NUJHS Vol. I, No.1-3, September 2011
Nitte University Journal of Health Science
Original Article

EVALUATION OF THE EFFICACY OF CARDAMOM AROMATHERAPY ON AEROBIC FITNESS & AUTONOMIC FUNCTIONS AMONG STUDENTS.

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Abstract:
Introduction: Aromatherapy is categorized as a form of complementary and alternative medicine (CAM), and has been steadily gaining popularity in today's society. Aromatherapy is considered by many to promote comfort, well-being and invigorating. However there appears to be insufficient supporting evidence to validate physiological changes that may reflect invigoration.
Objectives: This study examined the physiological effects of cardamom (Elettaria cardamomum) aromatherapy as indicated by heart rate variability. Aerobic fitness is one of the non invasive and simplest parameters which help in accessing one's fitness. In this present study we have also evaluated the efficacy of aromatherapy on the individual's physical fitness.
Methods: Total thirty healthy college students were selected as a subject who has attended four sessions in random order involving only exercise, aromatherapy and exercise combined. Each intervention lasted 15 minutes. Heart rate data were recorded for all sessions, and heart rate variability was analyzed. Aerobic fitness parameters also evaluated with the help of standard methods.
Results: There was statistically significant difference in LF/HF between the two intervention studies. During this aromatherapy, physiological responses such as oxygen consumption, respiratory exchange ratio and minute ventilation were significantly altered among different groups. Aerobic fitness was observed higher in aromatherapy combined exercise group against the only exercise group.
Conclusion: These results suggest significant physiological effect of cardamom (Elettaria cardamomum) aromatherapy interventions occurs in the autonomic nervous system as indicated by heart rate variability. The present study demonstrates that good estimated aerobic fitness was independently associated with aromatherapy and exercise.
Keywords : Aromatherapy, autonomic function, aerobic fitness, exercise.

Introduction

Ancient writings provide insight into how religions and cultures of old used the aroma of burning herbs, flowers, tree leaves and other natural sources in their spiritual practices. It is learnt from the Hebrew, Christian, Buddhist and Hindu cultures more about these types of ritualistic observances[1]. All these cultures from around the world had access to various plants from which to develop a recipe for pleasing the nose and mind. They assigned mystical energies to these plants and learned over the ages which ones provided results and which ones failed. They also provided us with instructions for using aromas that were pleasing not only to the senses of the human nose, but also to the senses of the Divine forces in their lives. Incense sticks are part of the 16 essential offerings during a Hindu ritual. According to Saurabh Bhattacharya[2] each of these offerings has symbolic spiritual significance and is offered to the Divine in a particular order.

Physical activity is defined as any bodily movement produced by skeletal muscles that result in energy expenditure[3]. Physical fitness can be defined in multiple ways, such as a set of outcomes or traits that relate to the ability to perform physical activity[3]. Aerobic fitness determines the degree of fatigue that almost everybody experiences in daily life. The higher the aerobic fitness, the less fatigue one experiences. Aerobic fitness is the ability to sustain work for prolonged periods. In order to

enhance aerobic fitness, athletes are known to try a variety of aids to enhance performance and boost their chances of winning. The term ergogenic aids identifies those agents or procedures which if followed before a competition will potentially enhance the athlete's performance[4].

Aromatherapy, another possible ergogenic aid, has been growing in recent years and has received much attention by both traditional and alternative medicine practitioners. However, there is very little evidence which supports or refutes the claims made by merchants, practitioners, and manufacturers[5]. Since smell is the least understood of all our senses[6] it is logical to understand why the number of discrepancies exist within the lay and scientific literature regarding the validity of aromatherapy. Buckle et. al. (1998) argues that aromatherapy is becoming more and more valuable in holistic nursing practice and should be a part of nursing protocols[7]. Martin et. al. (1996) suggested that drawing conclusions regarding aromatherapy is premature since much of the data is qualitative as much of it is based on pure historical content and anecdotal reports from individuals[8]. Researchers have argued against aromatherapy secondary to the poor follow-up of clients after sessions. Additionally many reports are purely subjective in nature and cannot be considered truly scientific[9].

