THE CANON OF POLYKLEITOS: A QUESTION OF EVIDENCE

It is now rather over a century since the marble statue of a youth in Naples was recognised as a copy of the Doryphoros of Polykleitos, and the first attempt made to extract from it the mathematical principles of the Polykleitan canon.[1] Periodic warnings uttered on the subject by such scholars as Gardner and Furtwängler[2] failed to deter further speculation, which culminated in Anti's monumental publication of 1921.[3] Understandably enough, this seems effectively to have checked research in the field, with only one or two exceptions,[4] for a number of years. In the past decade or so, however, the pendulum, apparently never stable for long, has swung back again: a spate of books and articles on Polykleitos and his school has appeared, including no fewer than four major attempts to recover the principles of the canon from the surviving copies of his works.[5] Again, murmurings to the contrary have passed unheeded,[6] the gulf between believers and unbelievers now, it seems, having become virtually unbridgeable. With this in mind, and considering that Polykleitan studies have undergone a quiet revolution in the last year or two through the identification of fragments of casts of the Doryphoros and an Amazon among those recently discovered at Baiae, it seems an opportune moment to try to restate a few principles, basic but all too often ignored, and to indicate a number of directions that further research might take.

I. The Monumental Evidence

In working from the Roman copies the would-be reconstructor of the canon faces two insuperable difficulties: with the partial exception of the arm (see passage 4, below) he does not know the exact locations of the points selected by Polykleitos for the application of the canon to the human body, and the copies themselves vary sufficiently to render mendacious any results he might succeed in extracting from his material. Considering the first, Greek athletic and medical terminology might perhaps provide some clues as to what divisions of the human frame were considered important, at least from the fourth century on, but as far as I know no work has been done towards investigating this line of inquiry.[7] Even were some kind of a pattern to appear, to

[1] K. Friederichs, 'Der Doriphoros des Polyklet' in *23 Berl. Winckelmannsprogramm* (1863); O. Benndorf, 'Der Kanon des Polyklet' in *Zeits. Oest. Gymn.* xx (1869) 260–8.

[2] E. Gardner, *A Handbook of Greek Sculpture* (1915) 360; A. Furtwängler, *Masterpieces of Greek Sculpture* (1894) 226.

[3] C. Anti, 'Monumenti policletei' in *MAL* xxvi (1920–1) 501–792.

[4] E.g. S. Ferri, 'Nuovi contributi esegeteci al 'Canone' della scultura greca' *RIA* vii (1940) 117–52.

[5] D. E. Gordon and D. E. L. Cunningham, 'Polykleitos' "Diadoumenos"—Measurement and Animation' in *Art Quarterly* (summer 1962) 128–42; P. E. Arias, *Policleto* (1964); F. Hiller, 'Zum Kanon Polyklets' in *Marburger Winckelmannsprogramm* (1965) 1–15; *EAA* (1966) s.v. 'Canone', 'Embater', 'Policleto', 'Quadratus' (L. Beschi, S. Ferri); *Encyclopedia of World Art* (1966) s.v. 'Polykleitos' (E. Berger); E. Lorenzen, *Technological Studies in Ancient Metrology* (1966), *passim*, but esp. 48–9 and 97–100; A. Linfert, *Von Polyklet zu Lysipp* (1966); D. Arnold 'Die Polykletnachfolge', *JdI Ergänzungsheft* xxv (1969); C. Vermeule, *Polykleitos* (Boston 1969); T. Lorenz, *Polyklet* (1972); H. von Steuben, *Der Kanon des Polyklet* (1973); J. J. Pollitt, *The Ancient View of Greek Art* (1974) 14–22 and s.v. '*ἀριθμός*', '*συμμετρία*' and '*τετράγωνος*-quadratus'; R. Tobin, 'The Canon of Polykleitos', *AJA* lxxix (1975) 307–22; H. Philipp, 'Zum Kanon des Polykleitos' in *Wandlungen: E. Homann-Wedeking gewidmet* (Waldsassen 1975) 132–40; W. Schindler, 'Der Doryphoros des Polyklet. Gesellschaftliche Funktion und Bedeutung' in *Der Mensch als Mass der Dinge* (ed. R. Müller, Berlin 1976) 219–37.

