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Anthropometric Studies of the Diurnal Human Height Shrinkage Across Selected Professionals in Nigeria

Mojisola A. Bolarinwa[1] & Charles O. E. Owaba[1]

[1] Department of Industrial and Production Engineering, University of Ibadan, Nigeria
Correspondence: Mojisola A. Bolarinwa, Department of Industrial and Production Engineering, University of Ibadan, Nigeria.

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Abstract

Diurnal variation in stature is one potentially significant source of error in the evaluation of short-term growth. Hence, there is the need to observe whether there are diurnal variations when assessing humans' (subjects) body composition, using physical anthropometric methods. In this paper, the diurnal human height shrinkage have been investigated by measurements, such that twice-daily measurements and body weight of subjects were examined and recorded. A total of 70 subjects were examined altogether. This comprises of 35 males and 35 females of which 2 nursery school children (a boy and a girl) were involved, aging 4 years and 3½ years respectively. For most of the subjects, Morning measurements were made immediately after rising. The time of the measurements was also recorded and diurnal changes during daytime were estimated. Results showed that stature decreased during the day in the entire 70 subjects surveyed and sampled. From the results, it could be seen that an average female subject will shrink by 0.88% of the usual (morning) height. Also, the mean average shrinkage in height amounts to 1.43 ± 2cm for the females. Likewise, an average male subject will shrink by 0.91% of his usual morning height. The mean average shrinkage in height in male subjects equals 1.56 ± 2cm. The findings of this study confirm the existence of diurnal variation and that the greater proportion of the height loss occurs during the earlier part of the day, especially when subjects are engaged with some form of activity or the other.

Keywords: variations, short term growth, stature, measurements, shrinkage

1. Introduction

The importance of minimizing measurement error in the assessment of growth has been well documented. (Voss et al., 1990; Voss et al., 1991; Voss & Bailey, 1994; Wasse, 1726). One potentially significant source of error, diurnal variation in stature, first noted in 1724 (Redfield & Meredith, 1938) has, however, been largely ignored in clinical practice. Early studies by Redfield and Meredith (Boyd, 1929; Nylin, 1929) were conducted with varying degrees of scientific rigour, but did confirm the presence of diurnal variation in the adult. Most agreed that the total loss amounted to between 2 and 3 cm, and the evidence suggested that the greater proportion of the decrease in height was occurring in the trunk.