Earlier it was demonstrated that inhaling peppermint is reported to be a stimulant for increased energy which would certainly benefit any athletic or non-athletic individual during an exercise bout[10]. By definition, peppermint could be considered an ergogenic aid. Lavender is marketed as an aroma which promotes relaxation and a calming effect[7]. As with any ergogenic aid, multiple questions arise regarding legal and ethical issues. Also important is the additive being used a substance the athlete would normal consume or use in everyday life[4]. How effective are the aromatherapy and environment conditioning fragrances? It has been said that aromas from lavender, basil, cinnamon and citrus flavor aid relax, whereas cardamom, peppermint, thyme and rosemary invigorate. Ginger, cardamom, licorice and chocolate are supposed to arouse a sense of romance, while rose combat depression[11, 12]. Stimulating or invigorating odors such as cardamom, rosemary and lemongrass affect the locus ceruleus with the resultant release of noradrenalin into the brain and this has the effect of arousal/waking up. Researchers at the Royal Berkshire Hospital NHS Trust recently broke new ground by studying the effects of aromatherapy in the intensive care unit as a means of helping to alleviate anxiety and stress[13].

The purpose of this pilot investigation was to examine the potential benefits that common cardamom (Elettaria cardamomum) aromas might have on basic physiological measures before, during and after a 15-minute exercise bout. There is little evidence in the literature addressing the actual physiological responses after the introduction of an aromatherapy during exercise. It was hypothesized that cardamom (Elettaria cardamomum) aromatherapy can induce significant changes in the autonomic activity. Our main concern is to elucidate the effect of cardamom aromatherapy is synergistic or antagonistic. It was hypothesized that the effect of aromatherapy on heart rate would be a greater alteration in autonomic nervous system activity than the effect of exercise alone.

MATERIALS METHODS

Subjects: Sixteen male and fourteen female apparently healthy college students volunteered to participate in this investigation. Mean ages were 22.5 ± 0.8 for males and 21.75 ± 0.9 for females. These students considered themselves sedentary. In this investigation, an individual was considered sedentary if he/she did not regularly participate in physical activity more than two days per week at equal to or greater than 60% of their maximal heart rate. All subjects were familiar with exercise

protocols and walking on a motorized treadmill. This study was approved by the departmental review board for institutional ethical committee. Informed consent was obtained from every individual who has participated in this study. Using an in-house designed questionnaire, background information was gathered from the subjects.

Methods:

Anthropometric measurements: All subjects underwent a clinical examination; weight, height, and waist and hip circumferences have been measured. Blood pressure was recorded by auscultatory method with a mercury sphygmomanometer according to the American Heart Association guidelines.

Measurement of Peak Expiratory Flow Rate (PEFR): Peak expiratory flow rate was examined with an Airmed peak-flow meter. The test was performed in standing position holding the peak flow meter horizontally. A tight fitting disposable cardboard mouthpiece was inserted in the inlet nozzle. After proper rest, subject was requested to take a deep breath and followed by exhalation as forcefully as possible in one single blow into the instrument. The procedure was repeated three times and best of the three was recorded.

Measurement of Physical Fitness Index (PFI): PFI was measured by Harvard step test[14]. The standard procedure for the original step test was modified and used with a difference that the stepping height is reduced from 20 inches to 18 inches in the line of originator of the tests who suggested that for evaluating subjects with body surface area below 1.85sq.m, an 18 inches stool should be appropriate. The subjects stepped up and down on a stool at the rate of 30 complete steps per minute keeping time to a metronome for duration of 5 minutes unless one stops from exhaustion. The recovery pulse counts were measured at 1 to 1.5, 2 to 2.5, 3 to 3.5 minutes recovery. Physical fitness is scored as PFI = [Duration of exercise in sec x 100] / [2 x (sum of 1 to 1.5 min., 2 to 2.5 min., 3 to 3.5 minutes recovery)].

Oxygen consumption (VO_2), minute ventilation (VE) and respiratory exchange ratio (RER) were obtained via open circuit spirometry using a metabolic analyzer. HR (Heart rate) was recorded using a Polar Heart Rate Monitor. A motorized treadmill was used for the exercise mode. RPE was obtained using the modified Borg scale[15].

