Transverse fingernail curvature in adults: a quantitative evaluation and the influence of gender, age, and hand size and dominance.

Sudaxshina Murdan*

Department of Pharmaceutics, The School of Pharmacy, University of London, 29-39 Brunswick Square, London, WC1N 1AX, UK

* Corresponding author: Email: sudax.murdan@pharmacy.ac.uk
Tel: +44 207 753 5810; Fax: +44 207 753 5942

SYNOPSIS

The nail plate's convex shape in both the longitudinal and transverse directions is thought to contribute to its mechanical rigidity, and overcurvature can be a symptom of local and/or systemic disorders. While a number of methods to measure the longitudinal nail curvature have been proposed, evaluation of the transverse nail curvature has been largely limited to visual estimation of overcurved nail plates. The aim of this study was therefore to measure the transverse curvature of healthy adult fingernail plates, and thereby provide a baseline range for 'normal curved' nail plates. In addition, the influence of gender, age, hand size and hand dominance on the transverse fingernail curvature was investigated. The transverse fingernail curvature in 92 males and 90 females (aged 21-90 years) was measured using a set of radius gauges, and the nail plate curvature was expressed as the radius of a circle whose curve most closely approximated that of the nail plate. ANOVA was used to investigate the influence of digit nature on curvature, while general linear model was used to assess the influence of gender, age, and hand length, breadth and dominance on transverse nail curvature. Subsequently, the influence of hand dominance and age were further examined by paired t test and ANOVA respectively. In this paper, baseline values for the transverse nailplate curvature of the thumb, index, and middle, ring and little fingers are presented. The thumbnail is the flattest, followed jointly by the index and middle fingernails, then the ring fingernail and finally the little fingernail. Transverse nail curvature is influenced by a person's gender, age, hand dominance and hand width, but not by hand length. Thus, nails are flatter in the dominant hand, in males, in older individuals, and in those with wider hands.

Keywords: nail, curvature, transverse, measurement, finger

INTRODUCTION

Commonly referred to as the nail, the nail plate - a thin, hard yet slightly elastic, convex structure - is curved both longitudinally (in the direction of nail growth) and transversely (perpendicular to the direction of growth). This double curvature is thought to contribute to its mechanical rigidity [1]. Overcurvature is associated with local and systemic disorders. For example, nail clubbing, where the nail plates are overcurved in both longitudinal and transverse axes is a symptom of broncho-pulmonary and cardiovascular diseases, while excessive longitudinal overcurvature such that the nails are claw-like is seen in chronic crack cocaine use [2]. Overcurvature that is confined to the transverse axis can also occur, and has been observed in pincer nail, onychomatricoma [3], subungual myxoid cysts [4], median rhomboid glossitis [5] and in patients suffering from systemic sclerosis, where nail changes were suggested as potential diagnostic clues [6]. The transverse overcurvature can remain the same along the whole nail length or occur sharply at one or both of the lateral margins of the nail plate, or increase along the length of the nail becoming maximal at the distal fingertip [7].

Despite the importance of nail curvature as a symptom of local and/or systemic disorders, there is little literature on the quantification of *transverse* nail curvature, although a number of methods have been developed to quantify *longitudinal* overcurvature [8, 9]. Changes in transverse nail curvature have been largely observed visually [3-6], and to the author's knowledge, there is no data on the nail plate's 'normal' transverse curvature, although morbidity associated with transverse overcurvature is well documented [7].

Thus, the aim of the reported study was to measure the transverse curvature of healthy adult nail plates in order to provide a baseline range for 'normal' transverse curvature. The provided baseline values could, in future, be used when transverse nail curvature is considered as a diagnostic tool in disease states.