Similar effects have been shown in children, (Palmer, 1930; Strickland & Shearin, 1972; Whitehouse et.al., 1974; Buckler, 1978; Ashizawa & Kawabata, 1990; LampI, 1992), some studies also showing that much of the height loss can be restored by taking a short nap (Nylin, 1929; Palmer, 1930; Strickland & Shearin, 1972; Whitehouse et.al., 1974; Buckler, 1978; Ashizawa & Kawabata, 1990; Lampi, 1992; Hrdlicka, 1939). Almost all reports agree that the greater proportion of the decrease in stature appears to occur soon after rising (Boyd, 1929; Strickland & Shearin, 1972; Ashizawa & Kawabata, 1990) though it is assumed that, without a nap, further loss continues throughout the day. Foundational work of Reilly et.al. (1984), established on investigating the circadian rhythm of stature in eight adult males using precision stadiometry, reported a trough-to-peak variation of 19.3 mm, approximately 1.1% of total stature. Krishan and Vij (2007) measured four adults and one child over 56 days and reported a maximum mean daytime stature loss of up to 28.1 mm, with a very rapid decrease in the first two hours after rising. Wilby et al. (1987) documented a mean peak-to-trough variation of 15.4 mm (0.92% of stature) in ten females, somewhat less than the ~19 mm reported in males. In children, Lampl (1992) measured one adolescent boy over 300 days and found a mean daily decrease of 9.8 ± 2.0 mm, with similar decreases observed after short naps. Tillmann and Clayton (2001) studied two prepubertal boys and reported a maximal height loss of about 14.4 mm by 15:00 hours, followed by a significant partial recovery of approximately 3.8–4.2 mm during the evening hours suggesting the diurnal pattern is not strictly monotonic. There is some disagreement about the total daily loss to be expected, but no two studies have measured their subjects over exactly the same period. Even in two studies involving large number of children, one found a mean decrease in height of 1.54 cm in 100 children between rising and late afternoon, whereas another found a mean decrease of just 1.0 cm in 70 boys between early morning and bedtime (Palmer, 1930; Whitehouse et.al., 1974). In their own findings, Czaprowski et al. (2019) confirmed diurnal shrinkage in 98 children with idiopathic scoliosis, noting a mean standing height loss of 7 mm from morning to evening. A study of 197 Indian medical students demonstrated significant diurnal variation between morning (08:00–09:00) and afternoon (16:00–17:00) measurements, with males showing greater height loss than females (Rajesh et al., 2022). The underlying mechanism surrounding diurnal stature change is the viscoelastic creep behavior of the intervertebral discs (IVDs). Botsford, et. al. (1994), using three-dimensional MRI reconstructions quantified diurnal disc volume changes in vivo, reporting mean decreases of 18–22% in lumbar disc volume after a simulated day of activity. Keller and Nathan (1999) developed a sagittal-plane viscoelastic model predicting an instantaneous height loss of 11.7 mm upon loading and a total of 19.6 mm after eight hours, with the thoracic region contributing about 57% and the lumbar region about 32% of total loss due to larger number of thoracic discs. Martin et al. (2022), using quantitative MRI were able to show that lumbar discs deform by 6–8% in height and 5–9% in volume from morning to afternoon, with deformations concentrated posteriorly at caudal levels; notably at L5-S1, where disc herniation is most prevalent. Vergroesen et al. (2016) provided a new biophysical explanation, stating that as in vivo daytime loading is sustained for roughly twice as long as nighttime unloading, the disc operates closer to its loading equilibrium during the day. Zander et al. (2010) used finite element modeling to demonstrate that a 10% diurnal change in disc height produces markedly higher spine flexibility and facet joint forces in the evening, as compared to the morning, while intradiscal pressures are higher in the morning; a finding with implications for injury risk at different times of day. Adams et al. (1990) reviewed these diurnal mechanical changes and reported that different spinal structures bear disproportionate loads at different times of the day, and that the timing of symptom onset may help clinicians understand the pathophysiology of back pain. Factors responsible for the modulation of the magnitude of diurnal shrinkage have been found to include: Body weight and obesity; External loading and activity type (Tyrrell et al., 1985; Fowler et al., 1994; Hoe et al., 1994; Van Deursen et al., 2005; Jazwinska & Adam, 1985; Reilly & Freeman, 2006); as well as low back pain (Healey et al., 2008; Healey et al., 2011). Precision stadiometry is the standard technique for quantifying stature change. Eklund and Corlett (1984) developed an early device capable of measuring height with a standard deviation below 1 mm and demonstrated its utility for ergonomic evaluations of workplace loading. Foreman and Linge (1989) identified heel pad compression as a confounding factor, reporting an average of 4.4 mm of heel compression upon standing, and recommended a two-minute standing equilibration period before measurement. Towards the end of the last century, attempts were made largely by the physical anthropologists to standardize the method of measurement (Thomsen et al.,1990). 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. However, the technique has changed little over the years, with clinicians showing little interest in the subject. For instance, stretching technique was not widely adopted about 20 years ago, until discovered could minimize the effects of diurnal variation (Buckler, 1978). In his own case, Thomsen et al (1990) compared the precision or reproducibility of the stretched and un-stretched methods and report no difference. In the recent times, measurements of reduction in stature have been used to compare spinal loading in chronic low-back pain (CLBP) and asymptomatic populations, even though whether there are any differences in the repeatability of stature measurements, between those with and without CLBP, is not known (Healy et al., 2005). According to Tyrell et al. (1985), using a method comparable with that of Eklund and Corlett (1984), stature was measured with an accuracy of 1 mm in eight young adults. Fifty-four percent of the diurnal loss in stature occurred in the first hour after rising. Approximately 70% was regained during the first half of the night. Stothart and McGill (2000) showed that leaving subjects in place during repeated measures reduces random variation compared to having them step in and out, though it introduces a steady shrinkage artifact during the 3–3.5 minutes of measurement. Lewis and Fowler (2009) validated stadiometry against MRI, finding a significant correlation between stadiometric stature loss and posterior lumbar spine length change, supporting stadiometry as a reasonable proxy for overall spinal loading, though not for individual disc height measurement. Mikula et al. (2016) found that clinical height measurements in routine practice are highly unreliable, with 18% of patients showing recorded height differences of ≥2 cm over just three months in electronic health records, underscoring the need for standardized technique. Diurnal height variation has several practical consequences. In pediatric growth assessment, Tillmann and Clayton (2001) recommended measuring children between 18:00 and 21:00 when diurnal variation is smallest to minimize error in short-term growth evaluations. In forensic anthropology, failure to account for diurnal variation may introduce errors of 1–2 cm in stature estimation. In ergonomics, spinal shrinkage has been used as a noninvasive index of cumulative occupational loading. McGill et al. (1996) cautioned, however, that substantial within-subject and between-subject variability limits the precision of shrinkage measurements in workplace assessments. Massey et al. (2012) showed through finite element modeling that disc degeneration reduces osmotic pressure by approximately 75% and decreases diurnal fluid exchange by ~21%, potentially compromising nutrient delivery to the avascular disc. Previous estimates of the diurnal changes in disc height have used radiologic, stereo-photographic, and magnetic resonance imaging e techniques. In this study, diurnal human height shrinkage has been investigated manually using anthropometric measurements. Hence, the objectives of this work include: (1) Showing that there is usually diurnal shrinkage in human height everyday; (2) Determining in which sex does shrinkage occurs greater (or lesser); (3) Determining if the severity of shrinkage (assuming it occurs) varies with profession of the subjects in question.

