

## ORIGINAL RESEARCH

# Repeatability of Pulse Diagnosis and Body Constitution Diagnosis in Traditional Indian Ayurveda Medicine

传统印度韦达养生学中脉搏诊断和体质诊断的重复性

Repetibilidad del diagnóstico mediante el pulso y el diagnóstico mediante la constitución corporal en la medicina ayurvédica tradicional india

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## Disclosure

The authors declare no competing interests.

## ABSTRACT

In Ayurveda, pulse diagnosis and body constitution diagnosis have a long historical use; still, there is lack of quantitative measure of the reliability of these diagnostic methods. Reliability means consistency of information. Consistent diagnosis leads to consistent treatment and is important for clinical practice, education, and research.

The objective of this study is to study the methodology to evaluate the test-retest reliability (repeatability) of pulse diagnosis and body constitution diagnosis. A double-blinded, controlled, clinical trial was conducted in Copenhagen. The same doctor, an expert in Ayurvedic pulse diagnosis, examined the pulse and body constitution of 17 healthy participants twice, in random order without seeing them. A metric on pulse and body constitution variables was developed. Cohen's weighted kappa statistic was used as a measure of intra-rater reliability. Permutation tests were used to test the hypothesis of homogeneous diagnosis (ie, the doctor's diagnosis does not depend on the subject).

The hypothesis of homogeneous classification was rejected on the 5% significance level ( $P$  values of .02 and .001, respectively, for pulse and body constitution diagnosis). According to the Landis and Koch scale, values of the weighted kappa for pulse diagnosis ( $P = .42$ ) and body constitution diagnosis ( $P = .65$ ) correspond to "moderate" and "substantial" agreement, respectively.

There was a reasonable level of

consistency between 2 pulse and body constitution diagnoses. Further studies are required to quantify inter-subject and intra-subject agreement for greater understanding of reliability of pulse and body constitution diagnosis.

## 背景

在印度韦达养生学中，使用脉搏诊断和体质诊断已有很长的历史；如今仍然缺乏这些诊断方法可靠性的数量测定。可靠性意味着信息的如一性。如一诊断有助于如一治疗，对临床实践、教育和研究至关重要。

本研究的目标是探究评估脉搏诊断和体质诊断的测试一再测试可靠性（重复性）的方法。一项双盲、对照临床试验已于哥本哈根展开。同一名医生（一名印度韦达养生学脉搏诊断专家）在看不见参与者的情况下，按随机顺序对 17 名健康参与者的脉搏和体质进行两次检查。脉搏和体质变量的度量标准已经制定。使用 Cohen 的加权 kappa 统计来测量评估者的内信度。使用排列测试测试同构诊断假设（即医生诊断不取决于受试者）。

拒绝接受同构分类假设的比例达到 5% 的较高水平（脉搏和体质诊断的  $P$  值分别为 .02 和 .001）。根据 Landis 和 Koch 量表，脉搏诊断 ( $P = .42$ ) 和体质诊断 ( $P = .65$ ) 的加权 kappa 值分别对应“中等”和“高度”一致。

2 次脉搏和体质诊断之间达到合理如一水平。需要开展进一步研究来量化受试者间和受试者本身的一致性，以便更好地了解脉搏和体质诊断的可靠性。

## SINOPSIS

La medicina ayurvédica lleva mucho tiempo utilizando el diagnóstico mediante el pulso y la constitución corporal; no obstante, se sigue careciendo de medidas cuantitativas de la fiabilidad de estos métodos diagnósticos, la cual implica uniformidad de la información. Un diagnóstico coherente lleva a un tratamiento uniforme y resulta de gran importancia para la práctica clínica, la educación y la investigación.

El objetivo de este estudio, un ensayo clínico controlado doble ciego llevado a cabo en Copenhagen, es analizar la metodología para evaluar la fiabilidad (repetibilidad) del diagnóstico mediante el pulso y la constitución corporal. El mismo médico, un experto en el diagnóstico ayurvédico mediante el pulso, examinó en dos ocasiones el pulso y la constitución corporal de 17 participantes sanos, en orden aleatorio y sin verlos. Se desarrolló una escala de medida de las variables de pulso y constitución corporal. Como método de la fiabilidad en el mismo evaluador se usó el valor estadístico kappa ponderada de Cohen y se usaron pruebas de permutación para probar la hipótesis de la homogeneidad del diagnóstico (es decir, el diagnóstico del médico no depende del paciente).

