>53</td>
<td>35.76</td>
<td>8.632</td>
</tr>
<tr>
<td>5.</td>
<td>Working Years</td>
<td></td>
<td></td>
<td>1</td>
<td>33</td>
<td>11.03</td>
<td>8.888</td>
</tr>
</tbody>
</table>

### 3.2 Table of sAA Concentration and ELISA Graph

Conc. matrix

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>1866.294</td>
<td>1866.294</td>
<td>1136.259</td>
<td>1136.259</td>
<td>1081.680</td>
<td>1081.680</td>
<td>1330.453</td>
<td>1330.453</td>
<td>1307.448</td>
<td>1307.448</td>
<td>1229.625</td>
<td>1229.625</td>
</tr>
<tr>
<td>C</td>
<td>1148.609</td>
<td>1148.609</td>
<td>984.011</td>
<td>984.011</td>
<td>1148.609</td>
<td>1148.609</td>
<td>1326.374</td>
<td>1326.374</td>
<td>676.324</td>
<td>676.324</td>
<td>540.996</td>
<td>540.996</td>
</tr>
<tr>
<td>E</td>
<td>273.392</td>
<td>273.392</td>
<td>1344.110</td>
<td>1344.110</td>
<td>507.506</td>
<td>507.506</td>
<td>1056.757</td>
<td>1056.757</td>
<td>1100.901</td>
<td>1100.901</td>
<td>1398.268</td>
<td>1398.268</td>
</tr>
<tr>
<td>F</td>
<td>103.968</td>
<td>103.968</td>
<td>805.948</td>
<td>805.948</td>
<td>1360.621</td>
<td>1360.621</td>
<td>1342.740</td>
<td>1342.740</td>
<td>1228.332</td>
<td>1228.332</td>
<td>1288.701</td>
<td>1288.701</td>
</tr>
<tr>
<td>G</td>
<td>76.605</td>
<td>76.605</td>
<td>1035.667</td>
<td>1035.667</td>
<td>1481.539</td>
<td>1481.539</td>
<td>938.243</td>
<td>938.243</td>
<td>1409.557</td>
<td>1409.557</td>
<td>1138.722</td>
<td>1138.722</td>
</tr>
<tr>
<td>H</td>
<td>0.000</td>
<td>0.000</td>
<td>1018.279</td>
<td>1018.279</td>
<td>1239.997</td>
<td>1239.997</td>
<td>1188.685</td>
<td>1188.685</td>
<td>1278.067</td>
<td>1278.067</td>
<td>900.122</td>
<td>900.122</td>
</tr>
</tbody>
</table>
3.3. Figures ELISA Result Graph

3.4 Table of Factors Associated with [sAA]
### Variables and Salivary Alpha-Amylase Concentration

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pearson Correlation</th>
<th>Sig.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue (IFRC)</td>
<td>0.740</td>
<td>0.000*</td>
<td>Significantly Correlated</td>
</tr>
<tr>
<td>Sleep Quality (PSQI)</td>
<td>-0.721</td>
<td>0.000*</td>
<td>Significantly Correlated</td>
</tr>
<tr>
<td>Mental Workload</td>
<td>-0.211</td>
<td>0.192</td>
<td>Not Significantly Correlated</td>
</tr>
<tr>
<td>Age</td>
<td>-0.016</td>
<td>0.921</td>
<td>Not Significantly Correlated</td>
</tr>
<tr>
<td>Gender</td>
<td>0.102</td>
<td>0.530</td>
<td>Not Significantly Correlated</td>
</tr>
<tr>
<td>Level of education</td>
<td>-0.031</td>
<td>0.850</td>
<td>Not Significantly Correlated</td>
</tr>
<tr>
<td>Marital status</td>
<td>0.032</td>
<td>0.846</td>
<td>Not Significantly Correlated</td>
</tr>
<tr>
<td>Working years</td>
<td>0.089</td>
<td>0.587</td>
<td>Not Significantly Correlated</td>
</tr>
</tbody>
</table>

### Abbreviations:

IFRC = *Industrial Fatigue Research Committee*

PSQI = *Pittsburg Sleep Quality Index*

MWL = Mental Workload

### 3.5 Table of Final Model Results of Multiple Linear Regression Analysis

<table>
<thead>
<tr>
<th>Variabel</th>
<th>B</th>
<th>Std Error</th>
<th>Beta</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue (IFRC)</td>
<td>15.901</td>
<td>3.973</td>
<td>0.525</td>
<td>4.003</td>
<td>0.000</td>
</tr>
<tr>
<td>Sleep Quality (PSQI)</td>
<td>-13.38</td>
<td>4.006</td>
<td>-0.443</td>
<td>-3.34</td>
<td>0.002</td>
</tr>
<tr>
<td>Mental Workload</td>
<td>14.698</td>
<td>22.236</td>
<td>0.075</td>
<td>0.661</td>
<td>0.513</td>
</tr>
<tr>
<td>Age</td>
<td>0.082</td>
<td>12.282</td>
<td>0.002</td>
<td>0.007</td>
<td>0.995</td>
</tr>
<tr>
<td>Gender</td>
<td>142.754</td>
<td>75.612</td>
<td>0.205</td>
<td>1.888</td>
<td>0.068</td>
</tr>
<tr>
<td>Level of education</td>
<td>-4.705</td>
<td>84.631</td>
<td>-0.007</td>
<td>-0.056</td>
<td>0.956</td>
</tr>
<tr>
<td>Marital status</td>
<td>31.994</td>
<td>81.342</td>
<td>0.047</td>
<td>0.393</td>
<td>0.697</td>
</tr>
<tr>
<td>Working years</td>
<td>-0.837</td>
<td>13.041</td>
<td>-0.024</td>
<td>-0.064</td>
<td>0.949</td>
</tr>
</tbody>
</table>

