CHAPTER 7

RESULTS

7. RESULTS

The pulse data with clear systolic and diastolic peaks was considered for the study and it was observed that only for some individuals pulse data had shown proper systolic and diastolic peaks in all the three locations and in others peaks were not proper in one or other locations. As per the initial analysis it was concluded that the pulse would have been weak in those locations for *Nāḍī Taraṅgiṇi* to acquire it precisely, secondly if the sensors were not precisely aligned with *Tridoṣa* locations the pulse acquisition may not be appropriate resulting into missing peaks at those locations. This is a limitation with the instrument. The individuals with proper peaks at *vāta* location were entered into *vāta* group and similarly for other two groups. If an individual had proper peaks at *vāta* and *pitta* locations then the individual will be entered into both *vāta* and *pitta* groups and in similar lines the individuals with proper peaks at *pitta- kapha, vāta-kapha and vāta-pitta-kapha* locations were entered into respective groups . The individuals are not same in all the three groups as the individuals were grouped based on proper peaks at *vāta, pitta* and *kapha* locations and also the same individual can be part of more than one group based on the pulse data.

7.1 TRIDOSA STUDY

The characteristics of the study population are shown in **Table 7.1**. A total 42 participants (32 males , 10 females) in each group were identified after anlyzing 90 participants data for proper systolic and diastolic peaks at *vāta, pitta* and *kapha* locations.

Table 7.1: Demography details of subjects in *vāta, pitta* and *kapha* groups

Parameter		*vāta*	*pitta*	*kapha*
Age				
	all	57.830 ± 9.05	58.230 ± 11.370	55.88 ± 9.247
	males	59.840 ± 8.47	59.330 ± 11.978	56.62 ± 9.310
	females	51.400 ± 8.09	54.560 ± 8.618	52.59 ± 8.674
Height				
	all	165.64 ± 9.665	165.25 ± 9.248	166.467 ± 8.283
	males	167.437 ± 7.278	167.75 ± 8.818	168.49 ± 6.611
	females	159.89 ± 13.959	157.24 ± 5.308	156.357 ± 8.835
BMI				
	all	24.712 ± 4.105	24.988 ± 4.232	25.185 ± 4.740
	males	24.115 ± 3.885	24.502 ± 4.318	24.537 ± 3.905
	females	26.624 ± 4.411	26.542 ± 3.718	28.424 ± 7.241
SBP				
	all	130.88 ± 22.815	130.08 ± 19.98	127.24 ± 14.681
	males	131.81 ± 22.737	129.39 ± 20.136	127.68 ± 15.501
	females	128.00 ± 24.042	132.44 ± 20.421	125.14 ± 10.447
DBP				
	all	79.120 ± 9.842	78.980 ± 9.872	81.83 ± 9.680
	males	79.55 ± 9.712	79.260 ± 10.59	82.44 ± 9.998
	females	77.80 ± 10.654	78.00 ± 7.263	78.86 ± 7.904

data are shown as mean ± standard deviation; BMI, Body Mass Index; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure;

The one-way ANOVA analysis has reported that means of SI ($p < 0.001$) and RI ($p < 0.001$) were significantly different across *vāta*, *pitta* and *kapha* locations as shown in **Table7.2** As one-way ANOVA reported significant result and variances were not equal post hoc analysis was done using Tamhane's T2 test.

Table 7.2: Summary of one-way ANOVA results with *vāta, pitta* and *kapha*

Parameters	*doṣa*			p value*	n^2
	vāta	*pitta*	*kapha*		
SI (m/s)	5.669 ± 1.165	8.910 ± 3.509	8.021 ± 2.814	< 0.001	0.21
RI	0.846 ± 0.071	0.945 ± 0.043	0.952 ± 0.033	< 0.001	0.474

Data are shown as mean ± standard deviation

SI, Stiffness Index ; RI, Reflection Index;

*p value : comparing SI, RI across vata, pitta and kapha groups, significance at 0.05

$n^{2:}$ Effect size computed as Sum of Squares between groups / Total Sum of Squares

The means of SI and RI were assessed across males and females using independent samples t test as shown in **Table 7.3**