La hipótesis de la homogeneidad de la clasificación se rechazó al nivel de significación del 5% ( $P$  valor de 0,02 y 0,001, respectivamente, para el diagnóstico mediante el pulso y la constitución corporal). Conforme a las escalas de

Landis y Koch, los valores de kappa ponderada para el diagnóstico mediante el pulso ( $P = 0,42$ ) y mediante la constitución corporal ( $P = 0,65$ ) se corresponden con una con-

cordancia “moderada” y “sustancial”, respectivamente.

Se produjo un nivel de uniformidad razonable entre los dos diagnósticos mediante constitución cor-

poral y pulso, aunque se requieren más estudios para cuantificar la concordancia inter e intrapacientes con el objetivo de obtener una mayor comprensión de la fiabilidad

In clinical practice, refined physical examination is important for correct diagnosis and accurate treatment. In Ayurveda, physical examination includes observation, touch, and questions similar to the diagnosis process in Western medicine. Ayurvedic practitioners are interested in diagnosing a person's body constitution (*prakriti*) initially.<sup>1</sup> Thus, the core concept of health and disease in Ayurveda is built around a strong belief in the unique individuality of every person with regard to body constitution—*prakriti*, namely *vataja*, *pittaja*, *kaphaja*, *vata-pittaja*, *vata-kaphaja*, *kapha-pittaja*, and *tridoshaja prakriti*. This diagnostic classification is useful for individually suited treatment and lifestyle recommendations. “*Prakriti*” determines the effectiveness of a particular treatment (herbal/compound formulations), and this approach enhances the therapeutic effect and reduces the unwanted effects of the treatment. Body constitution a very important criterion in clinical research for uniform outcomes. If this diagnostic method is to be incorporated into clinical studies, a prerequisite is that it is reliable. Also, there are several interesting studies indicating either a genetic or a biochemical basis for these constitutional types.<sup>2-4</sup> In spite of this, quantitative measurement such as reliability of this method is unknown.

In Ayurveda, *vata*, *pitta*, and *kapha* are the main diagnostic variables. Change in the proportion of these three *bio-entities* is used as sign of change within the patient. *Ayurvedic* pulse diagnosis is the unique and noninvasive diagnostic method that determines the state of these *doshas*; however, this is only justifiable if pulse diagnosis yields a consistent result. The examiner observes different pulse attributes to draw an appropriate picture of a patient's health.<sup>5</sup> The efficacy of pulse diagnostic procedures depends heavily on the proficiency of the practitioners, including their skills and experience. Long historical use has been seen as documentation of the efficacy<sup>6</sup>; however, there is a lack of quantitative measurement on reliability of this diagnostic method.

The aim of this article is to study the methodology to quantify test-retest reliability of Ayurvedic pulse and body constitution diagnosis. We are not looking at reproducibility in this study. Reliability means consistency of information; that is, the extent to which similar information is acquired when a measurement is conducted more than once.<sup>7</sup> When the same observer repeats the observation, it is called test-retest reliability or repeatability. In this study, repeatability of the pulse diagnosis means that the doctor will observe the same quality of the pulse for the same person if the pulse

diagnosis is repeated under identical conditions. Poor repeatability of diagnosis will lead to a lack of consistency of diagnosis. Consistent diagnosis leads to consistent treatment and is important for clinical practice, education, and research.

Many studies have been conducted in Western medicine on the accuracy and reliability of physical examination and common clinical signs.<sup>8</sup> The physical examination includes many signs of marginal accuracy and reproducibility. In traditional East Asian medicine (TEAM) such as traditional Chinese medicine and Japanese meridian therapy, a few studies have assessed the reliability of diagnostic data collected during a TEAM examination. The majority of studies investigated the reliability of pulse diagnosis, with results ranging from a low to very good level of agreement.<sup>9</sup> Within the Japanese meridian therapy system, three studies have assessed the test-retest reliability of pattern diagnosis based on pulse diagnosis alone. In two of the studies,<sup>10,11</sup> no formal statistical analysis was done. Another study found that the reliability of the diagnostic pattern through pulse assessment alone was poor, but when two diagnostic factors were examined, it was statistically significant.<sup>12</sup>