**Note:** Dependent Variable: α amylase Concentration (U/mL)

Based on the descriptive analysis results, the data showed that of the 40 worker respondents are dominated by males (75%) with the distribution of higher education levels and marital status of 72.5%.

Based on the results of Mental Workload (MWL) scoring using the NASA-TLX instrument, the respondents had an average score of 70.91 which is categorized as a high workload category. The high workload is in line with the level of stress or fatigue, qualities experienced by workers.

Then based on the results of the bivariate analysis with the Pearson correlation, it showed that the variables of work fatigue and sleep quality had a significant correlation with the concentration of the salivary alpha-amylase (sAA) in workers. The relationship between sleep quality variables has a negative direction, so if the dependent variable increases, the independent variable decreases. This resulted in the finding that if the quality of sleep is getting better, the concentration of sAA will decrease and vice versa. Then the work fatigue variable is positive. This means that if it is positive, if the dependent variable increases, then the independent will also increase. This resulted in the finding that if the level of work fatigue increases, the concentration of sAA will also increase.
Based on the final model analysis, it was found that the factors that affect the salivary alpha-amylase (sAA) concentration in oil palm plantation office workers in Jambi Province are the work-related fatigue variable (p-value = 0.000) and sleep quality variable (p-value = 0.002). The work-related fatigue variable analyzed using the IFRC instrument showed that for every unit increase in work-related fatigue, the salivary alpha-amylase (U/mL) concentration will increase by 15,901 (U/mL). Meanwhile, the sleep quality variable showed that for every one-unit increase in sleep quality, salivary alpha-amylase (sAA) concentration will decrease by 13.38 (U/mL).

Salivary alpha-amylase concentration after waking up was not related to waking time, sleep duration, and sleep quality. However, participants who woke up without using an alarm clock in the morning showed a decrease in salivary alpha-amylase concentrations in the first hour after waking up (parameter=-0.4661, SE=0.2053, P=0.023). The mean salivary alpha-amylase concentration was reduced by 1.59 U/ml in the respondents. Comparison of salivary alpha-amylase concentrations in three measurements between alarm and non-alarm users showed that salivary alpha-amylase concentrations upon woke up were higher in alarm users (t=2.29, df=69, P=0.025), while the difference was weaker at 30 minutes after waking up (t=1.84, df=73, P=0.070) and disappearing 60 minutes after waking up (t=1.56, df=72, P=0.124) [9].

It is recommended that the diurnal profile of salivary alpha-amylase is relatively strong against transient effects and may therefore be useful in assessing sympathetic nervous system activity. In addition, there is a need to control time in studies using salivary alpha-amylase as the dependent variable [9]. To examine the independence of the effect of Body Mass Index, smoking status, and use of an alarm clock to wake up in the morning, the significant influence parameters of these variables were included in the combined model. The effect on salivary alpha-amylase is independent. Similar to the results of the separate models, the combined model showed that salivary alpha-amylase concentrations were significantly higher in respondents who used alarms, were negatively associated with BMI, and that salivary alpha-amylase concentrations after woke up decreased at a greater rate and had a clearer curve curvature in smokers than in nonsmokers.

This study used inclusion criteria, one of which is respondents who do not have a smoking history because smoking can affect the consistency and stability of salivary analytes [10,11]. Salivary alpha-amylase secreted by the salivary glands is a stress biomarker in humans whose concentrations will increase in stressful situations and conditions [12]. Although this study did not measure the stress level of the respondents, it did measure the level of fatigue and sleep quality of the respondents. Many studies have found a correlation between sleep quality and fatigue that occurs due to stress with salivary alpha-amylase concentrations.

Several factors can reduce the concentration of salivary alpha-amylase secretion in salivae such as smoking habits, alcoholic beverages, and drug consumption such as hypertension drugs, antidepressants, and drugs that interfere with salivary secretion which is regulated by the sympathetic and parasympathetic nervous systems [13]. According to [14,15] who conducted a study with samples in
children showed the results that sAA activity could be influenced by sleep time variables. Sleep deprivation is predicted as a marker of changes in neuroendocrine function. The results of this study provide information about pathways that can link poor sleep quality with health problems. Sleep has been correlated with daily patterns of stress-responsive physiological systems, in particular the Hypothalamus-Pituitary-Adrenal (HPA) and autonomic nervous system (ANS) axes [16].