As well as providing baseline values for 'normal' transverse nail curvature, the factors which might influence the transverse nail curvature in adults were investigated. Nail transverse curvature can be expected to be different in men and women as the latter's generally smaller size would be reflected in smaller hands and nails which could influence the nail plate's curvature. Even within the genders, hand size is expected to be a factor in nail curvature. The observation that the right and left opposite fingernails rarely had the same transverse curvature led to the hypothesis that an individual's handedness and consequent pronounced use of one hand at the expense of the other could influence nail curvature. Similarly greater cumulative use of one's hands/fingers as one ages could influence nail curvature. Thus, the influence of the following factors: gender, age, handedness and hand size (hand length and width) on the transverse nail curvature was investigated using general linear model.

MATERIALS AND METHODS

Data collection

The study was approved by the ethics committee, and participants (92 male & 90 female adults, age 21-90 years old) were recruited from the School, a residential home, and family and friends. Participants were recruited at random, ensuring approximately equal numbers of males and females and in the age groups 21-39, 40-59 and 60+ years. The participants were asked for their age, height (as an indicator of size) and preferred/dominant hand, and the length and breadth of both hands was measured to the nearest mm using a self-retracting pocket tape measure at the positions shown in Fig. 1. Hand length (midpoint of tip of middle finger to distal wrist crease) and breadth (across finger knuckles) was measured on the palmar side, with the hands held straight and flat, and with the fingers together.

Nail transverse curvature was expressed as the radius of the circle whose curve most closely approximates that of the nail plate as shown in Fig. 2, and was measured using a set of stainless steel radius gauges (0.3969mm-12.7000mm from JH Grant, England & 13.4938mm-17.4625mm were built in-house). The radius gauge was placed against the surface of the nail plate, mid-way along its length (excluding the opaque free edge), as shown in Fig. 3, and the gauge whose curvature most closely matched that of the nail plate was identified. It must be noted that because nail plates are rarely part of perfect circles, the methodology is not exact, but gives a close estimate. In all cases, the curvature of the topmost part of the nailplate was recorded, as shown in Fig. 2c. For each participant, the curvature of all healthy fingernails was measured; nails that were bitten or damaged in any way were excluded from the study. To eliminate inter-operator error, all measurements were conducted by the author.

Statistical analyses

Fingernail curvature of all five digits, of the right and left hands, in dextral and sinistral participants, in males and females of different ages were available for analysis. No gross deviation from normality was observed. ANOVA was used to investigate the influence of digit nature on transverse nail curvature in males and females, with the right and left hands and right- and left- handed individuals being grouped together. General Linear model was performed separately for the five digits to investigate the influence of gender, age, and hand length, breadth and dominance on transverse nail curvature. Subsequently, the influence of hand dominance was investigated further by using paired t tests to compare the left and right hand fingernail curvatures in dextral and sinistral individuals. The influence of age was also confirmed by grouping the participants into three age groups: <40, 40-59 and 60+ years old, and comparing the nail curvatures by ANOVA. In each age group, there were approximately 30 males and 30 females. SPSS 18.0 was used to conduct all statistical analyses.

RESULTS AND DISCUSSION

Summary statistics

Summary statistics for the age, hand length and breadth for the 92 adult males and 90 adult females who participated in the study are provided in Table I. Males and females had a fairly similar age range. However, as expected, males were taller and had larger (longer and broader) hands than females. The mean hand lengths and breadths measured in this study were similar to those reported by Kember et al [10] who measured the hands of 300 female and 300 male British workers. When handedness of the participants was analysed, it was found that the sample consisted of 10 sinistral males, 8 sinistral females, 82 dextral males and 82 dextral females. The small percentage (approximately 10%) of sinistral participants, and the greater preponderance of left-handedness in males (11% in males vs 9% in females) in the sample reflects similar percentages and preponderance in the general population [11].

Transverse fingernail curvature of digits 1-5

Transverse nail curvature was expressed as the radius of a circle whose curve most closely approximated the transverse curve of the nail plate as shown in Fig. 2. Thus, flatter nail plates have larger radii of curvature compared to curved ones. The nail curvatures in digits 1-5, of the left and right hands, in dextral and sinistral males and females are shown in Table II. The latter table shows large differences in nail curvature of the five digits and between males and females. In contrast, hand side (right/left) and handedness were associated with much smaller differences in nail curvature.