[6] E.g. those of G. M. A. Richter, *The Sculpture and Sculptors of the Greeks*[4] (1970) 190 and A. W. Lawrence, *Greek and Roman Sculpture* (1972) 153.

[7] As a basis for study, I would suggest the following treatises from the Hippocratic corpus: *De articulis, De fracturis, De locis in homine*, plus the pseudo-Aristotelian *Physiognomonica* and two later books, Philostratus' *De Gymnastica* and Rufus' *Onomasticon*. Recent literature: E. Benveniste, 'Termes greco-latins d'anatomie' in *RPh* xxxix (1965) 7–13; R. Herrlinger, 'Die Rolle von Idee und Technik in der Geschichte der Anatomie' in *AGM* xlvi (1962) 1–16; J. Jüthner, *Körperkultur im Altertum* (1928); F. Kudlien, 'Antike Anatomie und menschlicher Leichnam', *Hermes* xcvii (1969) 74–94; and L. Premuda, *Storia dell' iconografia anatomica* (1957). I thank Professor I. M. Lonie for his assistance in an unfamiliar field.

apply it to sculpture would be difficult, for rarely do the undulant surfaces of a sculptured nude give much in the way of sharp and readily definable transitions.[8]

The second problem has its roots in the processes employed by the Romans in copying Greek statues. Although the pointing machine was in general use at least from the end of the first century B.C. for replicas in marble, the Roman copyists appear to have used but few points compared with their more recent counterparts;[9] also there is, again, no guarantee that these coincided with those chosen for his canon by the sculptor of the original statue. I have no measurements on hand for the marble copies of the Doryphoros, though a glance through Arias' and von Steuben's magnificent plates will show the degree of variation to be expected, particularly in the heads and the detailing of the hair and features—often the very points of departure chosen for reconstructions of the canon.[10] Careful measurements of copies of the contemporary Kassel Apollo have been published by Schmidt, and may serve as a check: the variation (reckoning from the mean) can be up to $\pm 3\%$ for any given dimension, quite enough, it seems to me, to confuse the issue beyond hope of solution.[11]

Copies in bronze, like the herm by Apollonios used by von Steuben for his recent reconstruction, are another matter. Only very rarely indeed were these taken directly from casts of the original,[12] and it is clear that Apollonios's herm does not fall into this category. Instead, the sculptor first pointed off a replica in plaster from the original or a cast of it, then took piece-moulds from it in refractory clay. These were then assembled and cores of the same material suspended inside, leaving space into which the metal was poured. The result, as here, was a thick casting with obvious joins; a great deal of cold-work was required to remove the 'web' thus formed and to clean up the hair, eyes, lips and other details.[13] Copies produced in this way were at best only as accurate as the original replica, and the extensive contribution of the copyist at both the beginning and end of the work usually ensured that they fell considerably below the better of their marble counterparts in quality; they are, as a result, of considerably less use as evidence.[14]

The Baiae casts, almost unrecognised even in the most recent archaeological literature, and accorded no mention (so far as I am aware) in any of the studies of the canon cited above, have added a whole new dimension to the problem.[15] Recognisable among them are the remains of the left foot, calf, knee and thigh, both hands and the neck of the Doryphoros, and the left foot and hand and a fragment of the drapery of the Amazon (Capitoline type).[16] The style of the Doryphoros fragments is very severe and angular, and almost archaic in the way the veins and tendons are represented on the wrist and hands, and that of the Amazon soft and almost

[8] The difficulty of deciding exactly where a measuring point is to be located may be illustrated by comparing Kalkmann's, Lorenzen's and Tobin's estimates of the distance from the centre of the mouth to the chin of the Naples Doryphoros—4·975, 6·0 and 5·02 cms respectively (A. Kalkmann, 'Die Proportionen des Gesichts in der Griechischen Kunst', *50 Berl. Winckelmannsfeste* (1893) vol. liii, 36–7; Lorenzen, *op. cit.*, 48; Tobin, *op. cit.*, 315–16); a non-initiate might justifiably conclude that results obtained from data so erratically and subjectively assessed can hardly be called 'scientific' in any generally accepted sense of the term.

