The meaning of yoga "recombination" - A discussion of immunological change in yogic practice

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Abstract: Yoga, which means "recombination" in Sanskrit, has been recently confirmed to have various physiological effects. We examined changes of electroencephalographs (EEGs) and cellular immunity before, during, and after yoga exercises, in an endeavor to detect any correlation between them. During the pranayama period, we observed a positive correlation between the change in abundance of activated alpha waves and the ratio of changes in NK activity. Furthermore, a positive correlation was observed between the change in abundance of the activated alpha waves and the ratio of changes in the number of T lymphocytes. These findings suggest that yoga creates a stress-free and mentally concentrative state which activates the functions of NK cells and T lymphocytes within a short period of time. However, a negative correlation was observed between the change in the abundance of the activated alpha waves and the ratio of changes in the number of B lymphocytes during the pranayama period. We conclude from these results that yogic practice may be able to help recover a person's mental and physical harmony in our stress-laden modern society. The original meaning of yoga, "recombination", is considered to express some "re-activation" of a latent ability of harmonization which humans naturally possess.

Keywords: yoga, EEG, alpha wave, NK activity, T lymphocytes, B lymphocytes, cellular immunity, harmony

1. Introduction

The meaning of yoga is "recombination" in Sanskrit. Since ancient times, people have typically used yoga to bring their mind and body together in a deep relaxed state.

In Western countries, yoga has become a popular method in relieving stress. There have been some reports describing how yoga improves respiratory, circulatory, endocrine, and metabolic functions1-4. In recent years, several reports have suggested modulation of the immune system (psychoneuroimmunology)5,6. There is a reciprocal relationship between mind and body - physiologic exercises affect the mental/emotional state, and the mental/emotional state affects the physiology. Proficiency in yoga is considered to induce physiological changes based on these relationships, thus contributing to human health, especially the maintenance and promotion of immunocompetence.

Therefore, we investigated natural killer cell activity (NK activity), CD3 (T lymphocytes) and CD20 (B lymphocytes) counts, and changes in electroencephalographs (EEGs) before, during, and after yoga exercises in subjects who had several years of yoga experience.

2. Subjects and Methods

The subjects were eight yoga instructors (4 men
and 4 women) who had been practicing yoga for several years. During daytime, a 10-minute-rest period, followed by a 15-minute yoga exercise called asana (a series of postural changes), a 15-minute respiratory exercise called pranayama (various specialized respiration methods continuously performed with the eyes closed), and a 20-minute meditation (a method using mantra) were performed.

Throughout rest and yoga, brain rhythms were continuously recorded without auditory feedback via two disc electrodes placed on each subject's forehead (right frontal cortex, Fp2), using the Biofeedback-system produced by Futek Electronics Co. Ltd. It accumulated the measured brain rhythms at 2 second intervals, dividing them into five frequency ranges (theta wave, 3 zones of alpha wave (7 - 8 Hz, 9 - 11 Hz, and 12 - 13 Hz), and beta wave), and computed the mean frequency and abundance (appearance rate) of detected brain rhythms in each range.

Abundance and mean amplitude of brain rhythms of these five frequency ranges during the asana period, the pranayama period, and the meditation period were calculated. The activated frequency range(s) among the five frequency ranges were thus obtained for each subject.

An indwelling heparinized catheter was placed into each subject approximately 20 minutes before the rest period was started. This was used to draw blood samples before and after each exercise.

Each subject's blood sample was collected in tubes containing citrate phosphate dextrose (CPD). NK activity was measured using $^{51}$Cr labeled K562 targets. Effector and target cells were incubated at 37°C for 4 hours in microtiter plates. Wells contained $1 \times 10^5$ K562 cells and effector cells at a ratio of 20:1. Wells with K562 in medium alone or with 0.1N HCl were used to assess spontaneous and maximum release. Supernatants were collected and the percentage of cytotoxicity was calculated.

Percentages of T-cell subsets were measured using conjugated monoclonal antibodies.

The subjects were instructed to get plenty of sleep, not to drink alcohol during the 24-hour period prior to the experiment, and not to drink any caffeinated beverages on the day of the experiment.

3. Results

Abundance of alpha waves (9 - 11 Hz) increased in six of the eight subjects, and low frequency alpha waves (7 - 8 Hz) increased in one subject. As a result, it was decided that alpha waves of 9 - 11 Hz were the activated frequency range for six subjects while alpha waves of 7 - 8 Hz were the activated frequency range for one subject. As the abundance of both 7 - 8 Hz alpha waves and theta waves increased in the last subject, it was decided that both frequency ranges were activated. For this subject, the abundance and mean amplitude of these two frequency ranges were combined and calculated. Thus, the abundance and mean amplitude of the activated frequency range(s) of each subject were determined. The abundance and mean amplitude of the activated frequency range(s) of the eight subjects were then statistically analyzed. In the last period (the meditation period), the abundance and mean amplitude of the activated frequency range(s) of each subject were significantly ($t_1=-9.06, p<0.0001$ and $t_2=-2.38, p<0.05$), compared to the rest period. Statistically significant increases of abundance of the activated frequency range(s) were observed between the rest period and the asana period ($t_1=-4.29, p<0.005$) and between the asana period and the pranayama period ($t_1=-9.26, p<0.0001$). Mean amplitude of the activated frequency range(s) did not significantly change between any consecutive periods. There were no apparent changes in NK activity after a series of yoga exercises.

