

CHAPTER V

DISCUSSION

The current study comprises two parts which are concerned with the reliability test of the height loss measuring stadiometer (reliability of the digimetic indicator ($ICC_{1,1}$), reliability of the height loss measuring stadiometer ($ICC_{3,1}$), the standard error of measurement (SEM) and means of standard deviations (SDs) of measurement), and investigation of the effect of time of day and treadmill running on the vertical spinal creep response. The results show that the effect of time of day has no statistically significant difference on the magnitude of the VSC response in both groups, and the magnitude of the VSC response compared between groups shows no statistically significant difference in VSC response.

1. **The reliability test of the height loss measuring stadiometer**

The first invented stadiometer in Thailand is called the “height loss measuring stadiometer.” This study investigated the reliability of the height loss measuring stadiometer in a sitting posture by examining the reliability of the digimetic indicator device and the reliability of the measurement. The results show high reliability of the digimetic indicator ($ICC_{1,1} = 1.00$). This indicates that the digimetic indicator can be used to measure the magnitude of VSC response or height loss under spinal loading. Eklund and Corlett (1984) were the first researchers who built and used a device called a stadiometer which was designed to measure height loss in standing. They used a linear transducer to detect the height loss of the body instead of using the digimetic indicator. The VSC response data from the linear transducer was retrieved and converted from volts to millimeters. Then the VSC response data, at each measurement time, was subtracted from the VSC response measured at zero minutes so that the data represented the actual change in VSC response, whereas the representation of VSC response data by the digimetic indicator shows the results to be a numeral first on digimetic indicator and then these data are retrieved and converted to electrical signals. These electrical signals are translated and continuously recorded

to be the numerical data again, interfaced with a computer and specific software. Therefore, both devices are similar in function. The sensitivity of the linear transducer depends on the model of the linear transducer, as in the studies of Kanlayanaphotporn et al. (2002) and Puntumetakul et al. (2009) with the sensitivity of the linear transducer at $101.54 \text{ mV mm}^{-1}$, range 120 millimeters and measurement accuracy ± 0.05 millimeters. Moreover, the devices can record 150 VSC data in 15 seconds. Healey et al. (2008) used a linear transducer with accuracy of ± 0.01 millimeters even though the range of measurement of the digimetic indicator is lower than the linear transducer. However, the previous studies showed a height loss of up to 2 centimeters (De Puky, 1935; Twomey, 1987; Tyrrell et al., 1985) so the range of measurement of the digimetic indicator is enough to measure the height loss or the VSC response.

Intratester reliability test is equal to 0.96 (ICC $_{3,1}$). The ICC values of more than 0.75 are indicative of good reliability (Portney & Watkins, 2000). This finding was similar to a previous study by Stephen and Ahrens (1994) who found that the ICC $_{3,1}$ of high loss measurement in standing position was 0.998. This means that the ability of the researcher and the ability of the subjects for managing positioning when each subject was asked to sit in a height loss measuring stadiometer were fairly good.

The standard error of measurement (SEM) is 0.04 millimeters. The SEM was used to reflect the random variability of a single individual's values on repeated testing (Hopkins 2000). The SEM determines the range of VSC response that can be expected on retesting. Thus, small SEM values in relation to the means suggest small measurement error and high reliability.

Moreover, the means of standard deviations (SDs) was used to reflect the reliability of a single individual's values on repeated testing and the SDs in the current study were less than 0.2 millimeters which shows smaller measurement error and higher reliability to control the subject's posture before the VSC response measurement. Additionally, SDs value in the current study was less than the generally acceptable value that should be less than 0.5 millimeter (Garbutt et al., 1990; Healey et al., 2008; Kanlayanaphotporn et al., 2003; Leatt et al., 1986; Rodacki et al., 2001; Tyrrell et al., 1985; Wilby et al., 1987). Therefore, the height loss measuring stadiometer was used to measure the VSC response in this study.

2. The effect of time of day and treadmill running on the VSC response

The current study investigated the effect of time of day and treadmill running on VSC response. Sixty healthy subjects who had the same running experience were divided into control and treadmill running groups in order to compare the VSC response between the morning (6.00-8.00 AM) and the afternoon (4.00-6.00 PM) using the height loss measuring stadiometer which measured the magnitude of VSC response which occurred between pretest and posttest.

The results showed that the magnitude of the VSC response measured in the morning of treadmill running group, after the running test (1.95 mm) significantly increased from that measured in before the running test (1.52 mm) ($P = 0.007$). Similarly, the magnitude of the VSC response measured in the afternoon of treadmill running group, after the running test (1.61 mm) significantly increased from that measured in before the running test (1.88 mm) ($P = 0.023$). These findings support the results of Dowzer et al. (1998) and Garbutt et al. (1990), that treadmill running is the activity to produce the spinal loading which leads to increased VSC and supports the result of Fowler et al. (2006) who studied the task of postal workers walking as performed using a treadmill that allowed participants to adjust the walking speed according to their self-selected pace throughout the activity, that the loaded condition produced a stature loss double that observed in the unloaded condition. Therefore, this study supports that dynamic loading influences the VSC response. However, the differences of the magnitude of the VSC response were very tiny, which may be no clinical significant difference.

