



## Effects of prenatal yoga on women's stress and immune function across pregnancy: A randomized controlled trial



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### ABSTRACT

**Objective:** The effects of prenatal yoga on biological indicators have not been widely studied. Thus, we compared changes in stress and immunity salivary biomarkers from 16 to 36 weeks' gestation between women receiving prenatal yoga and those receiving routine prenatal care.

**Design:** For this longitudinal, prospective, randomized controlled trial, we recruited 94 healthy pregnant women at 16 weeks' gestation through convenience sampling from a prenatal clinic in Taipei. Participants were randomly assigned to intervention (n=48) or control (n=46) groups using Clinstat block randomization.

**Intervention:** The 20-week intervention comprised two weekly 70-min yoga sessions led by a midwife certified as a yoga instructor; the control group received only routine prenatal care.

**Main outcome measures:** In both groups, participants' salivary cortisol and immunoglobulin A levels were collected before and after yoga every 4 weeks from 16 to 36 weeks' gestation.

**Results:** The intervention group had lower salivary cortisol (p<0.001) and higher immunoglobulin A (p<0.001) levels immediately after yoga than the control group. Specifically, the intervention group had significantly higher long-term salivary immunoglobulin A levels than the control group (p=0.018), and infants born to women in the intervention group weighed more than those born to the control group (p<0.001).

**Conclusion:** Prenatal yoga significantly reduced pregnant women's stress and enhanced their immune function. Clinicians should learn the mechanisms of yoga and its effects on pregnant women. Our findings can guide clinicians to help pregnant women alleviate their stress and enhance their immune function.

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### 1. Introduction

During pregnancy, women undergo bio-physio-psycho-social changes that may cause stress.<sup>1,2</sup> This pregnancy-related stress can increase when pregnant women also experience stressful events such as the death of a loved one, family illness, divorce, work load or loss of employment.<sup>3</sup> These external stressors can lead to adverse

perinatal outcomes<sup>3,4</sup> such as perinatal depression,<sup>1,5,6</sup> postpartum depression,<sup>7</sup> as well as pregnancy-induced hypertension and preeclampsia.<sup>8</sup> Prolonged maternal stress during pregnancy has also been related to adverse birth outcomes such as premature and low birth-weight infants,<sup>9</sup> contraction of uterine artery blood,<sup>10</sup> and abnormal fetal brain development.<sup>2,11,12</sup> Excessive maternal stress during pregnancy has also been associated with children's later attention deficit hyperactivity disorder<sup>13</sup> or lower executive-function performance.<sup>12</sup>

The stress response is modulated by the hypothalamic–pituitary–adrenal (HPA) axis, in which the hypothalamus produces corticotropin-releasing factor that stimulates the pituitary to produce adrenocorticotropin, in turn leading to adrenal secretion of cortisol.<sup>14,15</sup> During pregnancy, the placenta

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also produces corticotropin-releasing factor, increasing adrenal secretion of cortisol even more.<sup>11</sup> Cortisol levels rise continuously after 15 weeks' gestation and fall abruptly after delivery.<sup>16</sup>

To prevent adverse outcomes, pregnant women's stress should be managed and interventions should be provided to reduce elevated cortisol levels. Promoting maternal health is important because it determines fetal and infant health, consistent with US<sup>17,18</sup> and global<sup>19</sup> goals to promote maternal, fetal, and infant health. Good maternal health can help reduce public health challenges for families, communities, and health care systems by preventing preterm birth or child disability.<sup>18</sup> Furthermore, good mental health predisposes mothers to have better interactions with their children to stimulate their development, thus helping them reach their full developmental potential.<sup>20</sup> In contrast, children of mothers with poor mental health have significantly delayed development.<sup>20</sup> Therefore, promoting maternal, fetal, and infant health requires appropriate interventions to alleviate women's stress before, during, and after pregnancy.

However, pharmacological stress management may not be acceptable for pregnant women due to concern about the potential teratogenic effects of some commonly used pharmaceuticals, such as barbiturates, opioids, benzodiazepines, thalidomide, and paroxetine. Indeed, use of these drugs by pregnant women has been associated with increased risk for severe fetal limb defects and organ dysgenesis.<sup>21,22</sup> Therefore, physicians should encourage pregnant women to avoid taking over-the-counter drugs, explain the teratogenic effects of these drugs, and provide guidelines for safely using these drugs.<sup>22</sup>

Thus, non-pharmacological stress-relief interventions are important during pregnancy to promote maternal and fetal health and improve perinatal outcomes. Non-pharmacological interventions shown to relieve prenatal stress include music therapy,<sup>23</sup> cognitive-behavioral intervention,<sup>24</sup> aromatherapy,<sup>25</sup> yoga,<sup>6,26–31</sup> and relaxation techniques.<sup>32</sup> However, most of these studies, including nine of 10 randomized controlled trials in a systematic review<sup>29</sup> of yoga's effects on pregnant women, measured intervention effects on pregnant women's stress by self-report questionnaires. Another four studies measured yoga effects on heart rate fluctuation.<sup>25,26,28,32</sup> Nine studies in a systematic review found that practicing yoga during pregnancy relieved stress; reduced anger, anxiety and depression; and improved birth outcomes.<sup>29</sup> Among all studies we reviewed, only four measured effects on salivary cortisol levels after yoga.<sup>6,27,30,31</sup> Cortisol is considered a biomarker of both psychological and physical health.<sup>33</sup> Furthermore, stress-associated increases in cortisol levels may reduce cellular immunity, increasing risk of infection<sup>4</sup> and inhibiting secretion of salivary immunoglobulin A (IgA).<sup>34–36</sup>