[9] See esp. Richter, 'How were the Roman copies of Greek portraits made?' in *MDAI (R)* lxix (1962) 52–8.

[10] E.g. by von Steuben, *op. cit.* 12–26.

[11] E. Schmidt, 'Der Kasseler Apollon und seine Repliken' in *Ant.Plastik* v (1966) 38–9; my own measurements of the two runners in the Galleria of the Palazzo dei Conservatori (H. Stuart-Jones, *The Sculptures of the Palazzo dei Conservatori* [1926] nos. 49 and 52; W. Helbig, *Führer durch die . . . Sammlungen . . . in Rom* [4th edn. by H. Spier 1966] ii no. 1518), usually considered to be copies of a work of the Polykleitan school from *c.* 400–*c.* 380, confirm this estimate. A computer-controlled multivariate analysis (standard practice in the analysis of prehistoric artifacts) of every possible measurement from every known copy would be the only truly scientific approach, but even here there is, again, no guarantee that the points selected would coincide with those chosen by the sculptor of the original.

[12] *Cf.* G. Lippold, in *EAA* s.v. 'Copie' 806; the sole properly attested case is the torso in Florence, Richter, *Kouroi*³ (1970) no. 195 and figs. 585–8.

[13] On the process see Lippold, *loc. cit.*; K. von Kluge and K. Lehmann-Hartleben, *Die antiken Grossbronzen* (1927) i 88–9 (with direct reference to Apollonios's herm).

[14] Comparing the measurements of the head of the Naples statue published by Kalkmann, *loc. cit.* (n. 8) with those of Apollonios's herm given by von Steuben (*op. cit.*, 12–21) one finds about a 1–2% discrepancy in most cases; for further comparison with n. 8, von Steuben's estimate from the centre of the mouth to the chin of the bronze would be about 4·72 cm (*ibid.*, 19 and fig. 1: $dB + [\frac{cd}{2}]$).

[15] W.-H. Schuchhardt, 'Antike Abgüsse antiker Statuen' in *AA* (1974) 631–5; I have examined casts of the fragments in Munich, and thank Dr R. Wünsche and Dr H. Sichtermann for pointing out the relevant pieces.

[16] On the Amazon, see D. von Bothmer, *Amazons in Greek Art* (1957) 216–22 and pl. 89; von Steuben, *op. cit.* 56–68 and pls. 40–3, 45, 48–51 (with bibliography). *Cf.* however M. Weber, 'Die Amazonen von Ephesos' in *JdI* xci (1976), 28–96, esp. 86 ff. (Sciarra type by Polykleitos).

voluptuous, with exquisite detailing of the drapery. The marble copies are a world away, which suggests to me both that the casts *are* taken from the originals (a view already argued on other grounds by Richter in her publication of the cast of the face of the Aristogeiton) and that the copies of the Doryphoros in particular are all of them 'modernised' to a greater or lesser degree, to suit the less austere tastes of Roman patrons.[17] Yet, here again, attempts to reconstruct the canon from these precious remains will run into difficulties hardly less severe than those mentioned above: we still have no idea of the points used as its basis, and the casts themselves are sadly fragmentary.

Still, as Graham has reminded us, and as a whole series of studies on the present subject has proved, 'The modern Procrustes can reduce even the most intractable set of data to almost any system he fancies.'[18] True enough as this is of sculpture and architecture in general, with Polykleitos he clearly faces an even harder task than usual. The monumental evidence thus being practically useless for his purposes, is the ancient literature on the subject any more promising?