Table 7.3 : Summary of independent samples t test between males and females

parameter	males (n = 32)	females (n = 10)	p value*	ES [CI]
SI (m/s)				
vāta	5.768 ± 1.138	5.353 ± 1.258	0.368	0.345 [-0.542, 1.371]
pitta	9.282 ± 3.633	7.720 ± 2.923	0.182	0.472 [-0.798, 3.922]
kapha	8.344 ± 2.953	6.404 ± 1.008	0.004	0.878 [0.656, 3.224]
RI				
vāta	0.845 ± 0.075	0.847 ± 0.058	0.928	-0.03 [-0.049, 0.046]
pitta	0.942 ± 0.048	0.955 ± 0.022	0.260	-0.348 [-0.035, 0.009]
kapha	0.951 ± 0.035	0.955 ± 0.020	0.646	-0.140[-0.025, 0.016]

Data are shown as mean ± standard deviation

SI: stiffness index; RI: reflection index; n: number of participants

*p value comparing SI, RI of vata, pitta and kapha between males and females , significance at 0.05

ES: Effect Size (mean of males – mean of females) / pooled standard deviation of males and females

CI: 95% Confidence Interval of Mean Difference between males and females

SI for males was higher than females at all the three pulse locations and SI at *kapha* ($p < 0.05$) was statistically significant. There were no significant differences in RI between males and females.

The means of SI and RI at *vāta*, *pitta* and *kapha* locations were analyzed across three age groups as shown in **Table 7.4**.

Table 7.4 : Variation of Stiffness parameters (SI and RI) across *vāta*, *pitta* and *kapha* with age

Age Group	Parameters	*vāta*	*pitta*	*kapha*
Group1 (40 – 50 years) (n = 8)				
	SI	5.494 ± 0.371	8.339 ± 3.841	7.806 ± 2.281
	RI	0.814 ± 0.068	0.946 ± 0.051	0.944 ± 0.032
	Ht	168.37 ± 12.50	166.51 ± 11.08	166.50 ± 4.686
Group2 (51 – 60 years) (n = 19)				
	SI	5.516 ± 1.032	9.557 ± 3.175	7.838 ± 2.559
	RI	0.848 ± 0.072	0.951 ± 0.032	0.960 ± 0.023
	Ht	166.205 ± 8.081	162.90 ± 7.541	167.092± 10.13
Group3 (above 60 years) (n =15)				
	SI	5.956 ± 1.549	8.844 ± 3.732	8.108 ± 3.470
	RI	0.859 ± 0.070	0.946 ± 0.035	0.959 ± 0.031
	Ht	163.467 ± 10.08	165.425 ± 9.01	166.23 ± 9.898

Data are shown as mean ± standard deviation

SI: stiffness index; RI: reflection index; Ht: Height of the subject

n: number of participants

Groups are created based on age

7.2 DIABETES STUDY

The characteristics of the study population are listed in **Table 7.5**

Table 7.5: Characteristics of Study Population across *vāta*, *pitta* and *kapha* groups

Parameters		*vāta*	*pitta*	*kapha*
Age				
	Non Diabetes	58.17 ± 9.756	58.44 ± 10.897	55.88 ± 9.247
	Diabetes	53.98 ± 11.324	57.95 ± 12.048	57.08 ± 11.893
Height (cm)				
	Non Diabetes	164.111 ± 9.131	165.012 ± 8.632	166.467 ±8.283
	Diabetes	166.002 ± 8.131	164. 495 ±9.058	163.944 ± 13.605
BMI (Kg/m2)				
	Non Diabetes	24.970 ± 4.071	24.843 ± 4.102	25.185 ±4.740
	Diabetes	25.351 ± 4.209	24.388 ± 4.679	25.357 ± 8.265
SBP (mm Hg)				
	Non Diabetes	133.88 ± 23.155	132.17 ± 20.864	127.24 ± 14.681
	Diabetes	126.94 ± 25.510	123.67 ± 26.967	127.90 ±16.004
DBP (mm Hg)				
	Non Diabetes	79.87 ± 10.568	79.17 ± 10.303	81.83 ±9.680
	Diabetes	80.21 ±10.213	77.46 ± 10.733	81.65 ± 11.026
FPG (mg/dl)	Non Diabetes	101.021 ± 14.31	102.231 ±13.803	100.905 ± 13.910
	Diabetes	186.609 ± 67.104	194.375 ± 61.219	188.210 ± 61.067