In this study, a double-blinded, controlled, methodological clinical trial was conducted. For the scientific basis of Ayurveda, an experimental, quantitative, and analytical approach is needed. Progress has been made in the area of conducting methodological studies on the concept of *dosha* as a basis for the scientific evaluation of Ayurveda.<sup>13,14</sup> Here, for the experimental analysis, a metric on *dosha* diagnosis is developed and additional interpretation of Cohen's weighted kappa statistic is provided for analysis of categorical pulse and body constitution variables.

## OBJECTIVE

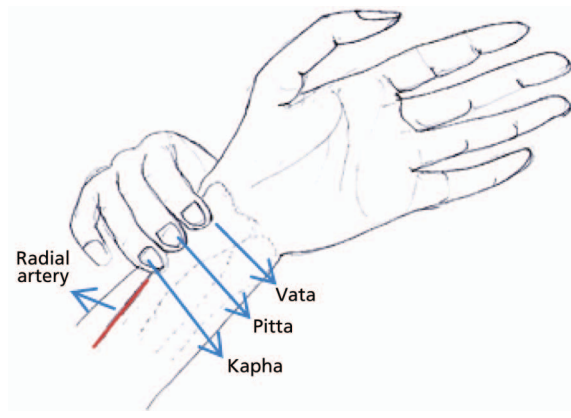
The objective of this study is to study the methodology to evaluate the test-retest reliability (repeatability) of pulse diagnosis and body constitution diagnosis.

## Methods

A double-blinded, controlled, observational clinical trial was conducted at Art of Living Centre in Copenhagen, Denmark.

## Pulse Examination Method

In this study, the doctor examined the most commonly observed nadi, *jivanadi* (radial artery). The doctor placed his index finger below the radial styloid on the radial artery of the subject, as shown in Figure 1.



**Figure 1** Pulse examination method

The middle and ring fingers were placed next to the index finger. Pulse was taken from the left hand of female participants and from the right hand of the male participants.

An experienced doctor is able to predict physiological condition, mental state, and general pathological state by pulse reading. But the most important aspect of the pulse diagnosis is to determine the qualities of *tridoshas* within the pulse (Table 1). The patterns of pulse also depend on the level of *tridosha*. Natural qualities of *dosha*, such as a snake’s curved scrawling under the index finger for *vata dosha*, a sensation like a frog jumping under the middle finger for *pitta dosha*, and a swan’s smooth, slow movement felt under the ring finger for *kapha dosha*, are diagnosed during the pulse examination.<sup>15</sup> Determination of *dosha* pulse and interpretation of *dosha* manifestation in the body may vary depending on practice. However, in this study, the doctor did the current *dosha* diagnosis (*vikriti*) by feeling the superficial pulse of healthy participants.

Health is defined differently in Ayurveda than it is in the biomedical model. According to Ayurveda, health is defined as the state of equilibrium of bio-entities (*dosha*), digestive juices, enzymes and hormones (*agni*), body tissues (*dhatu*), and the normal

excretion of waste materials (*mala*), along with a happy state of soul (*atma*), sensory and motor organs (*indriya*), and mind (*manas*).<sup>16</sup> This equilibrium tends to be influenced by some unhealthy conditions such as irregular diet, stress, and weather change. Thus, the doctor is able to diagnose subtle subclinical change in the *dosha* in a relatively “healthy” subject.

**Body Constitution Diagnosis Method**

*Prakriti* means consequence of the relative proportion of three *doshas*. Each *dosha* has specific attributes (*gunas*), which are expressed in physical, physiological, and psychological characteristics. In practice, according to these characteristics, the dominance of one or more *dosha* is assessed to classify individual *prakriti* subtypes by observation, touch, and questions. Some characteristics for *prakriti* evaluation have been described in detail.<sup>1</sup> However, in the present study, to avoid the carryover effect of the first diagnosis, blinding has been imposed on the doctor. So the body constitution diagnosis was based on the pulse at deep level (ie, with more pressure by the three fingers on the radial pulse at bone level) and a physical examination of the hand, such as feel of the hand; observation of color and texture of skin, nails, and hair; and observation of the bones and joints of the hand.