Due to the small influence of hand side and handedness on nail curvature, it was decided to group these variables in order to reduce the large amount of data in Table II and establish mean nail curvatures of the different digits (Fig. 4). It can be seen that in both males and females, thumbnails are have the largest radii, i.e. are the flattest, followed jointly by the index and the middle fingernails, then the ring fingernails and finally by the little fingernails i.e. thumb > index = middle > ring > little finger. The difference in curvature was statistically significant (ANOVA, males: $p<0.01$; females: $p<0.01$). The multiple comparison Tukey test indicated that the mean curvature of the fingernails were significantly different from one another except for the index and middle fingernails which had similar curvatures ($p=0.3$ and 0.6 for males and females respectively).

The order of radius of nail curvatures: thumb > index = middle > ring > little finger could reflect the size of the fingers at the distal phalanx. While the latter was not measured in this study, an indication of the distal finger size is provided by the hands' distal interphalangeal joint breadths shown in Table III (calculated from [10]). Bearing in mind that the data are from two different studies, the order of nail curvature (thumb > index = middle > ring > little finger) seems to reflect that of the distal interphalangeal joint breadth.

Influence of gender, age, hand size and hand dominance on transverse fingernail curvature

As mentioned above, gender, hand side and handedness appear to influence nail curvature (Table II). Hand side and handedness can be more effectively combined into one variable – hand dominance. Preliminary investigations also showed nail curvature to correlate with age, hand length and breadth. Subsequently, General Linear Model was performed separately for the five fingernails to investigate the influence of gender, age, hand length, breadth and dominance on transverse nail curvature. As gender was shown to have a large influence on nail curvature (Fig. 4, Table II), hierarchical multiple regression was performed, to control for the influence of gender.

The general linear models for the five digits nail curvatures showed a highly significant influence of gender ($p<0.05$), which explained between 26% and 33% of the total variance. Males have flatter fingernails. After controlling for gender, age, hand breadth and hand dominance explained a further 10% to 18% of the total variance, and were also significant factors ($p<0.05$). The nails of the dominant hand are flatter, and older persons and those with wider hands have flatter nails. In contrast, hand length was not significantly associated with nail curvature ($p>0.2$).

The observed influence of gender i.e. males having flatter nails than females, reflects the males' larger size (Table I). Larger adults generally have larger hands and thicker fingers whose fingernails would be flatter, in an analogous manner to the flatter nail in the wider thumbnail compared to the other fingernails as discussed above. Similarly, the influence of hand breadth could be explained. Wider hands are expected to have thicker fingers, whose fingernails would be flatter.

The influence of hand dominance on nail curvatures was intriguing and was investigated further by examining dextral and sinistral individuals separately. It can be seen from Table II that the dominant fingernail was *always* flatter (i.e. had a greater radius of curvature) than the non-dominant one in dextral individuals, but not in sinistral ones. Statistically, the difference between the dominant and non-dominant nail curvature was significant in dextral individuals (paired t-test, $p <0.01$), but not in sinistral ones (paired t-test, $p>0.01$). While the much larger number of dextral compared to sinistral participants (164 versus 18) is expected to make even small differences statistically significant, the slightly greater and consistent difference in dominant/non-dominant nail curvature in dextral individuals compared to sinistral ones can be seen in Table II.

The influence of hand dominance on nail curvatures suggests that a greater usage of a particular hand/fingers leads to flatter nails. While speculative, this could explain the difference between dextral and sinistral individuals. It is known that a large proportion of dextral individuals are strongly right-handed i.e. they carry out more tasks with their preferred hand, while sinistral subjects are less extreme in their use of preferred hand, due to the fact that sinistral subjects live in a 'right-handed world where most artefacts are built for right-handers' [11] . The pronounced usage of the right hand in dextral subjects and less pronounced use of the left hand in sinistral subjects could thus lead to a greater difference in nail curvature of the two hands in dextral subjects, and a smaller difference in sinistral ones. The speculation that greater usage of a particular finger leads to flatter nails could be tested in a few years' time when current children and teenagers who have been using their thumbs (as opposed to their index finger) to a far greater extent than their predecessors, for example for mobile phone text messaging and using game consoles, reach adulthood.