Data are shown as mean ± s.d

BMI, Body Mass Index; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; FPG, Fasting Plasma Glucose;

SI, Stiffness Index; RI, Reflection Index;

A total of 53 *vāta*, 49 *pitta*, 42 *kapha* pulses in non diabetes group and 47 *vāta*, 40 *pitta* and 41 *kapha* pulses in diabetes group were included for the study after analyzing the pulse for proper systolic and diastolic peaks.

The mean values of SI and RI between diabetes and non diabetes groups was tested using independent samples t test and summary of the test is shown in **Table 7.6**.

Table 7.6: Means of SI and RI compared across diabetes and non-diabetes groups

Tridoṣa	Parameters	Non-Diabetes	Diabetes	p value*	ES [CI]
vāta					
	SI (m/s)	5.414 ± 1.179	5.898 ± 0.786	0.019	0.483 [-0.177, -0.016]
	RI	0.837 ± 0.076	0.851 ± 0.073	0.326	0.188 [-0.044, 0.149]
	Ht (cm)	164.11 ± 9.13	166.002 ± 8.131	0.276	
pitta					
	SI (m/s)	8.726 ± 3.474	7.308 ± 1.929	0.023	-0.505 [0.039, 0.528]
	RI	0.945 ± 0.041	0.946 ± 0.032	0.966	0.027 [-0.016, 0.015]
	Ht (cm)	165.01 ± 8.63	164.49 ± 9.058	0.784	
kapha					
	SI (m/s)	8.021 ± 2.814	6.529 ± 1.389	0.003	-0.671 [0.104, 0.493]
	RI	0.952 ± 0.033	0.951 ± 0.036	0.953	-0.028 [-0.147, 0.016]
	Ht (cm)	166.46 ± 8.28	163.94 ± 13.61	0.313	

Data are shown as mean ± s.d

BMI, Body Mass Index; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; FPG, Fasting Plasma Glucose; SI, Stiffness Index; RI, Reflection Index;

SI at *vāta* ($p < 0.05$) was significantly higher in diabetes group compared to non-diabetes group with medium effect size. SI at *pitta* ($p < 0.05$) and *kapha* ($p < 0.05$) were

significantly lower in diabetes group compared to non-diabetes group with moderately large effect size. There was no significant difference in RI (p = 0.405) in all the *doṣa* locations when compared between diabetes and non-diabetes groups.

In univariate analysis SI has shown significant differences in Pearson correlation coefficient between the two groups as shown in **Table 7.7**.

Table 7.7: The correlations between stiffness indices and Fasting Plasma Glucose

Tridoṣa	SI (m/s)		RI	
	r value	p value*	r value	p value*
vāta				
Non-diabetes	-0.313	0.023	-0.132	0.347
Diabetes	-0.020	0.893	0.128	0.393
pitta				
Non-diabetes	-0.076	0.605	0.119	0.414
Diabetes	-0.015	0.926	0.024	0.885
kapha				
Non-diabetes	-0.059	0.709	0.206	0.190
Diabetes	0.290	0.066	0.249	0.117

SI, Stiffness Index; RI, Reflection Index;

* *P*value comparing diabetes and non-diabetes groups; significance at 0.05 level

There was a significant negative correlation between SI at *vāta* and fasting plasma glucose (r = -0.313; p < 0.05) in non-diabetes group where as in diabetes group SI at *vāta* was not significantly correlated with fasting plasma glucose (r = 0.075; p = 0.615). There

were no significant correlations between FPG and SI at *pitta* and *kapha* locations. There was no significant correlation between RI and fasting plasma glucose in both the groups. There was a significant positive correlation between SI and RI at *vāta* in non-diabetes group ($r = 0.387$; $p < 0.01$), at *pitta* in both diabetes ($r = 0.362$; $p < 0.05$) and non diabetes groups ($r = 0.337$; $p < 0.05$) and at *kapha* in diabetes group ($r = 0.344$; $p < 0.05$).