II. The Literary Evidence

Two fragments of Polykleitos's book survive, plus two summaries of some of its principles in Galen and possibly another in Plutarch; all other statements in the sources are later value judgements as to the effect of the Polykleitan style on the observer. It is worth quoting these five passages in full, since this distinction is often overlooked, and in their contexts, since these are important:

1. *πολλοὶ γοῦν ἐνστησάμενοι κατασκευὴν ἰσομεγεθῶν καὶ χρησάμενοι τῇ τε αὐτῇ συντάξει καὶ ξύλοις ὁμοίοις καὶ σιδήρῳ τῷ ἴσῳ οὐδὲ τὸν σταθμὸν αὐτὸν μεταβάλλοντες, τὰ μὲν μακροβολοῦντα καὶ εὔτονα ταῖς πληγαῖς ἐποίησαν, τὰ δὲ καθυστεροῦντα τῶν εἰρημένων· καὶ ἐρωτηθέντες διὰ τί τοῦτο συνέβη, τὴν αἰτίαν οὐκ εἶχον εἰπεῖν. ὥστε τὴν ὑπὸ Πολυκλείτου τοῦ ἀνδριαντοποιοῦ ῥηθεῖσαν φωνὴν οἰκεῖαν εἶναι τῷ μέλλοντι λέγεσθαι· τὸ γὰρ εὖ παρὰ μικρὸν διὰ πολλῶν ἀριθμῶν ἔφη γίνεσθαι. τὸν αὐτὸν δὴ τρόπον καὶ ἐπὶ ταύτης τῆς τέχνης συμβαίνει διὰ πολλῶν συντελουμένων τῶν ἔργων μικρὰν ἐν τοῖς κατὰ μέρος παρέκβασιν ποιησαμένους μέγα συγκεφαλαιοῦν ἐπὶ πέρας ἁμάρτημα.*[19]

Philo Mech. iv 1.49, 20

2a. *οἵ γε προκόπτοντες οἷς ἤδη καθάπερ ἱεροῦ τινος οἰκοδομήματος καὶ βασιλικοῦ τοῦ βίου 'κεκρότηται χρυσέα κρηπίς', οὐδὲν εἰκῇ προσίενται τῶν γιγνομένων, ἀλλ' οἷον ἀπὸ στάθμης τοῦ λόγου προσάγουσι καὶ προσαρμόττουσιν ἕκαστον, ὑπέρευ τὸν Πολύκλειτον οἰόμενοι λέγειν ὡς ἔστι χαλεπώτατον αὐτῶν τὸ ἔργον, οἷς ἂν εἰς ὄνυχα ὁ πηλὸς ἀφίκηται.*[20]

Plut. *Mor.* 86a

[17] On the Baiae Aristogeiton see *AJA* lxxiv (1970) 296–7 and pl. 74; the best studies concerning 'modernised' Roman copies are R. Wünsche's short article 'Der Jüngling vom Magdalensberg: Studie zur römischen Idealplastik' in *Festschr. L. Düssler* (Vienna 1972) 45–80, esp. 62 ff., which discusses the principles, and P. Zanker, *Klassizistische Statuen* (Mainz 1974), which explores the practice.

[18] Quoted in O. Broneer, *Isthmia i: The Temple of Poseidon* (1971) 181; this whole Appendix (i.e. pp. 174–81) should be prescribed reading for those who would venture into the perils of metrology. Thus, not only Carpenter's but *both* Lorenzen's 'Archaic' and 'Classical' canons fit the 'Blond Boy', Akr. 689, quite well—given, of course, the latitude usually and conveniently allowed in the selection of measuring-points and rounding-off of measurements (cf. *Greek Sculpture* [1960] 93; *Technological Studies* 46–7).

[19] 'Many, though, have begun the construction of weapons of the same size, have made use of the same system of rules, the same types of wood and the same amounts of iron, and have kept to the same weight; yet of these some have made machines that throw their missiles far and with great force, while those made by others have lagged behind their specifications. When asked why this happened, the latter have not been able to give an answer. So, it is appropriate to warn the prospective engineer of the saying of Polykleitos the sculptor: beauty, he said, comes about *para mikron* through many numbers. And in the same way, as far as concerns our science, it happens that in many of the items that go to make up the machine a tiny deviation is made each time, resulting in a large cumulative error.'