**Study Participants**

There were 17 healthy participants (males: n=2, females: n=15, aged 18-60 years) in the trial. Participants were given a lecture on Ayurveda and pulse diagnosis. Written consent was obtained from all. The inclusion criterion was that participants be aged 18 years or older. All were in good health and none was on medication.

**Ayurvedic Practitioner/Doctor**

A registered practitioner and expert in pulse diagnosis who has practiced in Europe for more than 10 years conducted the study.

**Randomization and Blinding**

Before pulse diagnosis, all participants fasted for 2

**Table 1** Characteristics of Pulse Diagnosis

Pulse	Vata	Pitta	Kapha
Characteristics	Fast, feeble, cold, light, thin, disappears on pressure	Prominent, strong, high amplitude, hot, forceful, lifts palpating finger	Deep, slow, broad, wavy, thick, cool or warm, regular
Location (Examiner placed his three fingers on patients radial pulse for pulse examination)	Index finger near on radial artery below radial styloid	Middle finger next to index finger	Ring finger next to middle finger
Movement ( <i>Gati</i> ) sensation of the three distinct wave patterns felt by examiner.	The sensation is like snake’s curved scrawling for high level of <i>vata</i> under the index finger of the examiner, swift and light pulsation	Sensation like a frog jumping under the middle finger, strong and forceful, bounce, powerful pulsation	Sensation like pigeon’s or swan’s smooth and slow movement felt under the ring figure, glide, floating pulsation
Rate ( <i>Vega</i> )	80-95	70-80	50-60
Rhythm ( <i>Tala</i> )	Irregular	Regular	Regular
Force ( <i>Bala</i> )	Low+	High+++	Moderate++

A characteristic of pulse diagnosis table is based on “Secrets of Pulse” by Lad V.<sup>5</sup>

hours. The trial was conducted in the afternoon from 1 PM to 3 PM. The doctor examined each participant twice. First, he diagnosed body constitution. Then, he diagnosed pulse at the same setting, leading to a total of 34 body constitution diagnoses and 34 pulse diagnoses. To avoid change in pulse pattern by the time difference, the trial was conducted on the same day and in a short time period.

Because the objective of the study is to investigate the repeatability of pulse diagnosis, randomization and blinding were used to avoid a possible carryover effect of the first diagnosis. Blinding and randomization were implemented as follows: participants placed their arms (only palm and wrist) through a hole in a curtain separating the doctor from the participant. The doctor did not speak to any of the participants until completion of the session. The participants entered in a random order as shown in Table 2, unknown to the doctor, and the doctor was unaware of the number of participants. Although the body constitution diagnosis was done based on deep pulse and hand observation, the doctor did not keep any record with him. Also, participants were asked to remove rings, wristwatches, and bracelets before presenting hands so that doctor could not recognize the participant.

**Table 2** Random Assignment of Participants

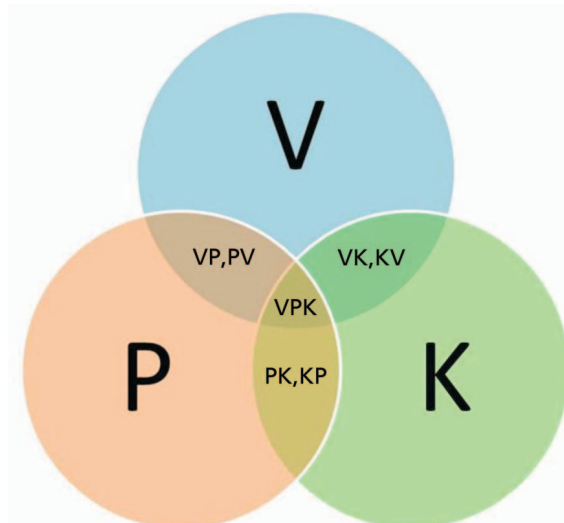
First round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Second round	5	4	1	7	3	9	8	2	10	6	14	11	15	12	13	17	16

