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Diurnal Variation of Stature in Three Adults and One Child

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ABSTRACT Stature is considered as a reliable measure of physical growth and development and its medico-legal significance is obvious in forensic examinations. The present study reports diurnal variation of stature in three adults and one child. The measurements of stature were recorded four times in a day for 56 days in all the subjects i.e. at 0600 hours, 0800 hours, 1800 hours and at 2200 hours. Significant diurnal variation in stature is observed in all the subjects and stature begins to decrease immediately after rising in the morning. A very rapid decrease in stature occurs within first two hours of the day and further loss continues throughout the day in small amounts. The effect of napping, short term lying down and other postural changes, is discussed. A maximum mean daytime loss of stature up to 2.81 cm is observed. The age and body weight seem to affect the diurnal variation in stature to some extent. The results have important implications regarding current practice in the study of growth, development and nutrition as well as in personal identification.

INTRODUCTION

Stature or standing height is the most often used anthropometric dimension and it is a quantitative measure of physique and indicative of physical growth and development of an individual. Anatomically, it is a composite of linear dimensions of skull, vertebral column, pelvis and legs. Over a decade, a close relationship between stature and dimensions of various body segments is reported and the results are frequently used in anthropometric studies of the allometry of body proportions, physical growth and development of children, medico-legal investigations and personal identification in forensic examinations by several scientists all over the world (Trotter and Gleser, 1951, 1952; Sharma et al., 1978; Jantz et al., 1995; Jason and Taylor, 1995; Klepinger, 2001; Krishan and Vashisht, 2002; Vashisht et al., 2003)

The difference between recumbent length and stature within an individual has also received considerable attention in the literature (Roche and Davila, 1974; Krishan and Sharma, 2002) but at the same time, intra-individual variation in stature has received little attention. Diurnal difference in stature was first described by Wasse (1726). Other studies which confirm the phenomenon of diurnal variation in stature (Boyd, 1929; Palmer, 1930; Redfield and Meredith, 1938; Lampl, 1992) were largely confined to American and European countries. All these studies report that stature is maximum in the morning and less by 1.5 cm to 3.0 cm in the evening, the studies further confirm that greater proportion of decrease in height is occurring in the vertebral column due to reduction of elasticity of inter-vertebral discs.

The purpose of the present study is to:

a) Confirm the intra-individual diurnal variation of stature in Indian subjects and how do these differences change with age, body weight and sex.
b) Define the time of the day, if any, at which stature loss effectively ceases.

MATERIALS AND METHODS

The subjects were two adult males (A and B), one adult female (C) and one child (D) residing in a village Mullanpur Garibdass near Chandigarh city in north-west India. The study was conducted from 6th March 2002 to 30th April 2002 when the subjects were 59.1 years, 31.8 years, 25.1 years and 9.0 years of age respectively (Table 1). The subject A is older than the other subjects. All the subjects were healthy and free from any ailment and deformity.

Stature of each subject was measured four times in a day for 56 days by a trained physical/ forensic anthropologist (KK).The measurement was taken with a GPM anthropometer (Siber

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Hogner Maschinen AG, Switzerland) using standard technique described by Weiner and Lourie (1969) to the nearest 0.1 cm. The body weight of each subject was also recorded with minimum possible clothing to the nearest 0.1 kg.

The stature of each subject was measured on four occasions in a day i.e. immediately after rising within 30 seconds at around 0600 hours, at 0800 hours, then at 1800 hours and at 2200 hours just before going to bed. During the 56 days period, the stature of each subject was recorded by the same observer to avoid inter-observer error. Each measurement was recorded independently of the previous measurement i.e. the measurement was recorded 'blindly'.

Means of stature taken at different times of the day for 56 days for each subject were calculated. Mean stature loss at different times of the day for 56 days in all the subjects was computed as follows:

The mean value of stature at 0800 hours was subtracted from value of stature taken immediately after rising i.e. at 0600 hours; mean value of stature at 1800 hours is subtracted from that at 0800 hours; similarly, the mean value at 2200 hours was subtracted from that at 1800 hours. The mean diurnal stature loss was calculated by subtracting the stature measured at 2200 hours from that at 0600 hours.

Technical error was calculated by measuring the stature of the individual for 10 times (10 days) in morning and the measurement error was calculated by using the method devised by Cameron (1986).