However, during the pranayama period, a positive correlation between the change in abundance of the activated alpha waves and the ratio of changes in NK activity ($r=0.83, p<0.02$), and also a positive correlation between the change in abundance of the activated alpha waves and the ratio of changes in the number of T lymphocytes ($r=0.78, p<0.05$), were observed. But a negative correlation ($r=-0.79, p<0.02$), was observed between the change in abundance of the activated alpha waves and the ratio of changes in the number of B lymphocytes during the pranayama period.

4. Discussion

Anand, et al.\textsuperscript{2} reported an augmentation in the amplitude of alpha wave activity following meditation in yoga. Satyanarayana, et al.\textsuperscript{8} reported that over the course of 30 days of yoga exercise, increases in alpha index, (abundance of alpha rhythms) for both occipital and
pre-frontal lobes were observed bilaterally, suggesting an increase in calmness. Our subjects showed the activation of alpha rhythms, mainly, and thus agreed with these previous reports. Asana exercise is a kind of stretching exercise. However, slow and rapid respiration in respiratory exercise (pranayama) requires a conscious regulation of the breathing rhythm, and is considered to require mental concentration. In proficient kendo (Japanese fencing) players, we previously reported significant increases in NK activity during kendo matches compared to jogging while swinging a sword for the same amount of time. Therefore, mental concentration during kendo matches was considered to increase the NK activity. In this study, the observed increase in the appearance of alpha rhythm activity in the eight subjects was most pronounced during the respiratory exercise (pranayama), a stress-free state that requires mental concentration. The positive correlation between the increased alpha activity and increases in NK activity in this study may be relatively dependent on the proficiency of these yoga practitioners in creating a stress-free state.

The correlation between the frontal alpha wave activation and the increase in NK activity using one type of photic stimulation system has been reported, implying that enhanced immune function can be caused by the activation of alpha rhythm.

Both positive correlations between the increased alpha activity and increases in NK activity, as well as increased alpha activity and increases in the number of T lymphocytes suggests that mental concentration in a stress-free state activates the functions of NK cells and T lymphocytes in a short time. These results indicate a certain neuroimmunological effect by performing this fifteen minute unique respiratory exercise (pranayama). One possible mechanism is the stimulation of the respiratory center located in the upper 1/3 of the pons, resulting in the release of a certain neurotransmitter. Another possible mechanism is that markedly changed blood O₂ levels, caused by extraordinary changes in ventilation, stimulate the release of a certain neurotransmitter. Behaviors, such as yoga respiratory exercise (pranayama), that activate frontal alpha rhythm may promote both enhanced immune surveillance and mental health. But this mechanism is not clear.

Yoga does not have side effects. However the effect and proficiency of yoga is different in every individual due to their skill level of yoga. Continuing yogic practice is known to increase the effectiveness of yoga and the recovery of a person's mental and physical harmony. "Recombinations" of mind and body and of mind to mind that have been noted from experience may be a latent ability to achieve harmony which all humans naturally possess. Yoga may be a representative training method to re-activate this latent ability.

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ヨーガ（再結合法）の意味——ヨーガの行による免疫の変化からの考察
(The meaning of yoga "recombination" - A discussion of immunological change in yogic practice)

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要旨：サンスクリット語で「再結合」という意味のヨーガには、近年、多彩な生理学的効果があることが明らかになってきている。われわれは、ヨーガの行を数年以上経験しているインストラクターで、行の最中と前後の脳波と細胞性免疫能の変化と相関性の有無について検討した。その結果、ブラーナーヤーマ（呼吸法）におけるα波の出現率の増加とNK活性の上昇との間に正の相関があり、同じくα波の出現率の増加とT細胞系リンパ球の増加との間にも正の相関が見出された。これらは、ストレス負荷を伴わないような精神の集中が、NK細胞やT細胞系の機能を短時間のうちに増強させる可能性を示唆している。なお、B細胞系リンパ球の増加との間には、負の相関が見出された。ストレス社会に生きる現代人は、ヨーガの行により心身の調和を取り戻す可能性は高いと思われる。ヨーガの意味である「再結合」は、人間が本来持つ調和のための潜在能力の再活性化を表現していることが考えられた。

Keywords: yoga, EEG, alpha wave, NK activity, T lymphocytes, B lymphocytes, cellular immunity, harmony

1. はじめに

ヨーガは、サンスクリット語で「再結合」という意味で、「人間のいろいろな不調和を調和のとれた姿へと正すこと」を基本的解釈としている。このように、人間は古くから、心身の相関性が健康に与える影響の大ささに人間は気づいてきて、より深くリラックスした状態に心身を導ける修養法を経験的に確立してきた。ヨーガはその典型例と言える。