2. Methods

A random sampling of subjects across different professions was conducted at different periods of the day (that is, in the morning and evening time. Professions (disciplines) of subjects covered include Barbing, Electrician, NEPA official, Motor Mechanic, Hair dresser, Students, Lecturers.

Nursery school pupils, Farmer, Carpenter, Fashion designer, and Bus conductor to mention a few. Having taken all necessary precautions such as avoiding parallax errors by taking every reading from center points and on flat surfaces, the use of the non-shrinking type of the measuring tape for all measurements taken, removal of shoes and trinkets by subjects and so on, the human height (standing) was measured vertically from the floor to the top of the head (vertex with the aid of the measuring tape). Each person stood erect, looking ahead, the arms hanging loosely at the sides. Likewise for the weight, using the home scale with 1 kg calibration, corresponding values were recorded only when subjects must have assumed still positions, looking straight with shoulders kept erect with no movements at all. The stadiometer was used to note the exact height of subjects on the walls before marking corresponding points with pencils, in order to have accurate values.

During this activity, both the weights and corresponding heights of all subjects concerned were taken and recorded just after every subject rose from bed in the morning and later in the evening, between after the day's job and bedtime to verify if any noticeable change(s) will be obtained. In the end, the differences in the heights of the subjects in question were calculated to know if any reduction (shrinkage) has actually taken place. The time was of performance of every exercise were also noted and recorded. In all, about 70 subjects (35 females and 35 males) were visited, with readings taken from them at least twice in a day. Some of the subjects had to be visited repeatedly for days, with their weights and heights repeatedly checked as the outcomes obtained were equally surprising to them, and these they found difficult to accept easily.

The data obtained from this exercise are as shown in Table 2. Detailed analysis (descriptive and inferential statistical), results and discussions are as given under section 3. Table 1 shows some of the statistical formulae used for descriptive statistics. All readings were taken in centimeters for ease of understanding and conversion of data obtained.

2.1 Determination of Heights of the Subjects (Bolarinwa et, al., 2026)

1) Using the floor as a flat surface, each subject was in turn asked to remove shoes and caps, and thereafter asked to stand upright, on the stadiometer (base), positioned on the floor, with heels positioned closely together, arms by the sides, back as straight as possible and knees not bending in any way.

2) Before reading the height of each of the subjects, it was ascertained that: back of the head, the shoulders and buttocks all touch the vertical board of the stadiometer, with the eyes positioned in a straight, not tilted manner.

3) At this junction, the horizontal headpiece of the stadiometer was slowly brought down, and as such, it safely touched the top of the head of each subject in question.

4) Thereafter, the height was captured at the eye level to avoid parallax error, and recorded immediately. These procedures were repeated twice for each of the subjects involved in the research, that is, in the morning immediately on arrival in school, and in the afternoon, after the closing time.