The means of SI and RI at *vāta*, *pitta* and *kapha* locations were analyzed across three age groups in non diabetes group as shown in **Table 7.8**.

Table 7.8 Summary of variations in SI and RI across age groups in non diabetes group

Age Group	Parameters	*vāta*	*pitta*	*kapha*
Group1 (40 – 50 years)				
	SI	5.307 ± 0.66	5.945 ± 0.748	5.910 ± 0.533
	RI	0.812 ± 0.064	0.927 ± 0.054	0.933 ± 0.038
Group2 (51 – 60 years)				
	SI	5.45 ± 1.035	10.123 ± 2.881	7.838 ± 2.559
	RI	0.852 ± 0.068	0.952 ± 0.027	0.960 ± 0.023
Group3 (above 60 years)				
	SI	5.553 ± 1.182	8.559 ± 3.659	8.108 ± 3.470
	RI	0.829 ± 0.084	0.948 ± 0.034	0.959 ± 0.031

SI, Stiffness Index; RI, Reflection Index;

Groups were created based on age of the participants

The means of SI and RI at *vāta*, *pitta* and *kapha* locations were analyzed across three age groups in diabetes group as shown in **Table 7.9**.

Table 7.9 Summary of variations in SI across age groups in diabetes group

Age Group	Parameters	*vāta*	*pitta*	*kapha*
Group1 (40 – 50 years)				
	SI	6.046 ± 0.455	6.247 ± 0.574	6.685 ± 0.533
	RI	0.829 ± 0.060	0.948 ± 0.021	0.976 ± 0.039
Group2 (51 – 60 years)				
	SI	6.015 ± 0.799	7.427 ± 1.874	6.813 ± 1.358
	RI	0.855 ± 0.074	0.951 ± 0.034	0.951 ± 0.048
Group3 (above 60 years)				
	SI	5.831 ± 0.999	7.406 ± 2.294	6.038 ± 1.395
	RI	0.829 ± 0.084	0.938 ± 0.038	0.948 ± 0.032

SI, Stiffness Index; RI, Reflection Index;

Groups were created based on age of the participants

7.3 OBESITY STUDY

The characteristics of the study population are listed in **Table 7.10**.

Table 7.10: Demographic details of the participants

Parameter	Group1 (n = 5)	Group2 (n = 7)	Group3 (n = 6)
Age	49.80 ± 19.728	26.57 ± 11.745	60.17 ± 10.834
Height (cm)	161.20 ± 3.347	164.891 ± 8.455	157.823 ± 3.136
Weight (kg)	58.236 ± 10.054	87.071 ± 20.728	80.203 ± 14.934
BMI (kg/m^2)	22.31 ± 3.144	32.159 ± 7.859	32.072 ± 4.977
SBP (mm Hg)	123.20 ± 11.454	116.67 ± 11.361	133.33 ± 15.002
DBP (mm Hg)	77.60 ± 5.367	76.67 ± 13.486	81.33 ± 6.002
PR	74.40 ± 8.259	81.33 ± 12.044	78.17 ± 7.548

Data was represented as mean ± standard deviation

Group1: non obese participants; Group2: younger adults with obesity; Group3: older participants with obesity

BMI: Body Mass Index; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; PR: Pulse Rate; n: number of participants

The pulse data at *vāta* was having proper peaks for all the participants but the peaks were not proper at *pitta* and *kapha* locations for many of the participants and hence only *vāta* data was considered for the study and the data corresponding to *pitta* and *kapha* locations was discarded.

The mean values of SI and RI for pre and post IAYT are shown in **Table 7.11**. The younger adults with obesity had shown significant reduction in SI ($P < 0.05$) after IAYT whereas there were no significant changes in other groups. RI was increased in all the groups but the change in older adults with obesity group was significant. In all the groups, BMI had reduced after IAYT and the reduction in older adults with obesity was

significant. The SI values in this study are significantly high when compared with SI values in other two studies. The reason being *Nāḍī Taraṅgiṇi* instrument used in this study was different and it was sampling the pulse data at 450Hz and *Nāḍī Taraṅgiṇi instrument* used in the other two studies was sampling the pulse data at 500Hz. The SI values have changed signficantly due to the difference in the sampling frequency.