The influence of age – older persons having flatter nails – was surprising, but can be clearly seen in Table IV where the participants were divided into three age groups as follows: 21-39, 40-59 and 60+ years old. The radius of nail curvature increased with age despite similar hand lengths and breadths. Though small, the differences were statistically significant (One-way between-groups ANOVA, $p<0.01$ for all the digits in both genders). Ageing is known to influence the nail plate, which grows at a slower rate [12] and becomes thicker, less smooth and more longitudinally ridged [13]. In addition, nail cells are larger [14] and the nail plate's thermal diffusivity, trans-onycheal water loss and composition, of for example, lipids, calcium and magnesium change upon aging [15-20]. This study suggests that nail plates also become flatter with age, after years of use. Interestingly, this would reflect the flatter nail plates in the (more used) dominant hands in the preceding section.

CONCLUSIONS

This study provides baseline values for the transverse curvature of healthy fingernail plates in adults. To the author's knowledge, this is the first systematic measurement of the nail plate's transverse curvature. The latter was measured using a set of radius gauges, and was expressed as the radius of a circle whose curve most closely approximates that of the nail plate. As expected, the different digits have different fingernail curvatures. The thumbnail is the flattest, followed jointly by the index and middle fingernails, the ring fingernail and finally the little fingernail. Nail plates are flatter in the dominant hand, in males, in older individuals, and in those with wider hands.

REFERENCES

1. Forslind, B. Biophysical studies of the normal nail. . Acta Derm. Venereol. 50, 161-168 (1970).
2. Payne-James, J.J., Munro, M.H.W., Rowland Payne, C.M.E. Pseudosclerodermatous triad of perniosis, pulp atrophy and 'parrot-beaked' clawing of the nails--a newly recognized syndrome of chronic crack cocaine use. J Forensic Leg Med. 14, 65-71 (2007).
3. Baran, R., Kint, A. Onychomatrixoma - filamentous tufted tumor in the matrix of a funnel-shaped nail - a new entity (report of 3 cases). Br. J. Dermatol. 126, 510-515 (1992).
4. de Berker, D., Goettman, S., Baran, R. Subungual myxoid cysts: Clinical manifestations and response to therapy. J. Am. Acad. Dermatol. 46, 394-398 (2002).
5. Karen, J.K., Schaffer, J.V. Pachyonychia congenita associated with median rhomboid glossitis. Dermatol. Online J. 13, 21 (2007).
6. Tunc, S.E., Ertam, I., Pirildar, T., Turk, T., Ozturk, M., Doganavsargil, E. Nail changes in connective tissue diseases: Do nail changes provide clues for the diagnosis? J. Eur. Acad. Dermatol. Venereol. 21, 497-503 (2007).
7. Baran, R., Dawber, R.P.R., Richert, B. Physical signs. In: Baran and dawber's diseases of the nails and their management, edited by R., B., RPR., D., D., D.B., E., H., A., T. pp. 48-103. Blackwell Oxford:(2001).

8. Carroll, D.G. Curvature of the nails, clubbing of the fingers and hypertrophic pulmonary osteoarthropathy. Trans. Am. Clin. Climatol. Assoc. 83, 198-208 (1972).
9. Myers, K.A., Farquhar, D.R.E. Clinical description of nail clubbing - reply. Jama-Journal of the American Medical Association. 286, 1972-1973 (2001).
10. Kember, P., Ainsworth, L., Brightman, P. A hand anthropometric survey of british workers.: Cranfield Institute of Technology (1981).
11. McManus, C. Right hand, left hand: The origins of asymmetry in brains, bodies, atoms and cultures. BCA, London (2002).
12. Hamilton, J.B., Terada, H., Mestler, G.E. Studies of growth throughout the lifespan in japanese: Growth and size of nails and their relationship to age, sex, heredity, and other factors. J. Gerontol. 10, 401-415 (1955).
13. Tosti, A., Piraccini, B.M. Biology of nails and nail disorders. In: Fitzpatrick's dermatology in general medicine edited by Wolff, K., Goldsmith, L.A., Katz, S.I., Gilchrest, B.A., Paller, A.S., Leffell, D.J. pp. 778-794. McGrawHill,New York:(2007).
14. Germann, H., Barran, W., Plewig, G. Morphology of corneocytes from human nail plates J. Invest. Dermatol. 74, 115-118 (1980).
15. Brosche, T., Dressler, S., Platt, D. Age-associated changes in integral cholesterol and cholesterol sulfate concentrations in human scalp hair and finger nail clippings. Aging-Clinical and Experimental Research. 13, 131-138 (2001).