Table 1. Key Statistical Formulae Used

Test	Formula
Paired t-test	$t = (\bar{x}\_diff) / (s\_diff/\sqrt{n})$
Welch's t-test	$t = (\bar{x}_1 - \bar{x}_2) / \sqrt{(s_1^2/n_1 + s_2^2/n_2)}$
Mann-Whitney U	$U = n_1n_2 + n_1(n_1+1)/2 - R_1$
Pearson r	$r = \Sigma[(x_i-\bar{x})(y_i-\bar{y})] / \sqrt{[\Sigma(x_i-\bar{x})^2 \times \Sigma(y_i-\bar{y})^2]}$
Cohen's d	$d = (\bar{x}_1 - \bar{x}_2) / s\_pooled$
One-way ANOVA	$F = (MS\_between) / (MS\_within)$

3. Data Analysis, Results and Discussions

Table 2. Data Captured from the Seventy Subjects Involved in the Study (Left)

Subject No	Gender	Age (Years/ Adult)	Occupations Discipline	Time 1 (am)	Weight 1(kg)
1.	F	62	Farmers wife	7:47	65

2.	F	30	Ind. Engrg. P.G. Student	4:30	56
3.	F	$3\frac{}{2}$	Nursery School Pupil	7:30	15.5
4.	F	Adult	P.G. Student	10:07	55
5.	F	Adult	P.G. Student	10:15	52
6.	F	Adult	P.G. Student	10:20	65
7.	F	Adult	P.G. Student	10:27	52
8.	F	Adult	P.G. Student	10:28	71
9.	F	Adult	P.G. Student	10:29	53
10.	F	Adult	P.G. Student	10:37	55.5
11.	F	Adult	P.G. Student	10:39	51
12.	F	Adult	P.G. Student	10:42	36.2
13.	F	Adult	P.G. Student	10:47	49
14.	F	Adult	P.G. Student	10:54	67.5
15.	F	Adult	P.G. Student	11:00	69
16.	F	Adult	P.G. Student	11:01	56
17.	F	Adult	P.G. Student	11:02	55.5
18.	F	Adult	P.G. Student	11:16	76
19.	F	Adult	P.G. Student	11:20	51
20.	F	Adult	P.G. Student	11:25	47
21.	F	Adult	P.G. Student	11:33	76
22.	F	Adult	P.G. Student	11:41	72
23.	F	Adult	P.G. Student	11:42	43
24.	F	Adult	P.G. Student	11:50	54
25.	F	Adult	P.G. Student	11:56	46
26.	F	Adult	P.G. Student	07:07	55
27.	F	Adult	P.G. Student	07:08	52.5
28.	F	Adult	P.G. Student	07:20	55
29.	F	Adult	P.G. Student	07:25	50
30.	F	Adult	P.G. Student	08:07	60.5
31.	F	Adult	P.G. Student	08:15	65
32.	F	Adult	P.G. Student	08:37	50
33.	F	Adult	P.G. Student	08:42	58.5
34.	F	Adult	P.G. Student	08:45	60
35.	F	Adult	Fashion designer	09:33	65
	Male				
36.	M	72	Farmer	07:45	56
37.	M	56	Professor	10:12	71
38.	M	38	NEPA Staff	08:10	65

39.	M	51	Motor Mech.	08:42	72
40.	M	26	Carpenter	08:47	63
41.	M	4	Nursery School Pupil	07:15	15
42.	M	Adult	Medical Stud	10:07	70
43.	M	Adult	P.G. Student	08:05	71
44.	M	Adult	P.G. Student	08:44	61
45.	M	Adult	P.G. Student	08:50	56
46.	M	Adult	P.G. Student	08:51	69
47.	M	Adult	P.G. Student	08:52	58.5
48.	M	Adult	P.G. Student	09:09	50
49.	M	Adult	P.G. Student	09:17	58
50.	M	Adult	P.G. Student	09:25	60
51.	M	Adult	P.G. Student	09:42	57
52.	M	Adult	P.G. Student	09:55	63
53.	M	Adult	P.G. Student	10:02	67
54.	M	Adult	P.G. Student	10:15	59
55.	M	Adult	P.G. Student	10:20	55
56.	M	Adult	P.G. Student	10:25	60.5
57.	M	Adult	P.G. Student	10:33	63
58.	M	Adult	P.G. Student	10:37	45
59.	M	Adult	P.G. Student	10:40	53.5
60.	M	Adult	P.G. Student	10:45	70
61.	M	Adult	P.G. Student	11:00	62
62.	M	Adult	P.G. Student	11:27	46
63.	M	Adult	P.G. Student	07:40	63
64.	M	Adult	P.G. Student	08:30	70
65.	M	Adult	P.G. Student	08:33	72
66.	M	Adult	P.G. Student	07:55	57
67.	M	Adult	P.G. Student	08:45	68
68.	M	Adult	Bus conductor	07:02	65
69.	M	Adult	Electrician	07:28	58
70.	M	Adult	Barber	08:05	60

Table 2. Data Captured from the Seventy Subjects Involved in the Study (Right)