Table 7.11: Summary of paired samples t test

Group	Parameter	pre IAYT	post IAYT	*P* value
Group1				
	SI (m/s)	17.488 ± 6.24	16.736 ± 3.693	0.779
	RI	0.964 ± 0.028	0.970 ± 0.029	0.240
	BMI	22.31± 3.14	21.99 ± 2.90	0.236
Group2				
	SI (m/s)	18.745 ± 2.828	16.072 ± 1.731	0.036*
	RI	0.963 ± 0.024	0.966 ± 0.025	0.733
	BMI	32.16 ± 7.86	31.15 ± 7.03	0.076
Group3				
	SI (m/s)	15.118 ± 4.479	13.606 ± 4.404	0.319
	RI	0.941 ± 0.043	0.976 ± 0.022	0.057
	BMI	32.07 ± 4.98	31.49 ± 5.01	0.019

Data was represented as mean ± standard deviation

SI, Stiffness Index; RI, Reflection Index; BMI, Body Mass Index;

IAYT, Integrated Approach of Yoga Therapy;

Group1: non obese participants with age above 50 years;

Group2: younger adults with obesity with age less than 50 years;

Group3: older participants with obesity with age above 50 years;

The correlations between stiffness indices (SI and RI) and age, BMI are summarized in **Table 7.12**. The SI and RI were not significantly correlating with age and BMI.

Table 7.12: Summary of correlations between SI, RI, age, BMI

Parameter	age	p value*	BMI	p value*
Group1				
SI	0.045	0.943	0.709	0.180
RI	-0.861	0.061	-0.642	0.243
Group2				
SI	-0.114	0.808	-0.487	0.268
RI	0.128	0.785	-0.197	0.672
Group3				
SI	-0.256	0.624	0.512	0.299
RI	-0.631	0.179	0.368	0.473

SI, Stiffness Index; RI, Reflection Index; BMI, Body Mass Index;

IAYT, Integrated Approach of Yoga Therapy;

Group1: non obese participants with age above 50 years;

Group2: younger adults with obesity with age less than 50 years;

Group3: older participants with obesity with age above 50 years;

CHAPTER 8
DISCUSSION

8. DISCUSSION

8.1 TRIDOSA STUDY

Significance of SI and RI measured across *Tridoṣa* locations was studied wherein SI corresponds to arterial stiffness and RI corresponds to endothelial function (Sandrine C Millasseau et al., 2006). The systolic and diastolic peaks were clear in pulse waves at *vāta, pitta* and *kapha* locations and the peaks resembled closely with digital volume pulse signal from PPG (Photoplethysmography). In the current study, SI and RI measured at *vāta, pitta* and *kapha* locations were significantly different. The post hoc test revealed that SI at *pitta* was high compared to *vāta* and *kapha* and it has shown a gradual increase from *kapha* to *pitta* and then decreased at *vāta*. The effect sizes of SI (0.21) and RI (0.485) were significantly high. The significant difference in SI across the three groups may be due to either height of the person or arterial stiffness and hence the heights across the three groups were tested using independent samples t test. The heights were not significantly different across *vāta - pitta*, *pitta - kapha* and *vāta - kapha* groups which confirmed that SI was significantly different due to the arterial stiffness and not due to height of the person.

The classical texts *Śārṅgadhara Saṁhitā* (P. H. C. Murthy, 2007), *Yoga Ratnākara* (SSB, 2011), *Bhāvaprakaśa* (Murthy, 2008) and *Basavarājīyam* (Rangacharya, 2007) have discussed the nature of *Nāḍī* in detail which includes method of pulse examination, pulse locations, pulse characteristics in various conditions. It is in *Basavarājīyam* the hardness