伝統医学が近年見出される傾向にあり、ヨーガについても、①自律神経系の安定（副交感神経優位）②代謝の比較的低下 ③血栓症に対する予防効果 ④温度調節機能の向上 ⑤呼吸機能の改善 ⑥内分泌機能の向上 ⑦α波の活化 が報告されている1。このうちの⑤と⑦については、ヨーガの行による血流コルチゾール値の低下傾向、及び、その低下率とα波の出現率の関の負の相関を、近年われわれは見出している2。

そして、ヨーガ療法の対象となる疾患・症状および用途には、a)不眠症 b)めまい c)高血圧症 d)気管支喘息 e)妊娠のためのヨーガ（マタニティー・ヨーガ）f)高齢者のためのヨーガなどが挙げられている。

われわれは、ヨーガの行を数年以上経験しているインストラクターで、行の最中と前後の脳波と細胞性免疫能の変化を調べて両者の相関性の有無を確認し、ヨーガの基本的解釈が正しいかどうかを検討した。

2. 実験方法

ヨーガの行を数年～十数年間継続しているインストラクター8名（男性4名、女性4名）を対象に、日中の時間に、右前頭部で脳波を測定しな
がら、アーサナ（Asana：座法。一連の体位変換。）を15分間、プラーナーヤーマ（Pranayama：呼吸法。）を15分間、プラーナーヤーマ（Pranayama：呼吸法。）を行って、例えば、腹式呼吸を速く行う、片鼻だけである呼吸をする等、一定の技法のもとに、特に呼吸を意識的に行う。）を20分間行なってもらった。アーサナの直前・アーサナとプラーナーヤーマの間、プラーナーヤーマとディヤーナの間、およびディヤーナの直後で、ナチュラルキラー細胞の活性（NK活性）・CD3・CD4・CD8・CD20の値を測定した。脳波の測定には、フューテックエレクトロニクス社製のバイオフィードバックシステムFMS15を用いて、脳波として使用した。

3. 実験結果

被験者8名のうちの7名は、ヨーガの行により9-11Hzのα波が出現し、1名は7-8HZのα波が出現した。免疫系の5項目は、ヨーガの行によって変化は見られなかった。しかし、プラーナーヤーマの前後で、α波の出現率の増加とNK活性の増加率及びCD3の増加率との間に、正の相関（順にp<0.02、p<0.05）が見られた。一方、α波の出現率の増加と、CD20の増加率との間に負の相関（p<0.05）が見られた。

4. 考察

Anandらは、α波の振幅はヨーガのディヤーナ（瞑想）によって増強することを報告している。また、Satyanarayanaらは、ヨーガの行を30日間継続することにより、α波の出現率が頭部と前頭葉前部付近で增大すると報告している3）。一方、われわれの研究では、熟練者は、アーサナ、プラーナーヤーマ、ディヤーナと進むにつれてα波の出現率が増加しており、行全体を通じて身のリラクゼーションが深まるものと考えられた。

一方、プラーナーヤーマは意識的に呼吸の調節を行う方法で4），それには少なからぬ精神の集中を必要とすると思われる。われわれの研究でも、α波の出現率は、頭部に比較して、アーサナの15分間に比較したプラーナーヤーマの15分間で最も有意に増加していた。つまり、ヨーガの熟練者にとっては、プラーナーヤーマは、精神の集中が必要でありながらも、リラックスできる行であることが推測される。われわれは、以前に、日本の伝統的スポーツである剣道の試合の前後で、NK活性が上昇することを報告し、これにより、精神の集中がNK活性の上昇をもたらすことを示唆していた5）。今回の実験では、プラーナーヤーマにおけるα波の出現率の増加とNK活性の上昇との間には正の相関が、同じくα波の出現率の増加とT細胞系リンパ球の増加との間には、負の相関が見出された。これらは、ストレス荷負を伴わないような精神の集中がNK細胞やT細胞系の機能を短時間うちに増強させることを示唆している。なお、α波の出現率の増加とT細胞系リンパ球の増加との間には、負の相関が見出されており、この意義については今後の検討を要する。

今回の結果から、心身のリラックス時においても、α波の周波数の変動を減らすことにより、人によって固有のα波のリズムの出現を高めることができれば、循環血中におけるNK活性を増強させ、T細胞系の機能を高めることとなることが考えられる。その機序には何かの神経伝達物質が介在すると思われが、それについても現在のところ不明である。

ヨーガには副作用は認められない。しかし、熟練に至るまでは効果には個人差があり、修養を続けることによりこの個人差を克服することで、ストレス社会に生きる現代人は、心身の調和を取り戻す可能性が高いと思われる。人間が精神的に気を悪くしていた人たちは、心だれとの「再結合」は、いかなる人にも持ち合わせる調和のための潜在能力ということかもしれない。これに再び活性化させる方法として、ヨーガのような修養方法が存在するということかもしれない。

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参考文献