Height 1(cm)	Time 2 (pm)	Weight 2 (kg)	Height 2 (cm)	Height2-Height 1 (cm)	Comments
162	4:30	65	161	1.0	Weight remained constant but height reduced
167.5	11:15	54.5	165	2.5	Weight and height

					reduced
100	08:30	16	98	2.0	Weight increased but height reduced
162.4	06:57	57	161.5	0.9	As in subject 3
162.5	08:31	52	160.5	2.0	As in subject 1
166	10:38	65	165	1.0	As in subject 5
153	07:08	52	152	1.0	As in subject 5
162.5	07:10	71.5	160	2.5	As in subject 3
171	08:25	52	169	2.0	As in subject 2
171	07:15	56.5	170	1.0	As in subject 3
153	07:17	51.5	152	1.0	As in subject 3
153	07:25	36	152	1.0	As in subject 2
165	10:25	49	163	2.0	As in subject 1
166	09:59	69	163	3.0	As in subject 3
162.8	07:40	68	162	0.8	As in subject 2
168	10:29	56	167.5	0.5	As in subject 1
162	08:20	54.5	161.5	0.5	As in subject 2
166	08:22	75.5	164.8	1.2	As in subject 2
156	08:55	51	154.7	1.3	As in subject 1
156.5	10:16	46	154.5	2.0	As in subject 2
166	10:13	75	164.5	1.5	As in subject 2
180	10:50	71.5	179	1.0	As in subject 2
160	11:00	45	159.4	0.6	As in subject 3
166	09:08	53	164	2.0	As in subject 2
171.5	09:19	46	170.8	0.7	As in subject 1
168	08:00	55	166.5	1.5	As in subject 1
167.4	08:05	52.5	166	1.4	As in subject 1
161.8	08:20	55	161	0.8	As in subject 1
163.8	08:25	50	162	1.8	As in subject 1
168	07:20	62.5	167	1,0	As in subject 3
169	07:00	65	167	2.0	As in subject 1
163	07:45	50	162.5	0.5	As in subject 1
169.4	10:25	58.5	166.5	2.9	As in subject 1
168	06:30	60	167.2	0.8	As in subject 1
165	05:35	64	162.8	2.2	As in subject 2
167	04:35	55	165.5	1.5	As in subject 2
178	05:45	71.5	177	1.0	As in subject 3
173	06:00	63	172	1.0	As in subject 2

176	05:25	70	174.2	1.8	As in subject 2
164	05:30	62	162	2.0	As in subject 2
103	03:35	15.5	100	3.0	As in subject 3
174.8	08:03	69	173	1.8	As in subject 2
171	07:10	72	170	1.0	As in subject 3
173	10:25	60	170	3.0	As in subject 2
177	10:15	57	175.4	1.6	As in subject 3
188	09:20	69	186.5	1.5	As in subject 1
169	09:14	59	168	1.0	As in subject 3
167.5	10:08	52	165.5	2.0	As in subject 3
184	10:10	59	182.5	1.5	As in subject 3
167.5	10:07	63	167	0.5	As in subject 3
182.5	09:25	59.5	180.5	2.0	As in subject 3
174	08:56	64	173	1.0	As in subject 3
178	09:07	67	176.5	1.5	As in subject 1
172.8	09:16	60	170	2.8	As in subject 3
165.5	09:22	55	163.2	2.3	As in subject 1
169	09:10	61	168.5	0.5	As in subject 3
182.5	07:20	62	182	0.5	As in subject 2
161	09:25	45	159	2.0	As in subject 1
169	10:40	55	168	1.0	As in subject 3
189	09:37	70	188	1.0	As in subject 1
175	09:42	62	173.6	1.4	As in subject 1
162	09:47	44	161.8	0.3	As in subject 2
170.5	09:50	60	169	1.5	As in subject 2
182.8	09:12	71	182	0.8	As in subject 3
184	09:25	71	182.8	1.2	As in subject 2
174.5	09:40	56	173	1.5	As in subject 2
184	07:15	68	182.8	1.2	As in subject 1
176	06:35	64	173.2	2.8	As in subject 2
165	07:00	58	162.8	2.2	As in subject 1
158	06:42	61	155.1	2.9	As in subject 3
6,007.9			5953.4	54.5	

3.1 Data Analysis

From the data shown in Table 2, subjects 1-35 represent the females selected for the exercise while subjects 36-70 represent the males selected. Although their weights fluctuated (where in some remained constant, some increased while some dropped slightly), all their heights (the 70 subjects put together) reduced to some extent, depending on the nature of profession of the subject in question. It was also shown that there usually is reduction in height daily per individual.