of *Nāḍī* is discussed in detail and in *pradhama prakaraṇa* of *Basavarājīyam* it is mentioned that due to increased *vāta doṣa*, *Nāḍī* will be hard like a string of *vīṇā* which can be interpreted that arterial stiffness increases with *vāta doṣa*. The word *kaṭhor* has been used to express the hardness instead of *kaṭhin*. There is no mention of hardness due to *pitta* and *kapha doṣas* but in the same *prakaraṇa* it is mentioned that *Nāḍī* will be slow due to *kapha doṣa*. As the pulse wave travels faster in hardened arteries compared to normal arteries, it can be interpreted that *Nāḍī* may not be hard but soft due to *kapha doṣa*. In *dvitīya prakaraṇa* while explaining the characteristics of *mṛtyu Nāḍī* it is mentioned that *kaṭhin Nāḍī* is one of the factors which can lead to death. In the recent past arterial stiffness is considered as a significant parameter in assessing cardiovascular risks which seems to be similar to what is explained in *mṛtyu Nāḍī*. The thickness of blood vessels has been discussed in *sūtra sthāna* of *Caraka samhita* (B.Dash, 1995) and the terms *dhamani pravicaya* and *dhamanī praticaya* are used to explain the hardness of arteries which is considered as atherosclerosis in modern medicine. *Vasant* has summarized the qualities of *Nāḍī* and according to him hard and rough artery corresponds to *vāta*, elastic and flexible artery corresponds to *pitta* and soft thickening artery corresponds to *kapha* (Vasant Dattatray, 2007). This implies that there is a gradual increase in thickness of the radial artery from soft at *kapha doṣa* to hard at *vāta doṣa* which in turn means pulse will be slow due to *kapha doṣa* and fast due to *vāta doṣa*. As

kāṭhinya can be closely associated to hardness of the artery, this can be interpreted that there is a gradual increase in *kāṭhinya* from *kapha* to *vāta*. The dominance of *doṣa* with age and time of the day is discussed in the classical texts of *Āyurveda* and according to *Aṣṭāṅga Hṛdayam doṣa* predominance varies from *kapha* in childhood, to *pitta* in middle age, to *vāta* in old age (K. R. S. Murthy, 2007). There will be a gradual increase in *kāṭhinya* with age also and as per *Āyurveda Nāḍī* will be soft in childhood which is *kapha* dominant age and will become hard in old age which is *vāta* dominant age. As per modern physiology arterial stiffness increases with age and the pulse travels faster in hardened arteries (Sandrine C Millasseau et al., 2006). The arterial stiffness is well understood with respect to both modern medicine and *Āyurveda* and hence arterial stiffness can be closely associated to *kāṭhinya*. The physiological reason behind such variations in arterial stiffness across *vāta*, *pitta* and *kapha* locations need further investigation. SI increased from *kapha* to *pitta* but decreased at *vāta* which implied that SI at *pitta* was high compared to *vāta* and *kapha*. The reason for increased SI at *pitta* could be due to age of the subjects. The average age of the subjects in our study was 50-60 years, a *pitta* dominant age and hence increase in SI at *pitta* can be attributed to age.

The subjects were further divided into three groups based on age of the participants namely Group1 (40 -- 50 years), Group2 (50 – 60 years) and Group 3 (above 60 years) and SI has shown variations across *Tridoṣas* in different age groups. Based on classical texts of *Āyurveda* Group 1 and Group 2 correspond to *pitta* dominant age group and the

Group3 corresponds to *vāta* dominant age group. SI is increasing with age at *vāta* and *kapha* locations in all the three groups whereas SI at *pitta* location has increased from Group1 to Group2 and it has decreased in Group3. Further analysis reveals that SI at *vāta* location has increased slightly in Group3 (*vāta* dominant age group) compared to Group2 (*pitta* dominant age group), while SI at *pitta* location has reduced from Group2 to Group3. There are multiple factors which can influence arterial stiffness such as age, *doṣa* dominance with age, diurnal variations and present state of *Tridoṣas*. The variations in SI at *Tridoṣa* locations across different age groups need further investigation considering various other factors.