**METHOD FOR ANALYSIS OF EXPERIMENTAL RESULTS**  
**Comparison of Pulse and Body Constitution Diagnoses**

The result of a pulse or body constitution diagnosis is a nominal variable and gives a classification into 10 classes, 1 to 10, corresponding to various mixtures of *vata*, *pitta*, and *kapha* (Table 3, Figure 2). Regarding combinations of types, *vatapitta* means that *vata* is dominant but *pitta* is also present. For *vatapittakapha*, all types are equally represented. When comparing pulse

**Table 3** Pulse Diagnosis and Body Constitution Diagnosis Classes 1-10

Class	Pulse Diagnosis (Combination of Doshas)	Type of Body Constitution	Weight for Each Type
1	vata	vataja	(1, 0, 0)
2	vatapitta	vatapittaja	(2/3, 1/3, 0)
3	vatakapha	vatakaphaja	(2/3, 0, 1/3)
4	pitta	pittaja	(0, 1, 0)
5	pittavata	pittavataja	(1/3, 2/3, 0)
6	pittakapha	pittakaphaja	(0, 2/3, 1/3)
7	kapha	kaphaja	(0, 0, 1)
8	kaphavata	kaphavataja	(1/3, 0, 2/3)
9	kaphapitta	kaphapittaja	(0, 1/3, 2/3)
10	vatapittakapha	vatapittakaphaja	(1/3, 1/3, 1/3)



**Figure 2** Various combinations of *vata*, *pitta* and *kapha*. Abbreviations: V, *vata*; P, *pitta*; K, *kapha*.

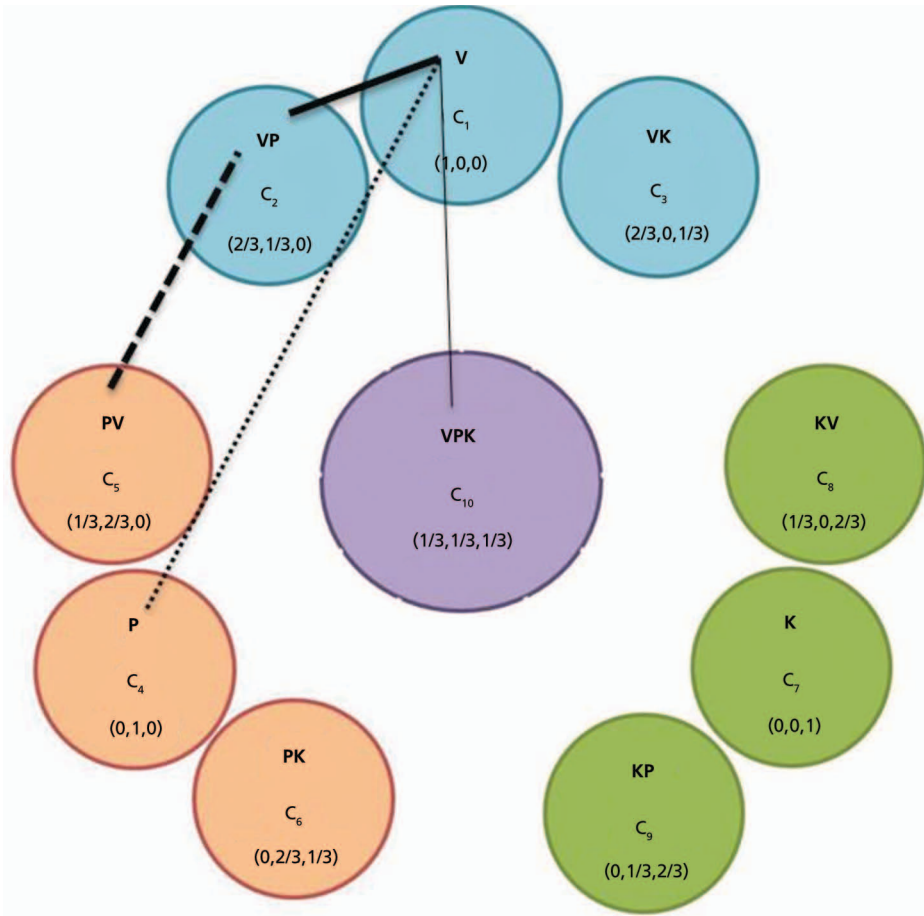
diagnoses it is obvious that, for example, class 1 (*vata*) is closer to class 2 and 3 (*vatapitta* and *vatakapha*) than to class 5 (*pittavata*) and 9 (*kaphavata*). For comparison of diagnoses, we have therefore developed a distance measure that takes into account the proportions of the basic types when comparing diagnoses.