16. Helmdach, M., Thielitz, A., Ropke, E.M., Gollnick, H. Age and sex variation in lipid composition of human fingernail plates. Skin Pharmacol. Appl. Skin Physiol. 13, 111-119 (2000).
17. Ohgitani, S., Fujita, T., Fujii, Y., Hayashi, C., Nishio, H. Nail calcium and magnesium content in relation to age and bone mineral density. J. Bone Miner. Metab. 23, 318-322 (2005).
18. Ohgitani, S., Fujita, T., Fujii, Y., Hayashi, C., Nishio, H. Nail calcium content in relation to age and bone mineral density. Clin Calcium. 18, 959-966 (2008).
19. Dias, D.T., Steimacher, A., Bento, A.C., Neto, A.M., Baesso, M.L. Thermal characterization in vitro of human nail: Photoacoustic study of the aging process. Photochem. Photobiol. 83, 1144-1148 (2007).
20. Jemec, G.B.E., Agner, T., Serup, J. Transonychial water-loss - relation to sex, age and nail-plate thickness Br. J. Dermatol. 121, 443-446 (1989).

Table I: Summary statistics for age, height, hand length and hand breadth of participants. N=90-92.

	Mean ± SD (minimum-maximum)	
	Males	**Females**
Age (years)	50 ± 16 (22-88)	49 ± 18 (21-90)
Right hand length (cm)	19.3 ± 0.9 (17.3-21.6)	17.5 ± 1.0 (14.6-20.1)
Left hand length (cm)	19.4 ± 0.9 (17.4-22.0)	17.6 ± 1.0 (14.6-20.4)
Right hand breadth (cm)	8.5 ± 0.4 (7.5-9.5)	7.6 ± 0.4 (6.6-8.5)
Left hand breadth (cm)	8.6 ± 0.4 (7.8-9.8)	7.7 ± 0.5 (6.6-8.8)
Height (m, as an indication of size)	1.8 ± 0.1 (1.6-2.0)	1.6 ± 0.1 (1.5-1.8)

Table II: Transverse curvature of the different fingernails in male (10 sinistral and 82 dextral) and female (8 sinistral and 82 dextral) participants. The mean and standard deviations are shown. N was between 8 and 10 for sinistral participants and between 79 and 82 for dextral ones. The variable number reflects hand dominance and the fact that, as explained in the text, not all ten fingernails could be measured in all participants.

Digit	**Handedness of volunteers**	**Hand**	**Radius of nail curvature (mm) (mean ± SD)**	
			male	**female**
Thumb	Dextral	Right	13.2 ± 2.0	10.4 ± 1.8
		Left	12.8 ± 2.1	9.8 ± 1.8
	Sinistral	Right	12.4 ± 1.2	11.5 ± 1.8
		Left	12.6 ± 1.3	11.5 ± 1.8
Index	Dextral	Right	11.2 ± 2.1	8.4 ± 1.9
		Left	10.4 ± 2.4	7.8 ± 1.6
	Sinistral	Right	10.4 ± 1.8	9.3 ± 2.3
		Left	10.6 ± 1.6	9.6 ± 2.7
Middle	Dextral	Right	10.7 ± 2.2	8.0 ± 1.7
		Left	10.1 ± 2.0	7.7 ± 1.4
	Sinistral	Right	10.3 ± 2.2	8.6 ± 1.3
		Left	10.4 ± 2.4	9.4 ± 2.7
Ring	Dextral	Right	8.7 ± 2.1	6.5 ± 1.5
		Left	8.1 ± 1.5	6.3 ± 1.2
	Sinistral	Right	8.2 ± 1.3	7.2 ± 1.4
		Left	8.2 ± 1.4	7.0 ± 1.9
Little	Dextral	Right	6.8 ± 1.2	5.3 ± 0.9
		Left	6.6 ± 1.2	5.1 ± 1.0
	Sinistral	Right	6.4 ± 1.2	5.6 ± 0.8
		Left	7.2 ± 1.6	5.7 ± 0.8