Aromatherapy: In this treatment schedule the subject has been categorized and in order to assess each subject's olfactory sensation, they were asked to identify three recognizable aromas: garlic, ginger and a control [water with food coloring made to resemble other aroma mixtures]. As subjects confirmed their olfactory sensation by recognizing each aroma, their suitability for participation was confirmed. After acclimatization to the laboratory, subjects returned once per week for three weeks. Each week cardamom (Elettaria cardamomum) aroma was administered in a double blind fashion. The administration of the cardamom essential oil was delivered through a sealed plastic container with the oil concentrated on a sterile cotton pad. Subjects inhaled the aroma with only nose breathing. The procedure of administration cardamom aromatherapy was modified from the Pournemati P. et.al.[16]. Each subject inhaled the aroma for one minute and began walking on the treadmill at a speed of 90.5 meters/minute for 15 minutes. At every three-minute interval, the subject's HR, VO_2, VE and RPE were obtained and recorded. Also at each interval the designated aroma was again administered using the sealed container for a period of 60 seconds. After the 15-minute period was completed, subjects walked for five minutes at a speed of 55.3 meters/minute. Recovery heart rates were obtained until it was confirmed that subjects had returned to within 15-20 beats of their pre-exercise heart rate.

Measurement of HRV parameters: The ECG was recorded using lead II to obtain a QRS complex of

sufficient amplitude and stable base line. ECG signals were conveyed through an A/D converter (Biopac MP 30, Biopac system) at a sampling frequency of 500 Hz to PC and were analyzed

Statistical analysis: The data obtained were analyzed for their statistical significance by one way ANOVA test and paired t-test using SPSS. P<0.05 was considered the level of significance.

RESULTS

The data represented in Table 1. highlights the characteristics features such as age, height, blood pressure and different habits of the subjects. In addition, weight and height was obtained to determine the body mass index of each subject, waist and hip measurements are included to determine waist to hip ratio.

The information gathered from the subjects during the interactive session clearly shows that few of them were also got the addiction to the alcohol, caffeine, and smoking. The collected information about the lifestyle parameters such as food habits, walking habits, health and sports habits and stress related conditions at the college. It was demonstrated that students are having poor attitude towards their lifestyle parameters and highly sensitive to the stressful conditions.

Table 1 – Base line general features of selected students

Particulars	
Age (Years)	22 ± 0.5
Weight (kg)	58.7 ± 5.95
Height (cm)	159.5 ± 6.74
BMI (kg/m^2)	23.2 ± 0.8
WHR (waist-hip-ratio)	0.69 ± 0.03
Systolic blood pressure (mmHg)	124 ± 10.68
Diastolic blood pressure (mmHg)	74 ± 2
Smoking	2 %
Alcoholics	1 %
Excess Caffeine	2 %

Subjects (n) in each group, n= 30. The values are expressed as mean ±SD.

Each subject completed three separate exercise bouts of treadmill walking lasting 15 minutes. During each bout subjects inhaled one of three samples in a double blind fashion. Table 1 contains the data obtained from analysis of expired gases Oxygen consumption (VO_2) minute ventilation (VE) and Respiratory Exchange Ratio (RER) remained the same among all three trials.

Table 2 - Comparison of selected physiological parameters among exercise and exercise combined aromatherapy.

Parameters	Excercise group	Aromatherapy combined exercise	P Value
Physical Fitness Index (PFI)	44.5 ± 2.42	49.4 ± 1.41	P<0.01
VO_2max (ml.kg^{-1}min)	29.6 ± 1.24	35.5 ± 3.79	P<0.01
Peak expiratory flow rate (PEFR) (Lmin^{-1})	376.1±67.67	429.9±.42.91	P<0.01
VE [L/min]	28.65 ± 2.7	32.16 ± 3.2	P<0.01
RER	1.55 ± 0.07	1.92 ± 0.08	P<0.01

Subjects (n) in each group, n= 30. The values are expressed as mean ±SD.

Table 1 shows the higher aerobic capacity in aromatherapy group as compared to exercise group, expressed by higher (P < 0.01) oxygen uptake and physical fitness index.

Heat rate response can be found in Table 2. During exercise, heart rate increased approximately 30 beats per minute above pre-exercise rate for all three trials. Based on the rate of exercise intensity which subjects performed, this response was considered normal. The exception to this increase was with the cardamom trial which only elicited a 29 beat increase secondary to the higher pre-exercise heart rate of 71 BPM as compared to 77 BPM for the exercise group.