RESULTS

Table 1 presents the means of stature measured at different times of the day for 56 days, in four subjects A, B, C and D. Age and body weight of each subject are also shown in the Table. In all the subjects, the stature begins to decrease immediately after rising i.e. at 0600 hours. A very rapid decrease occurs within first two hours and further continues to decrease slowly until the subjects lie down in recumbent position for nap and sleep at night. The extent of loss in stature can be judged from the average figures of stature immediately upon rising and in the evening at 2200 hours (Table 2, Fig. 1). The mean daytime loss of stature is 2.81 ± 0.29 in A, 2.55 ± 0.30 in B, 2.06 ± 0.27 in C and 1.95 ± 0.28 in D. The mean value is largest in the older subject (A) and smallest in the child (D). All the four subjects show significant differences in the mean values of stature in morning and evening. The mean loss of stature within the first two hours (0600 to 0800 hours) is the largest i.e. 1.73 ± 0.27, 1.58 ± 0.26, 1.19 ± 0.21 and 1.21 ± 0.20 for A, B, C, and D respectively. The mean values for the second and third intervals were significantly and noticeably smaller than for the first i.e. small amount of decrease in stature occurs after first two hours of rising (Table 2).

It is observed that during night time, when the subjects lie down and almost sleep, the stature increases, the extent of increase can be viewed from the Figure 1.

The daytime decrease in stature is smaller in

Table 1: Means of stature taken at different times of the day for 56 days i.e. from 07.03.2002 to 30. 04. 2002 in different subjects

Subject	*Age (in years) on first day of measurement*	*Body Weight (in kg)*	*Mean Stature (in cm) at*			
			0600 hours	*0800 hours*	*1800 hours*	*2200 hours*
A	59.1	82.7	174.86	173.13	172.53	172.05
B	31.8	80.5	172.53	170.95	170.36	169.98
C	25.1	52.3	154.80	153.61	153.13	152.74
D	09.0	27.5	126.30	125.09	124.76	124.35

Table 2: Mean stature loss at different times of the day for 56 days in different subjects

Period (Interval)	*Mean Stature Loss (in cm)*			
	A ± SD	*B ± SD*	*C ± SD*	*D ± SD*
0600-0800 hrs	1.73 ± 0.27	1.58 ± 0.26	1.19 ± 0.21	1.21 ± 0.20
0800-1800 hrs	0.60 ± 0.17	0.59 ± 0.19	0.48 ± 0.21	0.33 ± 0.18
1800-2200 hrs	0.48 ± 0.14	0.38 ± 0.18	0.39 ± 0.17	0.41 ± 0.19
0600-2200 hrs (Loss of stature during daytime)	2.81 ± 0.29	2.55 ± 0.30	2.06 ± 0.27	1.95 ± 0.28

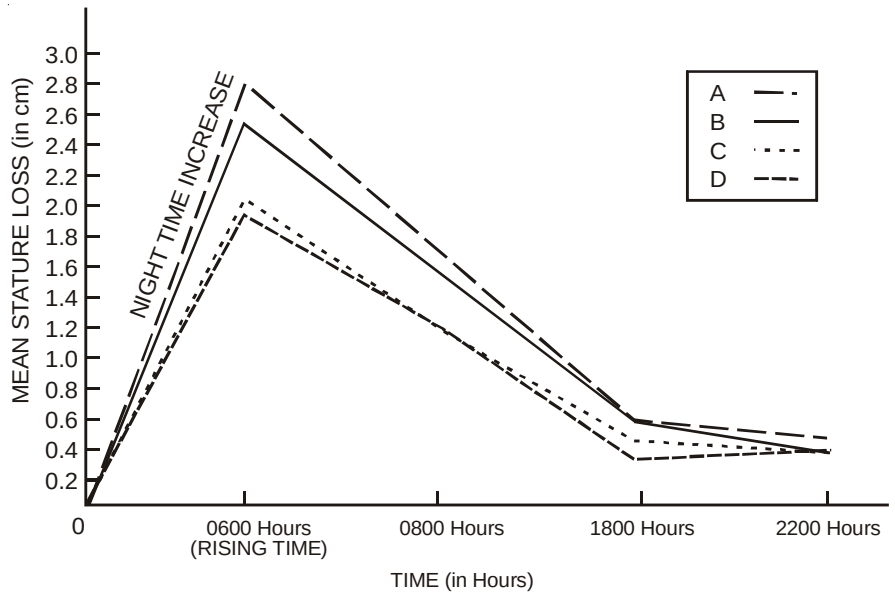

Fig. 1. Decrease in stature immediately after rising in the morning in four subjects

female subject (C, 2.06) as compared to the male subjects (A, 2.81; B, 2.55) and the differences are quite significant. In the child, the value is still lower (D, 1.95).

The technical error of the measurement was calculated by comparing repeated measurements for ten times. The results indicate that the measurement error contributes but little to the diurnal change in stature in an individual.