**Distance Measure on Diagnosis**

In order to formalize mathematically that some pulse diagnoses or body constitution diagnoses are closer than others, we assign numerical weights that quantify the proportions of the three basic types, *vata*, *pitta*, and *kapha*, for the 10 classes (Table 3). The weights for *vata*, *vatapitta*, and *vatapittakapha* are, for example, 1, 0, 0; 2/3, 1/3, 0; and 1/3, 1/3, 1/3, respectively. We then define a distance measure, D, so that the distance between two classes reflects how close the associated weights are. The distance measure is always between 0 and 1 so that the minimal distance “0” occurs when two classes are equal and the maximal distance “1” occurs for two classes that have none of the basic types (*vata*, *pitta*, or *kapha*) in common. Intermediate values of “D” are, for instance,  $D(C_1, C_2) = 0.11$  and  $D(C_1, C_{10}) = 0.42$ , where classes 1, 2, and 10 correspond to *vata*, *vatapitta*, and *vatapittakapha*. See Figure 3 for a graphical illustration. The exact definition of D is provided in the Appendix.

**Hypothesis of Homogeneous Classification**

When a doctor classifies a subject several times it may happen by chance that different diagnoses are obtained. Suppose  $n$  subjects  $j = 1, \dots, n$  are considered and let  $p_{jc}$  be the probability that the doctor chooses classification  $c$  for patient  $j$ . The hypothesis of homogeneous classification is  $H_0: p_{jc} = p_c$ . That is, the probability that the doctor assigns a classification  $c$  to a subject  $j$  does not depend on the subject. In other words, under  $H_0$  the doctor is essentially performing random diagnoses



**Figure 3** Weights and distance measure on diagnosis. Abbreviations: C, Class; K, kapha; P, pitta; V, vata. Weights are given in the parentheses. "D" is distance between two classes.  $D(C_1, C_1) = 0$ ;  $D(C_1, C_2) = 0.11$  ———;  $D(C_2, C_5) = 0.2$  - - -;  $D(C_1, C_4) = 1$  ·····;  $D(C_1, C_{10}) = 0.42$  ———

according to some common probabilities for the various classes. The hypothesis of homogeneous classification can of course only be rejected if the group of subjects is heterogeneous in terms of pulse characteristics.

**Statistic for Measuring Repeatability**

Cohen’s weighted kappa statistic<sup>17</sup> is a popular measure of intra- and inter-rater reliability. Given pairs of classifications  $(c_{j1}, c_{j2})$  for participants  $j = 1, \dots, n$  the weighted kappa is

$$\kappa = 1 - \frac{\bar{D}}{\bar{D}}$$

where,  $\bar{D}$  is the observed average distance between pairs of classifications, and  $\bar{D}$  is the expected average distance under the hypothesis  $H_0$  of homogeneous classifications. The maximal value 1 for  $\kappa$  is obtained if the observed distance is 0 while  $\kappa$  becomes 0 if the observed average distance is equal to its expected value in the case of random classifications. In general, a larger weighted kappa value means better agreement between pairs of classifications.

**Quantification of Repeatability and Permutation Test**

One way to assess the magnitude of the weighted kappa statistic is to use Landis and Koch’s scale where,

for example, a value between 0.61 and 0.80 is deemed to be “good.”<sup>18</sup> However, Bakeman et al pointed out that it may be misleading to use one common scale for interpreting kappa since the magnitude of kappa not only depends on observer accuracy (and hence repeatability) but also on for example the number of classes and the population probabilities of each class.<sup>19</sup> Another approach to quantify the magnitude of the weighted kappa is to compare the observed weighted kappa with its distribution under the hypothesis  $H_0$  of homogeneous classification. One can then compute a *P* value, ie, the probability of getting at least as favorable a weighted kappa as the observed one assuming  $H_0$  is true. As a measure of evidence against  $H_0$ , *P* values are comparable across different studies. Smaller *P* values signify better agreement, but as for the Landis and Koch scale, there is not a unique relation between a *P* value and a specific level of observer repeatability.