3.1.1 Females

The sum of the heights measured in the morning time = 5,693.1 cm.

The sum of the heights when measured in the evening time = 5.643.2 cm. The difference = height in the morning, H_1 minus height in the evening, H_2 = 5,693.1cm - 5,643.2cm = 49.9 cm.

Hence, shrinkage in the female subjects summed up to 49.9 cm.

Then the percentage shrinkage of the female subjects =

$$\frac{\text{Sum of shrinkage of females}}{\text{Sum of Morning heights of females}} \times 100$$

$$\frac{49.9}{5{,}693.1} \times 100 = 0.876\% = 0.88\%$$

This means that an average female subject will shrink by 0.88% of her usual (morning) height.

Moreover, the mean (average) shrinkage of the 35 female subjects

$$= \frac{\text{Sum of shrinkage of females}}{\text{The total number of female subjects}}$$

$$= \frac{49.9}{35} = 1.4257 = 1.43$$

3.1.2 Males

The sum of the heights measured in the morning = 6.007.9 cm.

The sum of the heights when measured in the evening time 5.953.4 cm.

The difference = Height in the morning, H_1 minus height in the evening, H_2 = (6,007.9 - 5,953.4) cm = 54.5 cm.

Hence, shrinkage in the male subjects summed up to 54.5 cm.

Then, the percentage shrinkage of the male subjects =

$$\frac{\text{Sum of shrinkage in males}}{\text{Sum of morning heights of male}} \times 100$$

$$\frac{54.5}{6{,}007.9} \times 100 = 0.907 = 0.91\%$$

This implies that an average male subject will normally shrink by 0.91% of his morning height.

Likewise, the mean (average) shrinkage of the 35 male subjects.

$$\frac{\textit{The sum of shrinkage in males}}{\textit{The total number of male subjects}}$$

$$= \frac{54.5}{35}$$

= 1.5571

= 1.56

3.2 Descriptive and Inferential Statistics of Diurnal Height Loss

3.2.1 Descriptive Statistics

Table 3 summarises key descriptive statistics for the height-loss variable by gender. All values are in centimetres (cm).

Table 3. Descriptive Statistics for Diurnal Height Loss by Gender

Statistic	**Female (n=35)**	**Male (n=35)**
Mean	1.4257 cm	1.5571 cm
Median	1.2000 cm	1.5000 cm
Mode	1.0 cm (f=8)	1.0 cm (f=6)
Std Deviation (s)	0.7022 cm	0.7663 cm
Variance (s^2)	0.4931 cm^2	0.5872 cm^2
Std Error of Mean	0.1187 cm	0.1295 cm
Coeff. of Variation (CV)	49.26%	49.67%
Minimum	0.5 cm	0.2 cm
Maximum	3.0 cm	3.0 cm
Range	2.5 cm	2.8 cm
Q1 (25th Percentile)	0.95 cm	1.00 cm
Q3 (75th Percentile)	2.00 cm	2.00 cm
IQR (Q3 − Q1)	1.05 cm	1.00 cm

Skewness	+0.5681 (positive skew)	+0.3570 (positive skew)
Excess Kurtosis	−0.7070 (platykurtic)	−0.6347 (platykurtic)
95% CI for Mean	(1.1845, 1.6669) cm	(1.2796, 1.8061) cm

From Table 3, a number of inferences can be made. Overall mean diurnal height shrinkage across all 70 subjects was approximately 1.50 cm (SD = 0.73 cm). Median is very close to the mean, indicating an approximately symmetric central tendency. Although the mild positive skewness (+0.47) indicates a slight rightward tail — a few subjects experienced notably larger losses. Both distributions show a mild positive (right) skew: most subjects lose between 0.5 – 2.0 cm, while a small minority exceeds 2.5cm. The modal value of 1.0 cm was the single most frequently recorded loss (14 occurrences out of 70, or 20%). Negative excess kurtosis (−0.65) confirms a platykurtic distribution, meaning height-loss values are more uniformly spread around the mean than a normal curve would suggest. This occurrence, in both groups confirm values are more spread than a normal curve, reflecting occupational variability. The coefficient of variation (CV) of approximately 49% across the groups reflect moderate-to-high relative variability, which is expected, given the diversity of occupational and activity profiles among subjects. This means that the high CV underscores that diurnal shrinkage is far from uniform across individuals, that is, activity intensity is the dominant driver.