SI of males was higher than females at *vāta, pitta and kapha* locations. SI at *kapha* was significantly high for males when compared to females with very high effect size (0.878) which signifies the difference in SI between males and females. The effect sizes of SI at *vāta* and *pitta* were moderately high. The effect size of RI at *vāta* was very low but was moderately high at *pitta* and *kapha*. The mean height of males in *kapha* group was significantly high ($p = 0.010$) and hence there could be a possibility that the significance could be due to height and not due to arterial stiffness. To confirm whether the significant difference was due to height only or even the arterial stiffness was significantly different, the height factor was removed by dividing SI by height and observed that the resultant SI ($p < 0.05$) was significantly different across males and females in *kapha* group. This confirmed that there was a significant difference in SI at *kapha* between males and

females. As per classical texts of *Āyurveda*, pulse examination varies between males and females. *Bhāvaprakāśa* compiled by *Bhāvamiśra*, has given importance to the specification of sides for pulse examination in males and females (Murthy, 2008). The results were promising but need to be proven with larger sample size.

The arterial stiffness is well established pulse parameter in modern medicine with rich literature support and is closely associated to *kaṭhinya* in the context of *Āyurveda*. This is the first attempt in evaluating the significance of arterial stiffness across *Tridośa* locations.

8.2 DIABETES STUDY

The focus of the study was to measure the arterial stiffness at *Tridośa* locations and investigate how these stiffness parameters were associated with diabetes. The study was done across diabetes and non-diabetes subjects. SI at *vāta* of non-diabetes group was negatively correlated with fasting plasma glucose which confirms with the previous study (H. T. Wu et al., 2011) measuring the arterial stiffness from radial artery. In the previous study, association of SI with FPG was studied by including both diabetes and non-diabetes into a single group. In this study, the association of SI with fasting plasma glucose was observed only in non-diabetes group and there was no such association in diabetes group. There were no such correlations for SI at *pitta* and *kapha* locations for both the groups. SI at *Tridoṣa* locations was significantly different with large effect size across both the groups. SI at *vāta* of diabetes group was high compared to non-diabetes.

The diabetes group has shown significantly lower SI at *pitta* and *kapha* locations when compared to non-diabetes group. Mizuho et.al in their study based on baPWV technique (Kinouchi et al., 2014) reported higher values of arterial stiffness in diabetes compared to non-diabetes. As the stiffness index computation included height of the person, the mean heights of the subjects in both the groups were tested using independent samples t test and found that the difference was not significant which confirmed that the significance of difference in SI was mainly due to arterial stiffness and not due to height of the persons. The stiffness index represents the time interval between systolic and diastolic peaks and based on the results it is observed that the diastolic peak at *vāta* arrived earlier in diabetes group compared to non diabetes group whereas the diastolic peaks at *pitta* and *kapha* arrived late in diabetes group compared to non diabetes group. The pilot study has shown variations in systolic to diastolic peaks across diabetes and non diabetes which is a significant result and there is a need to do in depth studies to understand the nature of arterial stiffness across *vāta, pitta* and *kapha doṣas* in diabetes group.

The subjects were further divided into three groups based on age of the participants in non diabetes group and the results were consistent with the results of *Tridośa* study. SI at *vāta* location is high in *vāta* dominant age group compared to SI at *vāta* location in *pitta* dominant age group. SI at *pitta* location is high in *pitta* dominant group when compared to SI at *pitta* location in *vāta* dominant group. In similar lines subjects were further divided into three groups based on age in diabetes group it is observed that the variations of SI at *pitta* location across different age groups are similar to non diabetes group

whereas SI at *vāta* and *kapha* locations have decreased with age which is not consistent with the results based on non diabetes group. The arterial stiffness increases not only with the age but also with the state of diabetes and hence the state of diabetes would have influenced the progression of SI with age.