DISCUSSION

Now, it is evident from the results of the present study that stature of a person shows variations at different times of the day. Stature is greater in the morning after rising from bed. This diurnal change in height of a person was indicated as early as 1726 by Wasse and the shortening in stature during daytime was reported and confirmed by various investigators in the past (Matsuguchi 1924; Tahara, 1924; Nomura, 1930; Hori, 1936). Kwabata (Ashizawa and Kawabata, 1990) measured the stature of her own children in morning and evening and showed which part of the body contributed to the diurnal differences. Lampl (1992) also measured stature of a boy twice a day for 300 days and showed a marked difference between the measurements of morning and evening stature. In all these studies, the morning stature was taken within 15 or 30 minutes after rising. The time that elapsed from the subjects' getting out of bed to the time of measurement was not indicated. As a study (Kobayashi and Togo, 1993) reports that a very rapid decrease in stature occurs within the first 30 minutes after rising. However, the loss of stature might vary depending on the time elapsed from rising to the time of measurement in the morning. Therefore, in the present study, stature was measured just within 30 seconds after rising.

In the present study, as the Figure 1 indicates that the stature begins to decrease immediately after rising and the major loss in stature occurs in the first two hours of the day. The finding is in conformity with the outcome from the previous studies and in general agreement with the statement given by Fairbank (1998). Over the period 0600 to 0800 hours, we found an average maximum loss of 1.73 cm in the subject A (the oldest subject) and average minimum loss of 1.19 cm in the subject C (the female subject).

Voss and Bailey (1997) reports that no further discernible decrement in stature occurs, once the person has been up for six or seven hours after rising. However, in the present study, there is no point of time where the loss in stature effectively ceases. Although, further loss is not as significant and effective as in the first two hours after rising.

The present subjects showed loss of 0.33 cm to 0.66 cm in the interval 0800 hours to 1800 hours and 0.38 cm to 0.48 cm in the interval 1800 hours to 2200 hours. This may be attributed to the fact that the subjects keep on changing their postures rather than standing in a straight position i.e. sitting on the chair, lying down for few minutes, napping, engaging in household and office work, bending etc. Kobayashi and Togo (1993) also report that a small amount of stature is gained after naps or lying down, after taking bath etc. According to Voss and Bailey (1997), though commonly used, the standard stretched technique does not appear to eliminate the effects of diurnal stature loss. It simply increases the measured height. Some suggest that 'gentle upward pressure on the mastoid processes' could minimize the effects of diurnal variation in stature (Whitehouse et al., 1974). Indeed, these authors claim to have shown that using this technique, loss in stature between morning and afternoon, though not entirely eliminated, can be reduced to a maximum of 0.46 cm.

The diurnal variation of stature in our subjects is greater than those in previous studies, since the stature in present study was measured just after rising in the morning. The subjects A and B are taller and hence give greater variation in stature than that of female subject (C) and the child (D). The greater diurnal variation in stature in A and B may also be attributed to larger body weight in the subjects (Table 1). Comparatively small diurnal variation in stature among the female subject is intriguing but can not be explained with any certainty because the measurements were taken on a single female subject. The reason may probably be cited with the explanation from the genetics; e.g. females are generally better canalized thus show less diurnal variation in stature. This may also be attributed to the fact that if one assumes that the females are not as involved as their male counterparts in activities that result in compression of the vertebral column and other joints in the body.

Now, it is possible to say that the stature of a person shows diurnal variation whether the person is a child, adult or old one in both the sexes. The amount and extent of variation depends upon the time of measuring the stature and varies from individual to individual. Diurnal stature loss can be a problem in short term longitudinal studies, in which apparent changes might simply reflect variations in the time of the day at which the measurement was taken (Malina and Beunen, 1996). This diurnal loss in stature may be attributed to the compression of fibrous discs of cartilage that separate the vertebrae. With the forces of gravity imposed by standing, walking and involving in physical activity, the discs are gradually compressed (Malina, 1995). The greater proportion of the change occurs in the vertebral column than in any other part of the body. Some agree that this is due not only to inter-vertebral shortening but also to bending of the vertebral column during the daytime (Hattori and Nishio, 1982) and still others say the diurnal variation in height is mainly due to loss of fluid from the inter-vertebral discs rather than postural changes (Fairbank, 1998).

CONCLUSION

It has been concluded that intra-individual variation in stature may substantially affect the reliability of height data and careful consideration should be given to the time at which the measurements are to be recorded. Therefore, in view of the accountable and significant variations in stature of an individual at different times of the day, the investigation alarms the scientists, researchers and clinicians engaged in conducting community based surveys involving stature as a measurement and for making reference data pertaining to growth, development and nutritional studies as well as for personal identification in forensic examinations.

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