Results from the control group showed that the magnitude of the VSC response after testing was higher than the magnitude of the VSC response before testing. However, there was no significant difference of the VSC response in both morning and afternoon. The magnitude of the VSC response in the control group increased since in the period of testing the subjects in the control group were asked to continue their normal daily activities and the most of activities in this group are standing and sitting which were in the upright posture. In the upright posture, the effect of gravity and the subject's body weight can produce a compressive load on the intervertebral discs causing fluid in the nucleus pulposus to be expelled into the

vertebral bodies and annulus fibrosus, leading to spinal height loss (Adams & Hutton, 1983).

The magnitude of the VSC response in both control and treadmill running groups demonstrated that the testing in the morning provided a greater VSC response than in the afternoon. However, time of day did not significantly affect the VSC response ($P > 0.05$). The finding was similar to previous studies (Althoff et al., 1992; van Dieen et al., 1994b; Puntumetakul et al., 2009). The study of Althoff et al. (1992) showed a trend towards greater VSC response in the morning than in the afternoon, but did not show a statistically significant difference. In contrast, van Dieen et al. (1994b) also found that the VSC response measured in the afternoon (1.00 PM) was greater than the VSC response measured in the morning (9.00 AM). However, there was no significant difference in VSC response measured in the morning and afternoon. The study of Puntumetakul et al. (2009) studied 48 asymptomatic subjects aged 24.7 ± 3.2 years, body weight 65.1 ± 11.0 kg, height 168.4 ± 8.9 cm and BMI 22.9 ± 3.0 kg/m². The VSC response was recorded over 25 minutes while subjects remained seated on the stadiometer, at 3 times [morning (8.00 - 9.00 AM), midday (12.00 AM - 1.00 PM) and afternoon (4.00 PM - 5.00 PM)] on the same day. Their results showed that there was no statistically significant difference on the magnitude of the VSC response using a static loading condition (15 percent of subjects' body weight). However, the load history between occasions of measurement was not controlled. The finding of the study suggests that the VSC measures can be taken at any time of day rather than being restricted to early morning. The previous studies used a different protocol and subjects, but the findings were similar to the current study.

In contrast, the results of the current study were differences from two previous studies (Healey et al., 2008; Wilby et al., 1987). Wilby et al. (1987) investigated the circadian variation in the stature of ten females (aged 22.2 ± 3.1 years, body weight 61.4 ± 6.7 kg, and height 166.0 ± 5.0 cm) who were studied in eight exercises which formed weight-training for 20 minutes and found that significantly more stature reduction occurred when load was applied in the morning (5.4 mm) (7.30 AM) compared to the evening (4.3 mm) (10.00 PM).

Moreover, Healey et al. (2008) studied on 11 chronic low back pain (aged 32.8 ± 7.9 years, body weight 74.4 ± 14.2 kg, height 173.0 ± 3.0 cm) and 11 asymptomatic participants (aged 31.0 ± 6.3 years, body weight 72.6 ± 11.5 kg, height 176.0 ± 9.0 cm). Both groups were of mixed gender (male = 6, female = 5). The subjects walked on a treadmill at self-selected pace for 20 minutes wearing a weighted vest (10 percents of body mass), one set in the morning (9.00 AM) and the other set in the afternoon (2.00 PM). Both sessions were completed approximately one week apart. Changes in stature were measured using a standing stadiometer which inclined backwards 15 degrees from the vertical. They found that the VSC response of the asymptomatic group, measured in the morning (5.4 mm), was significantly greater than the VSC response measured in the afternoon (3.7 mm). The VSC response of the chronic LBP group experienced a similar pattern. The value measured in the morning (4.9 mm), was greater than the VSC response measured in the afternoon (4.4 mm). However, the difference between the morning and the afternoon was not statistically significant in the chronic LBP group. There was no significant difference in the VSC response between groups.

They concluded that less disc height was lost in the evening due to the disc having a lower capacity to shrink due to diurnal change, and thus the disc and the surrounding spinal structures have a reduced ability to accept loading stress during evening activity, and are therefore at a greater risk of injury (Wilby et al., 1987). These two studies measured the VSC response in a standing posture may influence the VSC response, and different results between the current study and the two studies may be masked by the difference of measurement method. And the subjects who participated in the previous study had different characteristics from the subjects from the current study.

The magnitude of the VSC response between control and treadmill running group in the current study showed that the magnitude of the VSC response in the treadmill running group was higher than in the control group, but there were no statistically significant differences in the VSC response between groups. The results were similar to the study of Leatt et al. (1986) who found no significant difference in the VSC response between novices (3.25 mm) and experienced runners (2.35 mm). They compared nine novice runners (age 19.9 ± 2.2 years, body weight 69.4 ± 4.0 kg,

height 174.0 ± 5.0 cm) and seven experienced runners (age 31.0 ± 10.0 years, body weight 62.4 ± 5.3 kg, height 172.0 ± 4.0 cm) who ran a total of 6 km. The 6 km run is typical of a training regime advocated for recreational joggers (Pollock et al., 1987). Additionally, they compared the 6 km run and the 19 km run in experienced runners and found significant differences in the VSC response between distances. The data suggest that the duration of the exercise is a dominant factor in determining the total spinal loading during training runs. However, the current study in the treadmill running group was performed at a speed of 7.80 ± 0.81 km/hr⁻¹ for 30 minutes, and therefore the total distance running was about 3.9 km. This distance running of treadmill running group in the current study may be too low to make a significant difference in the VSC response between treadmill running group and the control group.