[20] 'But those who are making progress, of whose life already, as of some temple or regal palace "the golden foundation has been wrought", do not indiscriminately accept for it a single action, but using reason to guide them they bring each one into place and fit it where it belongs. And we may well conceive that Polykleitos had this in mind when he said that the task is hardest for those whose clay has come to the fingernail.' (Trans. F. C. Babbitt, Loeb, slightly adapted.)

or

2b. *καὶ γὰρ αἱ τέχναι πρῶτον ἀτύπωτα καὶ ἄμορφα πλάττουσιν, εἶθ' ὕστερον ἕκαστα τοῖς εἴδεσι διαρθροῦσιν· ᾗ Πολύκλειτος ὁ πλάστης εἶπεν χαλεπώτατον εἶναι τὸ ἔργον, ὅταν ἐν ὄνυχι ὁ πηλὸς γένηται.*[21]

ibid. 636b–c

3. *ἡ μὲν δὴ μέθοδος αὕτη· τὸ δ' ἀσκῆσαι γνωρίζειν ἑτοίμως ἐν ἑκάστῳ γένει ζῴου καὶ κατὰ τὰ σύμπαντα τὸ μέσον οὐ τοῦ τυχόντος ἀνδρός, ἀλλ' ἐσχάτως ἐστι φιλοπόνου καὶ διὰ μακρᾶς ἐμπειρίας καὶ πολλῆς γνώσεως ἁπάντων τῶν κατὰ μέρος ἐξευρίσκειν δυναμένου τὸ μέσον. οὕτω γοῦν καὶ πλάσται καὶ γραφεῖς ἀνδριαντοποιοί τε καὶ ὅλως ἀγαλματοποιοὶ τὰ κάλλιστα γράφουσι καὶ πλάττουσι καθ' ἕκαστον εἶδος, οἷον ἄνθρωπον εὐμορφότατον ἢ ἵππον ἢ βοῦν ἢ λέοντα, τὸ μέσον ἐν ἐκείνῳ τῷ γένει σκοποῦντες. καὶ πού τις ἀνδριὰς ἐπαινεῖται Πολυκλείτου Κανὼν 'των τῶν μορίων ἀκριβῆ τὴν πρὸς ἄλληλα συμμετρίαν ἔχειν ὀνόματος τοιούτου τυχών.*[22]

Galen *De Temperamentis* i 566 (Kühn)

4. *ἐδήλωσε* [Chrysippos] *γὰρ σαφῶς τοῦτο διὰ τῆς προγεγραμμένης ὀλίγον ἔμπροσθεν ῥήσεως, ἐν ᾗ τὴν μὲν ὑγίειαν τοῦ σώματος ἐν θερμοῖς καὶ ψυχροῖς καὶ ξηροῖς καὶ ὑγροῖς συμμετρίαν εἶναί φησιν, ἅπερ δὴ στοιχεῖα δηλονότι τῶν σωμάτων ἐστίν, τὸ δὲ κάλλος οὐκ ἐν τῇ τῶν στοιχείων, ἀλλὰ ἐν τῇ τῶν μορίων συμμετρίᾳ συνίστασθαι νομίζει, δακτύλου πρὸς δάκτυλον δηλονότι καὶ συμπάντων αὐτῶν πρός τε μετακάρπιον καὶ καρπὸν καὶ τούτων πρὸς πῆχυν καὶ πήχεως πρὸς βραχίονα καὶ πάντων πρὸς πάντα, καθάπερ ἐν τῷ Πολυκλείτου Κανόνι γέγραπται. πάσας γὰρ ἐκδιδάξας ἡμᾶς ἐν ἐκείνῳ τῷ συγγράμματι τὰς συμμετρίας τοῦ σώματος ὁ Πολύκλειτος. ἔργῳ τὸν λόγον ἐβεβαίωσε δημιουργήσας ἀνδριάντα κατὰ τὰ τοῦ λόγου προστάγματα καὶ καλέσας δὴ καὶ αὐτὸν τὸν ἀνδριάντα καθάπερ καὶ τὸ σύγγραμμα Κανόνα. τὸ μὲν δὴ κάλλος τοῦ σώματος ἐν τῇ τῶν μορίων συμμετρίᾳ κατὰ πάντας ἰατρούς τε καὶ φιλοσόφους ἐστίν.*[23]

id., *De placitis Hippocratis et Platonis* v 448 (Kühn)