Yoga, a type of mind-body-spirit relaxation exercise has been established as a potentially powerful intervention.<sup>37</sup> Indeed, yoga postures can be modified to fit pregnant women's competence. Practicing yoga has been proposed to modulate the HPA axis by buffering cortisol release in response to stress,<sup>38</sup> and is considered to keep women relaxed during pregnancy.<sup>28,29,39,40</sup> Yoga also improves perinatal outcomes,<sup>39</sup> i.e., fewer prenatal disorders and premature births as well as less labor pain,<sup>29</sup> stress,<sup>26,29,41</sup> anxiety,<sup>30,42</sup> depression,<sup>6,27,30,42</sup> and pregnancy-related lumbopelvic pain.<sup>43</sup> However, pregnant women who practiced yoga at home were reported to have an increased incidence of postnatal/intrapartum hemorrhage possibly associated with non-anemic low iron,<sup>44</sup> suggesting that yoga can negatively affect birth outcomes. These inconsistent findings emphasize the need for further studies on prenatal yoga effects on pregnant women and birth outcomes.

Four studies reviewed above found that salivary cortisol levels were lower after pregnant women regularly practiced yoga in the US,<sup>6,27</sup> the UK,<sup>30</sup> and Japan.<sup>31</sup> However, none of these studies

measured the effect of yoga on pregnant women's IgA levels. Furthermore, no studies explored the effects of practicing yoga on pregnant Taiwanese women's biomarker levels. Thus, more information is needed on yoga's effects on pregnant Taiwanese women's IgA levels.

To fill these gaps in knowledge, we designed this study to evaluate the effects of prenatal yoga on women's stress and immune biomarkers across pregnancy. Specifically, we measured monthly levels of salivary cortisol and IgA from 16 to 36 weeks of pregnancy. The framework to support the yoga intervention was the cognitive-behavioral model of relaxation.<sup>45</sup> This model emphasizes three components of relaxation: (1) reducing arousal or inducing a relaxation response, (2) developing cognitive-relaxation skills by focusing attention, passively letting go of stress, and becoming receptive to peacefulness, and (3) increasingly acquiring cognitive structures that support relaxation.<sup>45</sup> Yoga helps pregnant women release stress by focusing on stretching, deep breathing (focusing the mind), and guided imagery.<sup>45,46</sup>

Based on the mechanisms by which yoga affects stress<sup>45</sup> and the literature,<sup>38,45</sup> we hypothesized that pregnant women practicing yoga would have lower salivary cortisol and higher salivary IgA levels than pregnant women receiving routine prenatal care.

## 2. Methods

### 2.1. Design and randomization

For this prospective randomized control trial with a longitudinal, repeated-measures design, pregnant participants were randomly assigned by a blinded statistician using Clinstat block randomization<sup>47</sup> to the control and intervention groups. From 16 to 36 weeks' GA, participants in the control group received only routine prenatal care, and those in the intervention group received routine prenatal care plus the yoga intervention (see Section 2.4). This study followed the CONSORT guidelines.<sup>48</sup>

### 2.2. Participants and setting

Pregnant women around 16 weeks' GA were recruited by convenience sampling from February 2014 through February 2015 from the prenatal clinic of a medical center in Taipei. Women were included if they met these criteria: (1) normal pregnancy, (2) 20–45 years old, (3) agreed to follow-up collections of saliva samples, (4) could read and write Chinese, (5) if in the intervention group, willing to attend at least 85% of yoga sessions (34 sessions), and (6) able to abstain from eating, drinking caffeine-containing beverages, and engaging in strenuous physical activity for 2 h before saliva collection. Women were excluded by these criteria: (1) taking oral steroids, (2) history of severe illness (i.e., heart disease, systemic lupus erythematosus, metabolic disorders), or depression, (3) using drugs (prescribed or illicit), and (4) high-risk pregnancy (i.e., first-trimester vaginal bleeding, incompetent cervix or cervical cerclage, artificially inseminated, multiple gestations, fetal growth restriction or other abnormalities). Of 136 pregnant women screened, 115 met the study criteria (Fig. 1). Participation was refused by 14 women who could not follow our study plan; thus, the final sample included 101 pregnant women. With each participant's permission, we checked her prenatal screening status with her obstetrician to confirm her study eligibility. In the intervention group, two women dropped out due to moving and placenta previa. In the control group, five women dropped out due to moving ( $n = 1$ ), preeclampsia ( $n = 2$ ), and gestational diabetes ( $n = 2$ ). Pregnant women who did and did not complete the study did not differ significantly in any demographic characteristics measured. Study power was estimated using G\*Power version 3.1.9.2.<sup>49</sup> Our a priori power analysis

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