RI was not significantly correlated to FPG at *Tridoṣas* in both the groups and the mean value of RI was not significantly varying across both the groups. Mizuho et.al have reported similar results in their study wherein they have measured endothelial function using flow-mediated vasodilation (Kinouchi et al., 2014). The endothelial dysfunction and arterial stiffness are considered as independent markers for cardio-vascular risks such as Type 2 diabetes and Mizuho et.al demonstrated the significant association of these two parameters in their study. The significant positive correlation ($p < 0.01$) between SI and RI at *Tridoṣas* confirmed the association of these parameters with arterial stiffness and endothelial function respectively. In non-diabetes group SI and RI were correlated at *vāta* and *pitta* locations whereas in diabetes group they were correlated at *pitta* and *kapha* locations. Both diabetes and non-diabetes groups have shown significant correlation between SI and RI at *pitta* location. The study based on cfPWV has shown that arterial stiffness was positively correlated with fasting plasma glucose (de Oliveira Alvim et al., 2015) and another study based on baPWV technique has shown positive correlation between arterial stiffness and fasting plasma glucose in non-diabetes group (Shin et al., 2011). These studies have shown positive correlation between fasting plasma glucose and arterial stiffness whereas our study has shown negative correlation. The reason for such a difference in the direction of the correlation may be due to the location of the pulse which

needs to be investigated further. In another study based on PPG, stiffness index was not significantly correlating with fasting plasma glucose (Gunarathne et al., 2008) and these results were not matching with our results and also with other results. Further studies need to be done to establish the relationship between endothelial function and RI. As arterial stiffness may increase due to many other factors there is a need to prospectively study the significance of arterial stiffness in assessing the risk of Type 2 diabetes.

8.3 OBESITY STUDY

The effect of one week IAYT on arterial stiffness measured from radial artery across young and older adults with obesity was studied. There was a significant reduction in arterial stiffness (SI) in young adults with obesity but the changes in older adults with and without obesity were not significant after giving intervention of IAYT for one week. Wildman et.al in their study reported that the excess body weight is associated to aortic stiffness (Wildman et al., 2003) and in another study by Wildman et.al, authors have studied whether the changes in arterial stiffness are acute and reversible and they have reported that weight change is associated to change in arterial stiffness in young adults (Wildman et al., 2005).

In older adults there was a significant reduction in BMI but reduction in SI was not significant and this could be because the average age of the group was above 50 years. The studies have shown that arterial stiffness increases with age (Sandrine C Millasseau et al., 2006) and hence for older adults with obesity the arterial stiffness increases with age as well as BMI whereas in younger adults only obesity can be the cause of increase in arterial stiffness. In this study results have shown that one week IAYT program has

reduced BMI of obese participants across young and older adults but similar reduction in SI was observed only in young adults and not in older adults. One week duration may not be sufficient for older adults to see significant changes in SI and secondly older adults were having osteo-arthritis as co-morbidity and hence there is a need to study the change in SI with IAYT by considering only obesity without any other complications. There was no significant change in RI after one week of IAYT in all the three groups and needs further investigation.

In another study Duren Patil et.al reported that yoga program reduced the arterial stiffness levels when compared to brisk walk (Patil, Aithala, & Das, 2016) and in their study arterial stiffness was measured from pulse wave velocity using carotid-femoral and brachial ankle techniques whereas in this study the arterial stiffness was measured from radial artery. The effect of integrated yoga therapy on arterial stiffness measured from radial artery was not studied till now and this is the first time the effect of integrated yoga therapy on arterial stiffness measured from radial artery was studied. IAYT was selected as an intervention as previous studies with IAYT have shown significant improvements in the overall health of the patients (Ranjita, Badhai, Hankey, & Nagendra, 2016; Tekur, Chametcha, Hongasandra, & Raghuram, 2010). The pilot study has shown initial evidence of reduced arterial stiffness along with BMI in young adults with obesity participants after one week of IAYT intervention. This need to be further investigated with larger sample size and with control in place. There were some limitations in this study. The focus of the pilot study was to investigate the effect of IAYT on arterial stiffness measured from radial artery. There were no prior studies in the literature and hence we have selected relatively smaller sample size for our study. As the results were

promising extensive studies with larger sample sizes would help in establishing the effect of integrated yoga on arterial stiffness. Secondly IAYT was conducted for only one week and need to study the changes in arterial stiffness by increasing the duration of IAYT. The association of arterial stiffness with diabetes is well established (de Oliveira Alvim et al., 2015) and hence there is a need to study the effect of Yoga in general and IAYT in particular, in mitigating diabetic complications and improving overall health of the patients with diabetes. In the current study control group was not included and future studies should include control group to strengthen the study.