[5] *ὡς ἐν ἔργῳ γε παντὶ τὸ μὲν καλὸν ἐκ πολλῶν οἷον ἀριθμῶν εἰς ἕνα καιρὸν ἡκόντων ὑπὸ συμμετρίας τινὸς καὶ ἁρμονίας ἐπιτελεῖται, τὸ δ' αἰσχρὸν ἐξ ἑνὸς τοῦ τυχόντος ἐλλείποντος ἢ προσόντος ἀτόπως εὐθὺς ἑτοίμην ἔχει τὴν γένεσιν, ὥσπερ ἐπ' αὐτῆς τῆς ἀκροάσεως οὐ μόνον βαρύτης ἐπισκυνίου καὶ ἀηδία προσώπου καὶ βλέμμα ῥεμβῶδες καὶ περίκλασις σώματος καὶ μηρῶν ἐπάλλαξις ἀπρεπὴς ἀλλὰ καὶ νεῦμα καὶ ψιθυρισμὸς πρὸς ἕτερον καὶ μειδίαμα χάσμαι τε ὑπνώδεις καὶ κατήφειαι καὶ πᾶν εἴ τι τούτοις ἔοικεν ὑπεύθυνόν ἐστι καὶ δεῖται πολλῆς εὐλαβείας.*[24]

Plut. *Mor.* 45c–d

[21] 'And in the arts, formless and shapeless parts are fashioned first, then afterwards all details in the figures are correctly articulated; it is for this reason that the sculptor Polykleitos said that the work is hardest, when the clay is at [or on] the finger-nail.' (Trans. P. A. Clement, Loeb, slightly adapted.)

[22] 'This, then, is the mode of inquiry: to train to be able to recognise the mean readily in each class of living thing, and indeed in all things, is not the task of any common man, but for the most industrious, who through long experience and comprehensive and detailed knowledge of everything are alone able to discover the mean. Thus do modellers, sculptors, painters, and, indeed, image-makers in general, paint or model the most beautiful likenesses in each case (that is, the most beautiful man, horse, cow or lion), by observing the mean in that case. And one might comment upon a certain statue, the one called the 'Canon' of Polykleitos, since it received this name from its having a precise commensurability of all the parts to one another.'

[23] 'For Chrysippos showed this clearly in the statement from him quoted just above, in which he says that the health of the body is identical with due proportion in the hot, the cold, the dry and the moist (for these are clearly the elements of bodies), but beauty, he thinks, does not reside in the proper proportion of the elements but in the proper proportion of the parts, such as for example that of finger to finger and of all these to the hand and wrist, of these to the forearm, of the forearm to the whole arm and of everything to everything else, just as described in the Canon of Polykleitos. For having taught us in that work all the proportions of the body, P. supported his treatise with a work of art, making a statue according to the tenets of the treatise and calling it, like the treatise itself, the Canon. So then, all philosophers and doctors accept that beauty resides in the due proportion of the parts of the body'. See further n. 25 for the translations of *μετακάρπιον* and *βραχίων* adopted here.

[24] 'Now in every piece of work, beauty is the product of many numbers, so to speak, that come to a *kairos* through some system of proportion and harmony, whereas ugliness is ready to spring into being immediately if only one chance element is omitted or added out of place. And so, in the particular case of a lecture, not only

From passages 1–4 we learn that the canon was composed of many numbers that παρὰ μικρόν led to beauty; that it aimed at the mean; that the system adopted appears to have taken the form of a series of ratios, which related all the parts of the body proportionally to each other and to the whole;[25] that this apparently became particularly difficult when the modelling of the matrix became finicky; and finally (if passage [5] be accepted), that even so, the process described was insufficient to achieve the artist's goal by itself, for everything must nevertheless 'come to a καιρός' if beauty was to be achieved.