These results supported previous findings, that in addition to conditions of reported increased fatigue, basal activity concentrations of sAA were found to be higher in the sleep-restricted group than in the rested group. These findings also support data that increased sleep duration results in lower resting Salivary alpha-amylase concentrations [17]. The sAA becomes important in assessing sleepiness for the first time in a large population studied longitudinally. The sAA in the evaluation of sleep deprivation among the adolescent population. This suggests that the measurement of salivary alpha-amylase activity may be a suitable non-invasive biochemical parameter for the objective assessment of sleep deprivation among individuals as well as at the population level. However, studies on a larger population consisting of various sectors of society would be helpful for further validation [18].

The increase in salivary alpha-amylase concentrations in this study was in line with other studies which showed that stress caused by fatigue in Indonesian civil pilots resulted in higher salivary alpha-amylase concentrations compared to Indonesian civil pilots who did not experience stress due to work-related fatigue. There is a positive correlation between salivary amylase concentrations and burnout scores and women show a significant increase in sAA alertness after the presence of a stressor compared to men. In addition, women also had a more pronounced increase in sAA throughout the day than men [19,20,21,22].

Salivary alpha-amylase biomarkers can be measured exclusively in saliva. Over the last few years, there has been an increasing number of studies using salivary alpha-amylase as a biological marker as a non-invasive substitute for sympathetic nervous activity. Salivary alpha-amylase has been considered a sensitive candidate biomarker to detect stress-related changes in the body that reflect sympathetic nervous system activity, and more study is being conducted to support the validity and reliability of this biomarker parameter [23]. Salivary alpha-amylase (sAA) has emerged as a valid and reliable marker of ANS activity in stress studies and is therefore an important biomarker to consider. In addition, salivary fluid holds promise for the development of objective fatigue measurements applicable to a much wider population in the uncontrollable environment [24,4]. However, it is important to choose an appropriate study design when trying to decipher the clinically and biologically appropriate changes in the natural variation of diurnal cortisol and alpha-amylase [25]. According to the results of the study [26] in evaluating the effect of the firefighting activity simulation intervention on the parameters of salivary alpha-amylase (sAA), free cortisol, anxiety, and mood profiles, the results showed that at 30 minutes post-intervention there was an increase in sAA by 174% and sC by 109%. In addition, the results of this study indicate that sAA will increase concerning physical activity such as exercise and this reflects an increase in plasma catecholamines and thermal stress. According to studies [27-33], there are biochemical changes in respondents after mental and physical activities that cause fatigue, with subjective fatigue scores increasing. After mental
exhaustion sessions, urine vanillylmandelic acid levels were higher and plasma valine levels lower than after relaxation sessions. In contrast, after a physical session that causes fatigue, serum citric acid, triacylglycerol, free fatty acids, ketone bodies, total carnitine, acylcarnitine, uric acid, creatine kinase, aspartate aminotransferase, lactate dehydrogenase, cortisol, dehydroepiandrosterone, dehydroepiandrosterone sulfate, transforming growth factor beta1 and beta 2, white blood cell and neutrophil counts, cortisol and salivary amylase, and urinary vanillylmandelic acid levels were higher and serum-free carnitine and plasma total amino acids and alanine levels were lower than after the relaxation session. Salivary cortisol (sCort) and salivary alpha-amylase (sAA) are proxy measures of the two main stress response systems. The sAA profile is not sensitive to daily variations in sleep but is an indicator of stress-induced ANS dysregulation over a long period.

Conclusions

Saliva is a potential medium as a biomarker of fatigue due to its easy collection. However, special procedures are needed in the decision-making process and must consider many confounding variables so that the quality of the analysis results is still validated. Based on the final modeling analysis of this study, it was found that the factors that affect the concentration or levels of salivary alpha-amylase (sAA) in oil palm plantation industry office workers in Jambi Province were the work-related fatigue variable with a p-value of 0.000 and the sleep quality variable with a p-value of 0.002. In the measurement of the work-related fatigue variable using the IFRC questionnaire instrument, the data shows that for every one-unit increase in work-related fatigue, the salivary alpha-amylase (U/mL) concentration will increase by 15,901 (U/mL). Meanwhile, the sleep quality variable showed that for every one-unit increase in sleep quality, the sAA concentration will decrease by 13.38 (U/mL). Salivary alpha amylase can be used as a candidate biomarker in measuring stress and work fatigue.

Declarations

5. Conflicts of interest

All authors have no conflicts of interest to declare

6. Acknowledgements

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References


29. Klaus, Kristina, et al. Poor night’s sleep predicts the following day’s salivary alpha-amylase under high but not low stress. Psychoneuroendocrinology, 2019, 101: 80–86.


**Figures**

![ELISA Result Graph]

**Formula:**

\[
\text{Abs} = \frac{a_0 - a_3}{1 + \text{power}(C/a_2, a_1)} + a_3
\]

- \(a_0\): 0.08298
- \(a_1\): 0.8952
- \(a_2\): 3219.2
- \(a_3\): 5.17
- \(R^2\): 0.9943

**Figure 1**

ELISA Result Graph