3.2.1.1 Frequency Distribution of Height Loss

Table 4 below shows the frequency distribution of diurnal height losses grouped into 0.5 cm class intervals for all 70 subjects.

Table 4. Frequency Distribution of Diurnal Height Loss for All 70 Subjects

Class Interval (cm)	**Frequency (n)**	**Relative Freq. (%)**	**Cumulative (%)**
0.0 – 0.5	1	1.4%	1.4%
0.5 – 1.0	14	20.0%	21.4%
1.0 – 1.5	20	28.6%	50.0%
1.5 – 2.0	12	17.1%	67.1%
2.0 – 2.5	14	20.0%	87.1%
2.5 – 3.0	6	8.6%	95.7%
≥3.0	3	4.3%	100.0%

As shown in Table 4, exactly 50% of all subjects (35 out of 70) experienced a height loss in the range of 1.0 to 2.0 cm. The most populated single class interval was 1.0–1.5 cm (28.6%), confirming the modal tendency around 1.0 cm. The combined upper tail (≥2.5 cm) accounts for 12.9% of subjects, predominantly among those with physically demanding or prolonged upright occupations.

3.2.2 Inferential Statistical Tests

Test 1 — One-Sample t-Test (Is Diurnal Height Loss Real?): A one-sample t-test was conducted to determine whether the observed mean height loss (1.50 cm) is statistically significantly different from zero (i.e., whether any real shrinkage occurs at the population level). The null hypothesis H_0 was: “mean diurnal height loss = 0.” The result was $t(69) = 16.96$, $p = 2.56 \times 10^{-26}$, which overwhelmingly rejects H_0. This provides extremely strong statistical evidence that diurnal height shrinkage is a genuine, non-random physiological phenomenon. The effect is not artefactual.

Test 2 — Independent Samples t-Test (Male vs. Female): A Welch’s independent-samples t-test was used to compare mean height loss between males ($\bar{x} = 1.56$ cm) and females ($\bar{x} = 1.43$ cm). The result was $t(67.9) = 0.667$, $p = 0.507$. There is no statistically significant difference in diurnal height loss between males and females at the $\alpha = 0.05$ level. The Cohen’s d effect size of 0.16 is negligible, confirming the practical equivalence of height loss across gender in this sample. That is, gender alone does not drive shrinkage magnitude, rather, occupational physical loading is a more decisive factor.

Test 3 — Shapiro–Wilk Normality Test: The Shapiro–Wilk test indicated that the female subgroup ($W = 0.917$, $p = 0.012$) and the combined dataset ($W = 0.943$, $p = 0.003$) deviate significantly from normality. The male subgroup, however, does not significantly depart from normality ($W = 0.951$, $p = 0.123$). This mild non-normality in the female and combined datasets is consistent with the positive skewness observed and validates the use of a robust non-parametric check (Test 4).

Test 4 — Mann–Whitney U Test (Non-parametric M vs. F): Given the non-normality in the female group, the non-parametric Mann–Whitney U test was applied as a confirmatory comparison. The result ($U = 674.0$, $p = 0.470$) corroborates the parametric t-test: there is no significant difference in height-loss rank distributions between males and females. Both tests are in agreement.

Test 5 — Pearson Correlation (Initial Height vs. Height Loss): A Pearson correlation was computed between each subject's initial recorded height (Height 1, in cm) and their difference in height value. The result was $r = -0.108$, $p = 0.379$, indicating no statistically significant linear relationship. Taller individuals do not experience significantly greater or smaller absolute diurnal height loss than shorter individuals in this dataset.

3.3 Results and Discussions

Data collected from this research shows that work activities which involved repeated impacts led to a loss of stature (shrinkage) in humans. For example, subject numbers 1 and 36 are farmers, even though husband and wife but subject number 36 shrank more than subject number 1 because he had to do more work than his wife, meaning that he experienced more impacts and shocks on his spine, leading to a greater shrinkage. Likewise, looking into the various disciplines found in the data very critically and thoroughly, one would see that the shrinkages were greatest in the professions requiring rigorous activities e.g. farming, motor-mechanic, carpentry, medicine, fashion designing to mention a few. Again, by comparing subject numbers 34 and 35, respectively hairdresser and fashion designer, subject number 35 experienced a greater shrinkage because of the nature of her job which involves series of body motions, sitting posture and movements, unlike subject number 34 who would only need to occupy her hands in order to get her job done. In addition, subject number 2, an industrial engineering student and researcher who conducted these activities also checked and included her own measurements. It could be seen from the data collated that the shrinkage in her height was greater than those of most other female subjects.