Table 3. Heart rate and rating perceived exertion (RPE) response in exercise and exercise combined aromatherapy group.

Parameters	Excercise group	Aromatherapy combined exercise	P Value
Pre-exercise heart rate	77.23±8.5	71.64 ± 7.7	P<0.1
Exercise Heart Rate	100.23 ± 8.7	100.9± 9.3	P<0.1
Time of running (minute)	12.45 ± 1.2	14.30 ± 0.9	NS
RPE	2.4 ± 0.8	3.7 ± 0.8	P<0.1

Subjects (n) in each group, n= 30. The values are expressed as mean ±SD.

Subjective measures of the modified Borg Scale or Rating of Perceived Exertion [RPE] were obtained and these results demonstrated an increase for the aromatherapy combined exercise group [3.7] compared to a [2.4] for the exercise group. An RPE of 3 equates to a perception of hard work. An RPE of 2 equates to a perception of light work.[17]

The results depicted in table.4, Data are reported as medians and interquartile range. RR = standard normal RR interval; LF, HF = low and high frequency power, respectively; LF/HF = ratio of absolute LF power to HF power values. Frequency ranges: LF: 0.04-0.15 Hz and HF: 0.15-0.4 Hz.

According to the results presented in table. 4 It is apparent that after the aromatherapy treatment blood pressure shows significant changes in both systolic and diastolic. There was also an increase in heart rate, LF and LF/HF ratio. Apparently, treatment of aromatherapy decreases parasympathetic nervous activity.

The differences in the heart rate and other parameters between the two groups at baseline, before and after exercise are shown in Table 4, indicating a significant difference in LF between the exercise and exercise combined aromatherapy groups before and after exercise. The median LF, HF level in exercise combined aromatherapy group was significantly higher than those in the exercise group. The smaller HF and larger LF/HF after exercise may indicate possible elevation of sympathetic activity. All the other HRV measurements, indicates significant difference between the cardamom aromatherapy combined exercise and exercise group.

Table 4. Comparison of heart rate variability parameters in the exercise combined aromatherapy group.

Parameters	Exercise group		Aromatherapy combined exercise	
	Pre-exercise	Post-exercise	Pre-exercise	Post-exercise
Heart Rate (BPM)	69.32 ± 8.75	76.05 ± 6.11	78 ± 10.49*	82.7 ± 15*
LF(msec^2)	357.55 ± 159.84	305.88 ± 227.74	534.64 ± 567.80**	370.27 ± 257.52***
HF(msec^2)	1191.32 ± 1298.74	399.18 ± 419.84	787.73 ± 755.52**	482.36 ± 429.80**
LF/HF	0.299 ± 1.017	0.764 ± 1.351	0.705 ± 1.671**	0.968 ± 1.145***
Systolic blood pressure (mmHg)	112.04 ± 17.29	129.52 ± 11.31	123.27 ± 11.16**	139.09 ± 6.49**
Diastolic blood pressure (mmHg)	74.32 ± 8.72	83.00 ± 6.89	78.82 ± 8.94**	86.00 ± 6.72***

Subjects (n) in each group, n= 30. The values are expressed as mean ±SD.
*P < 0.05; **P < 0.01; ***P < 0.001.

DISCUSSION

Aromatherapy uses concentrated essential oils extracted from herbs, flowers, trees and other plants. The essential oils are believed to have an effect on both psychological and physiological level. Depending on the mix and blend, this effect may be either to stimulate or relax [18]. Cardamom (Elettaria cardamomum) is also known as cardamon; it is related to several spices, such as ginger (Zingiber officinale), and consequently possesses some similar therapeutic properties and benefits as ginger.

Some important neurotransmitters have been identified in cardamom, aceylcholine and choline, which explain herbal medicine's position that cardamom, may behave as a stimulant to the nervous system, and uses it to help prevent convulsions or spasms. Scientific studies have shown that cardamom has a blood thinning action, due to its high concentration of linoleic acid[18].

We found a significant increase in mean heart rate and increases in analysis of heart rate variability parameters after 15 min of cardamom inhalation. Moreover, HF is

also increased, and all these indices have been used to reflect primarily sympathetic influences. LF has been shown to reflect both sympathetic and parasympathetic influences, making the contributive components of this measurement less clear[19, 20]. However, the change in LF and ratio of LF/HF infer that there is an impact on sympathetic drive to the heart.