In practice, we compute the *P* values using random permutations of the observed classifications exploring that the pulse diagnoses are independent and exchangeable under  $H_0$ . More specifically, we repeat many times the following two steps: (1) randomly permute all 34 diagnoses among subjects and number of classification (first or second) and (2) com-

pute the weighted kappa statistic for the permuted data set. Finally, the *P* value is 1 minus the percentage of permuted data sets for which the computed weighted kappa statistic is smaller than the observed one.

**RESULTS**

In total, 34 body constitution diagnoses were made by the same doctor (Table 4). The doctor mainly classified subjects as *pitta*, *pittavata*, and *pittakapha*. Also, there are in total 34 pulse diagnoses, and the same doctor diagnosed *vata*, *vata-pitta*, and *pittavata* types of pulse (Table 5). For body constitution classification, the mean distance  $\bar{D}$  between classifications is 0.02 and the weighted kappa is 0.65. For pulse diagnosis  $\bar{D}$  is 0.085 and the weighted kappa is 0.42. According to the Landis and Koch scale, these values of the weighted kappa correspond to respectively “substantial” and “moderate” agreement (Table 6). These interpretations of the weighted kappa both depend on the distance measure used and the number of classes (in this case only three for each type of diagnosis). If we use a permutation test to test  $H_0$ , we obtain *P* values of .001 and .02 for body constitution and pulse diagnosis, respectively. In particular, the hypothesis  $H_0$  is rejected on the 5% significance level. One may argue that when only three classes are used, a high level of agreement may occur just by chance. However, this is taken into account by the permutation test, which is conditional on the observed diagnoses. Hence, in the permuted data sets, only *vata*, *vata-pitta*, and *pittavata* occur. For

instance, the *P* value of .02 for pulse diagnosis means that there is only a 2% probability of obtaining a higher level of agreement than the observed one if the doctor was choosing randomly between *vata*, *vata-pitta*, and *pittavata* according to the observed frequencies of these classes. Thus, the permutation tests show that the high levels of agreement are unlikely to occur just by chance even when only three classes are used.

**DISCUSSION**

Results show “substantial” and “moderate” agreement for the body constitution and pulse diagnosis, respectively. Moreover, the hypothesis of homogeneous classification was rejected on the 5% significance level for both types of diagnoses. This shows that the doctor performed pulse and body constitution diagnosis in a consistent manner. In this study, a higher level of agreement was obtained for body constitution than pulse diagnosis due to inclusion of more information for diagnosis, such as touch and observation. In practice, body constitution assessment always includes questioning. However, to avoid carryover effects in the study of pulse diagnosis, body constitution was diagnosed using only observation and touch without the doctor seeing and communicating with the patient. It would be interesting to investigate diagnostic consistency of body constitution when all the diagnostic methods are combined.

This study shows that the distance measure on the categorical pulse and body constitutional diagnosis variables and the permutation test using Cohen’s weighted kappa statistic provides a useful statistical methodology for further studies on pulse diagnosis and body constitution assessment.

Pulse diagnosis was conducted on healthy participants, meaning there is no biomedically defined disease or disorder in a person. Moreover, the majority of participants were Danish and live in cold weather conditions. If we had conducted the study on a more heterogeneous group of subjects possibly representing specific disease or symptoms well characterized in terms of *dosha* imbalance, there might have been even stronger evidence of consistency between the two diagnoses. A more heterogeneous group of subjects would allow for more intersubject variability in the pulse diagnosis and hence larger weighted kappa values and more power for the test of the hypothesis of homogeneous classification.

One may object to the fact that only one Ayurvedic practitioner was used in this study. However, the main objective of the study was to investigate methodology for studying repeatability of body constitution and pulse diagnosis, ie, when the same observer repeats the observations. To investigate reproducibility, ie, interrater reliability, more observers are needed. This is also necessary to obtain results regarding reliability that are valid for Ayurvedic practitioners in general.