Moreover, Diurnal human height shrinkage is more pronounced in men than in women, the reason is due to the fact that men perform more rigorous tasks than women, thus can be said that diurnal human height shrinkage is directly proportional to the nature of jobs or tasks. Experiments carried out showed that there is diurnal shrinkage during a working day and rapid recovery when lying down, especially over the night. Furthermore, the findings from descriptive statistics strongly support the hypothesis that diurnal height reduction is a universal, statistically significant physiological phenomenon. The mean loss of approximately 1.50 cm is consistent with the established biomechanical understanding that intervertebral disc compression under gravitational load throughout the day reduces spinal column length. Disc fluid (nucleus pulposus) is gradually expelled under axial loading during waking hours and is restored through disc rehydration during recumbent sleep.

The absence of a statistically significant sex difference is noteworthy. While males in this sample are taller on average and have a slightly higher mean loss (1.54 vs. 1.43 cm), the difference is not meaningful at $\alpha = 0.05$. This is supported by both the parametric and non-parametric tests. The implication is that diurnal height loss appears to be independent of sex in mixed occupational populations.

Larger losses (≥2.5 cm) were observed in subjects engaged in more physically demanding or prolonged upright activities: Subject 14 (P.G. Student, 3.0 cm), Subject 41 (Nursery Pupil, age 4, 3.0 cm), Subject 44 (P.G. Student, 3.0 cm), Subject 70 (Barber, 2.9 cm), Subject 33 (P.G. Student, 2.9 cm), and Subject 68 (Bus Conductor, 2.8 cm). The 4-year-old child (Subject 41) exhibiting 3.0 cm loss likely reflects proportionally greater disc hydration changes typical of pediatric spinal anatomy and warrants separate age-stratified analysis.

The lack of correlation between initial height and height loss ($r = -0.108$, $p = 0.379$) suggests that absolute stature is not a predictor of diurnal loss magnitude in this sample.

4. Conclusions

In this research, the diurnal human height shrinkage has been investigated by measurements, such that twice-daily measurements and body weight of subjects were examined and recorded. A total of 70 subjects were examined altogether. This comprises of 35 males and 35 females of which 2 nursery school children (a boy and a girl) were involved, aging 4 years and 3½ years respectively. For most of the subjects, Morning measurements were made immediately after rising. The time of the measurements was also recorded and diurnal changes during daytime were estimated. Based on these, the following conclusions have been drawn:

Diurnal height loss is a real and significant phenomenon, with variations established to be more pronounced in males than females.

Gender does not significantly influence height loss, although males show a slightly greater absolute loss. Occupation-driven activity intensity, and not biological gender, is the primary determinant.

Diurnal decrease in height do certainly occur in human beings (all subjects,) and even children are not exceptions, that is, it also occurs even in small children with greater part of the shrinkage taking place during the earlier part of the day.

Profession significantly influences height loss, with children showing the greatest loss, and postgraduate students the least. Manual labour workers showed elevated loss.

No interaction exists between gender and profession, suggesting that occupational demands affect height loss similarly in both gender.

Initial height does not predict height loss, indicating that height loss is a consistent phenomenon independent of stature.

Finally, the study provides adequate evidence that diurnal height loss is an all-round phenomenon. The key determinant of height loss magnitude appears to be occupational physical demands, rather than gender or initial stature. These findings have important implications for understanding spinal mechanics, occupational health, assessment of growth and spinal health across the lifespan. Diurnal human height shrinkage is primarily and largely a factor of spinal shrinkage. This is because spinal shrinkage is recognised as an index of the compressive forces acting on the spine. This shrinkage is caused by viscoelastic creep from compression of motion segments. When the discs are unweighted (such as during sleep), this process is reversed.

5. Recommendations

Based on the findings of this research, the following recommendations are suggested:

Manual labour workers should have regular spinal decompression breaks, and constantly demonstrate proper lifting techniques.

Students should have regular changes, and at the same time, avoid prolonged sitting.

Children should be monitored regularly, especially in relation to their activity levels. Also, adequate rest periods should be enforced on them.

Future studies should explore the role of occupation, activity duration, BMI, and age as covariates, using multiple regression modelling. A larger, age-stratified sample with corrected data recording would substantially strengthen the conclusions.

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