In this present study we also investigated that the differences in autonomic cardiovascular control could appear between exercise and exercise combined aromatherapy group during a situation of exercise stress, which is a natural stimulus, leading to sympathetic excitation and vagal withdrawal in the heart. During exercise the initial increase in the heart rate response is mediated by a decrease in vagal activity, followed by an enhanced sympathetic activity that maintains higher values of heart rate during the test.

The finding of increased low to high frequency (LF/HF) ratio in response to cardamom aromatherapy indicates that aromatherapy may in fact cause a sympathetic response, rather than a parasympathetic response. This finding warrants further research. Further, it is not known what mechanisms play a role with aromatherapy and metabolism. At 15 minutes of exercise the average individual is just beginning to achieve a true point when oxygen demands equal oxygen availability or more commonly referred to as steady state of oxygen consumption[17].

The use of aromatherapy is rapidly growing within western society. It is obvious from the literature that there are vast differences in opinion regarding the efficacy, validity and the overall claims towards the role of aromatherapy in all aspects of medicine, particularly preventative and rehabilitative medicine. Exercise does fall into both categories, preventive and rehabilitative; therefore the use of aromatherapy in concert with exercise is quite popular. Although it is claimed that peppermint may accentuate energy by stimulating the adrenal cortex[10] it is not known what dosage and how this increased energy may affect exercise performance.

Cardamom has reputation for having simulative effects on autonomic bodily systems like digestion and circulation. Cardamom may improve blood circulation to the lungs, and is indicated in folk medicines to relieve symptoms of asthma and bronchitis.[11-13] Our study clearly suggests that during dynamic exercise, heart rate increases due to both a parasympathetic withdrawal and an augmented sympathetic activity. The relative role of the two drives spectral depends on the exercise intensity.[20-25]

In the present investigation, cardamom aromatherapy had significant effect on resting or exercises heart rate during 15 minutes of moderate treadmill walking. The result of present study about rating perceived exertion shows a slight increase in aromatherapy groups. Rating perceived exertion is a good index for evaluating individual's effort during an exercise bout [15].

Earlier study mentioned that inhaling the essential oil can affect the performance in both positive and negative ways[20] and the cardamom essences is known as aphrodisiac and invigorating which may be the reason for increase in concentration and improves performance. The results of this study indicate that inhaling a cardamom essence has brought the significant differences when compared to exercise group. The value of respiratory exchange ratio indicates that fat is being consumed for energy generation during exercise. It is possible that cardamom aroma may have more beneficial effects when fat are the major fuel source as opposed to carbohydrate.

The higher aerobic capacity of the athletes was reflected in greater oxygen consumption and physical fitness index in both groups. Also, the resting heart rate was significantly lower in exercise combined aromatherapy group than in exercise group. Changes in the intrinsic mechanisms acting on the sinus node and alterations in

the autonomic nervous system control of the heart have been reported to contribute to this phenomenon.[23, 24] These data are exciting regarding aromatherapy and exercise performance; however, given the above limitations regarding time and introduction of aroma, these results are understandable.

The benefits of aroma on exercise performance is not yet established, the questions regarding their ethical use must be addressed. However, further research on the normal and strenuous exercise in combination with appropriate control needs to be conducted to clarify the efficacy of cardamom aromatherapy in the management of well-being in combating with lethargy, sedentary life style and or other health issues. Heart rate and other cardiac variables should have been measured during exercise to clarify physiological responses more in details. We demonstrate the need of further research to investigate subjects, measurement indicators, and experimental conditions to clarify the relationship between physiological and emotional responses produced by cardamom aromatherapy.

CONCLUSION

Everyone experiences some degree of pressure at work, and being under pressure can help improve performance and productivity. Excessive levels of pressure, however, can have adverse effects, resulting in stress and intense long-lasting stress can lead to mental and physical ill-health. In such situations, simple techniques that can help to cope up with stress, such as aromatherapy, can be of major benefit. We have demonstrated on young healthy adults the effect of inhaling the aroma from Cardamom (Elettaria cardamomum) essential oil on autonomic balance. The results provided support for the stimulatory effect of aroma, as indicated by a shift of the autonomic balance toward sympathetic predominance. Combining exercise with cardamom aromatherapy is not only enjoyable because of its effects on mood but also promotes physiological excitation, thereby increasing physical activation. Inhalation of cardamom essential oil may provide a relatively simple, safe, well-being, invigorating and effective method of handling the stressful conditions.