Table III: Mean distal interphalangeal joint breadth in 300 males and 300 females. Means have been calculated from Kember et al's (1981) separate means of left and right hands. Kember et al's SD varied from 0.09-0.19 cm.

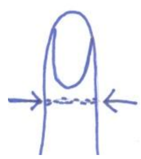
	digit	**Male**	**Female**
Mean breadth (cm) 	thumb	2.29	1.89
	index	1.88	1.58
	middle	1.86	1.56
	ring	1.71	1.42
	little	1.55	1.26

Table IV: Radius of nail curvature (mm) of digits 1-5 in the different age groups. Mean and SD are shown; right and left hands have been grouped. N=56-62.

gender	**measurement**	**digit**	**Age group (years)**		
			21-39	**40-59**	**60+**
males	Radius of nail curvature (mm)	thumb	12.2 ± 2.0	13.3 ± 2.2	13.3 ± 1.7
		index	9.9 ± 2.1	10.7 ± 1.9	11.6 ± 2.5
		middle	9.5 ± 1.9	10.5 ± 1.8	11.2 ± 2.3
		ring	7.5 ± 1.4	8.4 ± 1.2	9.3 ± 2.2
		little	6.1 ± 1.1	6.7 ± 0.9	7.3 ± 1.4
	Hand length/breadth (cm)	Hand length	19.2 ± 1.0	19.4 ± 0.9	19.4 ± 1.0
		Hand breadth	8.5 ± 0.5	8.6 ± 0.4	8.6 ± 0.4
females	Radius of nail curvature (mm)	thumb	9.7 ± 1.4	10.1 ± 1.6	11.0 ± 2.2
		index	7.3 ± 1.2	8.1 ± 1.8	9.3 ± 2.1
		middle	7.3 ± 1.1	7.9 ± 1.4	8.8 ± 2.0
		ring	6.0 ± 0.9	6.3 ± 1.3	7.2 ± 1.6
		little	4.9 ± 0.8	5.2 ± 1.1	5.6 ± 0.8
	Hand length/breadth (cm)	Hand length	17.4 ± 1.1	17.6 ± 1.0	17.6 ± 0.8
		Hand breadth	7.6 ± 0.5	7.6 ± 0.4	7.8 ± 0.4

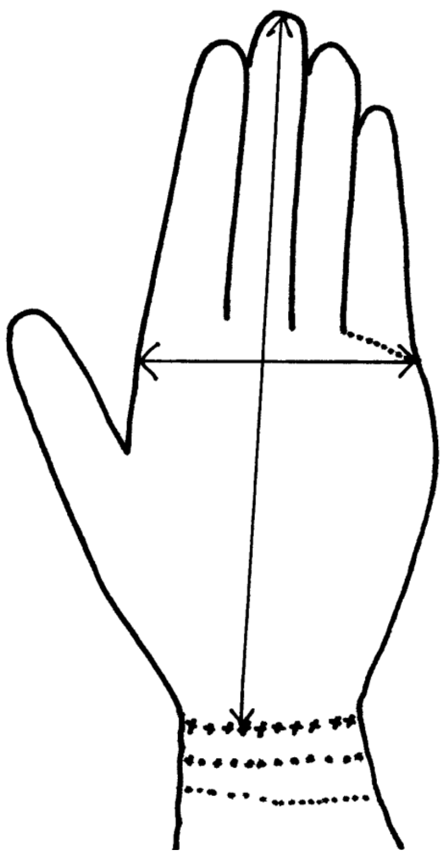


Figure 1: Shows the positions at which hand length and hand breadth were measured on the palmar side.