We finally comment on some limitations of this study. Pulse examination should preferably be conduct-

**Table 4** First- and Second-round Body Constitution Diagnosis

P	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
R <sub>1</sub>	6	6	4	4	6	4	4	4	4	4	4	4	6	4	4	4	4
R <sub>2</sub>	6	6	5	4	6	4	4	6	4	4	4	5	6	4	4	4	4
D	0	0	0.11	0	0	0	0	0.11	0	0	0	0.11	0	0	0	0	0

Abbreviations: P, participants; R<sub>1</sub>, diagnosis in first round; R<sub>2</sub>, diagnosis in second round; D, distance between two diagnoses.

**Table 5** First- and Second-round Pulse Diagnosis

P	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
R <sub>1</sub>	5	5	1	2	2	5	2	2	1	1	2	5	2	2	5	2	1
R <sub>2</sub>	2	5	2	2	2	2	1	2	2	2	1	5	1	1	2	1	1
D	0.2	0	0.11	0	0	0.2	0.11	0	0.11	0.11	0.11	0.11	0.11	0.11	0.20	0.11	0

Abbreviations: P, participants; R<sub>1</sub>, diagnosis in first round; R<sub>2</sub>, diagnosis in second round; D, distance between two diagnoses.

**Table 6** Results of Repeatability of Body Constitution and Pulse Diagnosis

Type of diagnosis	Mean distance between classification	<i>P</i> values	Weighted kappa	Landis and Koch scale level of agreement
Body constitution	0.02	0.001	0.65	Substantial
Pulse diagnosis	0.085	0.02	0.42	Moderate

ed in the morning when the participants are fasting. However, due to availability of location and the doctor, it was performed in the afternoon, a *pitta*-dominating period, which may be reflected in the pulse diagnosis. The implication is made that the doctor was unable to recognize the patients, but it was possible that in a small group of patients at least some could be identified by their arms alone because the doctor noted specific features of the hand and arm for body constitution diagnosis. However, we emphasize that the doctor was not keeping records of his diagnoses during the experiment.

## CONCLUSIONS

This is the first study on pulse diagnosis to investigate the test-retest reliability in Ayurveda. The small *P* values obtained from testing the hypothesis of homogeneous classification suggest that there was a high level of consistency between two pulse diagnoses, which demonstrates the repeatability of Ayurvedic pulse diagnosis. Moreover, the highest degree of repeatability is obtained with the body constitution diagnosis due to assessment of more information such as observation.

For statistical analysis, a metric on the categorical pulse and body constitutional diagnostic variables are developed. Moreover, it is discussed how the magnitude of the weighted kappa statistic may be interpreted using *P* values calculated from random permutations of the data. The developed biostatistical methodology will be beneficial for further studies of pulse diagnosis, tongue diagnosis and body constitution (*prakriti*) assessment of physical, physiological, and psychological characteristics of the individual.

## APPENDIX

1. Interpretation of Sanskrit words based on Charak Samhita Varanasi, India: Caukhambha Orientalia; 1995.

- *Dosha* – fundamental energies or entities or principle, which governs the function of body on the physical and psychological level. The Ayurvedic concepts of physiology, pathology, diagnosis, medicine and therapeutics are based on the doctrine of *tridoshas*.
- *Vata* – combination of air and ether elements representative of kinetic energy and movement, physical or mental functions, and degeneration.
- *Pitta* – combination of fire and water elements representing thermal energy and metabolism conversion, vision, and emotions.
- *Kapha* – combination of earth and water elements representing potential energy and structure in the body. It is associated with processes of generation, reunion, and synthesis.
- *Prakriti* – *Prakriti* assessment is the essence of Ayurveda for *prakriti*-specific prescriptions. *Prakriti* means consequence of the relative proportion of three *doshas*. *Prakriti* is specific for each individual. It is determined at the time of conception, and it remains unaltered over the individual's lifetime.

2. Mathematical definition of distance measure:

- For classes  $c_1$  and  $c_2$  with 3-dimensional weight vectors  $w_1$  and  $w_2$ ,  $D(C_1, C_2)$  is 1 minus the cosine of the angle between  $w_1$  and  $w_2$ . Thus,  $D(C_1, C_2)$  measures the closeness of the directions of the weights  $w_1$  and  $w_2$  interpreted as 3-dimensional vectors.

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