References:

1. White, Martha. Traditional home remedies, Time-Life Books, 1995
2. Bhattacharya, Saurabh. "Wisps of Worship", Life positive magazine, Magus Media Pvt Ltd, July 1998.
3. Caspersen, C. J., K. E. Powell and G. M. Christenson. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep 1985; 100(2): 126-31.
4. Wilmore JH, Costill D L. Physiology of sport and exercise. Champaign IL: human Kinetics Publications. 1994.
5. Vickers, Andrew. Yes, but how do we know it's true? Knowledge claims in massage and aromatherapy. Complementary therapies in nursing and midwifery 1997; 3, 63-65.
6. Guyton, Arthur. Textbook of medical physiology. Philadelphia: WB Saunders Co.1991
7. Buckle, Jane. Clinical aromatherapy and touch: complementary therapies for nursing practice. Critical care nurse 1998; 18, 54-61.
8. Martin, G. Neil. Olfactory remediation: current evidence and possible applications. Social science and medicine1996; 43, 63-70.
9. Lis-Balchin M. Essential oils and aromatherapy: Their modern role in healing. Journal of the royal society of health 1997; 117, 324-239.
10. Burton - Goldburg. Alternative medicine the definitive guide. 1993; Puyallup, Washington: Future Medicine Publishing.
11. Hunter BT. The sales appeal of scents (using synthetic food scents to increase sales). Consum Res Mag 1995; 78(10):8 – 10.
12. Amodio JV. Mood makers: an in-depth look at how scents claim to boost your spirit and de-stress your nerves. Good Housekeeping 1998; 227(5):53–5.
13. Dunn C; Sleep J; Collett D Sensing an improvement: an experimental study to evaluate the use of aromatherapy, massage and periods of rest in an intensive care unit. Journal of Advanced Nursing (ENGLAND) Jan 1995; 21 (1):34-40.
14. Brouha L, Health CW, Graybiel A. Step test simple method of measuring physical fitness for hard muscular work in adult men. Rev Canadian Biol, 1943; 2: 86.
15. American College of Sports Medicine. Guidelines for exercise testing and prescription, 5th edition; 1995; Williams and Wilkins.
16. Pournemati P., Azarbayjani M. A., Rezaee M. B.et. al. The effects of inhaling peppermint odor and ethanol in women athletes. Bratisl Lek Listy, 2009; 110(12) 782-787.
17. Powers Scott and Edward Howley. Exercise physiology 1998; McGraw Hill.
18. Jean-Charles Chebat, Richard Michon. Impact of ambient odors on mall shoppers' emotions, cognition, and spending A test of competitive causal theories Journal of Business Research 2003; 56: 529– 539
19. J. Penttilä, A. Helminen, T. Jartti, et al., Time domain, geometrical and frequency domain analysis of cardiac vagal outflow: effects of various respiratory patterns, Clinical Physiology, 2001; 21 (3): 365–376.
20. J.F. Thayer, S.S. Yamamoto, and J.F. Brosschot. The relationship of autonomic imbalances, heart rate variability and cardiovascular disease risk factors. International Journal of Cardiology, 2010; 141(2):122-131.
21. Perini R, Orizio C, Baselli G, et al. The influence of exercise intensity on the power spectrum of heart rate variability. Eur J Appl Physiol Occup Physiol 1990; 61 (1-2): 143-8
22. Arai Y, Saul JP, Albrecht P, et al. Modulation of cardiac autonomic activity during and immediately after exercise. Am J Physiol 1989; 256 (1 Pt 2): H132-41
23. Iellamo F. Neural mechanisms of cardiovascular regulation during exercise. Auton Neurosci 2001; 20: 66-75
24. Bernardi L, Piepoli M. Autonomic nervous system adaptation during physical exercise. Ital Heart J 2001; 2: 831-9
25. Brenner IK, Thomas S, Shephard RJ. Autonomic regulation of the circulation during exercise and heat exposure: inferences from heart rate variability. Sports Med 1998; 26 (2): 85-99