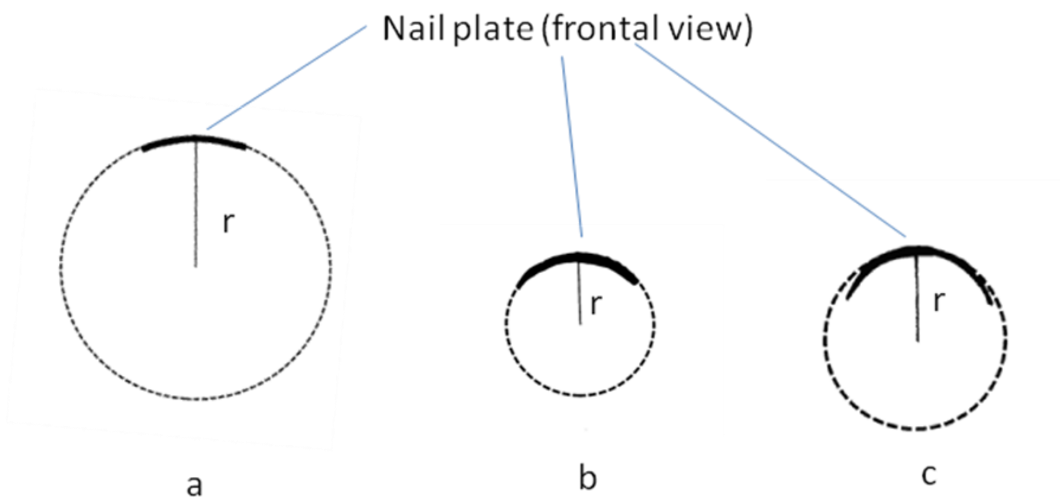


Figure 2: Transverse nail curvature was expressed as the radius of a circle whose curvature most closely approximates that of the nail plate. Flat nails (a) have a large radius, while curved nails (b) have smaller radii. The radius of the topmost part of the nail was recorded, as shown (c).

Figure 3: The measurement of transverse nail curvature using a radius gauge

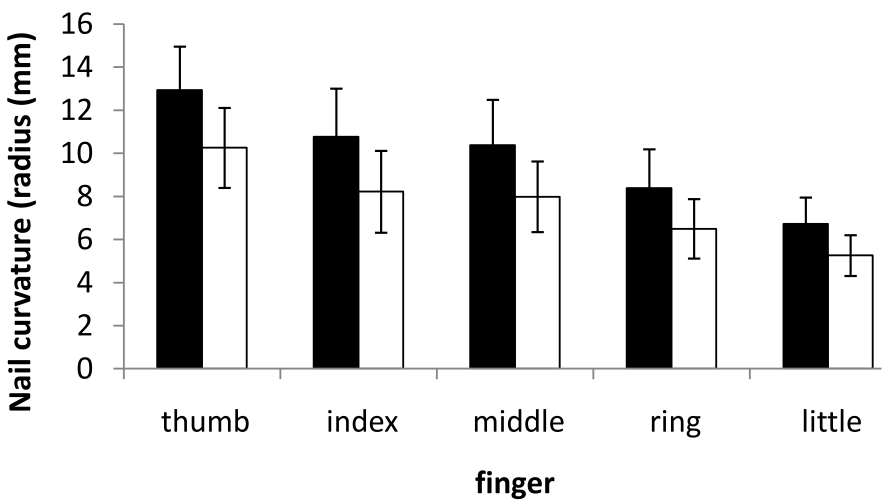


Figure 4: Transverse curvature of fingernails of digits 1-5 in males (black bars) and females (white bars). The left and right hands, and dextral and sinistral subjects have been grouped together. Means and SD are shown, N=178-183.