Two technical terms in this ensemble have caused hot dispute: παρὰ μικρόν and καιρός. For the former, four separate and mutually exclusive meanings have been proposed:

(a) 'from minute calculation,'[26]
(b) 'little by little,'[27]
(c) 'from a small unit' (or module),[28]
(d) 'except for a little', 'almost'.[29]

Of these, only the first would seem really to fit the context in Philo, his point being to stress the failure of those engineers whose calculations are insufficiently accurate; since however in the example he gives the error discussed is cumulative the second must remain a possibility. The third and fourth do not fit Philo's meaning and thus must be discarded.

As for καιρός, Schulz (who first recognised the importance of passage [5]) saw this as something basically uncanonic and beyond the scope of the πολλοὶ ἀριθμοί, the intuitive rightness of a work that cannot be calculated, only hit upon; this he linked with meaning (d) of παρὰ μικρόν and passage 2 above.[30] Yet, to insist upon the uncanonic (or rather, extra-canonic) nature of the καιρός in this way involves certain difficulties. For one thing Plutarch says quite plainly that perfect beauty can result only from the πολλοὶ ἀριθμοί 'coming to a καιρός' under the guidance of some system of συμμετρία and ἁρμονία; the status of the καιρός as in some way the *product* of the πολλοὶ ἀριθμοί, and hence the canon, is direct and unequivocal. The second part of the passage is even less favourable to the καιρός as some kind of chance element operating outside the scope of the canon—for here, ugliness is defined in precisely these terms, as the result of 'the inappropriate omission or inclusion of one such chance element.'[31]

With Polykleitos, then, if the καιρός was indeed the rightness of a given work of art, its operation did not lie outside the sphere of the canon but squarely within it. The καιρός must be the ideal canon, exactly the right choice among the various συμμετρίαι and ἁρμονίαι available 'across the board', the correct correlation, in fact, of the πολλοὶ ἀριθμοί in each particular case, which the sculptor must pinpoint to a nicety (στοχάζεσθαι). For each subject it is an absolute, and exists independently of whether this happens or not. Failure to discover it will result in a work that is αἰσχρόν, success in the perfect statue (Polykleitan, of course) described by Galen in passage 3.[32]

frowning, a sour face, a roving glance, twisting the body about, and crossing the legs, are unbecoming, but even nodding, whispering to one another, yawns, bowing the head, and all like actions are culpable and need to be carefully avoided.' (Trans. F. C. Babbitt, Loeb, slightly adapted.) This passage was added by D. Schulz, 'Zum Kanon Polyklets' in *Hermes* lxxxiii (1955) 200–20.

[25] The exact meaning of passage 4 is unclear. *Μετακάρπιον* is usually translated 'palm' (e.g. by Tobin, *op. cit.* [n. 5] 308–9 n. 9: 'from the knuckle or origin of the little finger to the head of the ulna'), but as E. Iversen points out in *The Legacy of Egypt*[2] (1971) 76 n. 3, the parallel passage in Vitr. iii 1.2 defines 'manus palma' as the area from the wrist to the tip of the middle finger: this is the translation adopted here. Also, *βραχίων* could refer either to the whole arm or to the upper arm only: in the former case the ratios would be $a:a+b$, $b:b+c$, etc., and in the latter $a:b$, $b:c$, etc. *Cf.* E. Panofsky, *Meaning in the Visual Arts* (1955) 64 and Gordon and Cunningham, *op. cit.* 129, 134 and n. 13 for the arguments on each side. Most would-be reconstructors of the canon either ignore these problems with the text or translate it to suit their own convenience. But see my *Postscript* p. 131.

[26] Proposed by Diels, in DK[6] i 392, and accepted, e.g., by Hiller, *op. cit.* 13 n. 8.

[27] Kranz, in DK *loc. cit.*; Pollitt, *op. cit.* (n. 5) 89.

[28] H. Stuart Jones, *Ancient Writers on Greek Sculpture* (1895) 129; Anti, *loc. cit.* (n. 3); Beschi, in *EAA* s.v. 'Policleto', 273; Tobin *op. cit.* (n. 5) 319 n. 16.

[29] Rhys Carpenter, *The Esthetic Basis of Greek Art* (1921) 124; *id.*, *Greek Sculpture* 101; Schulz, *op. cit.* 215. Von Steuben, *op. cit.* 50–1 proposes a variant of this, whereby the *ἀριθμοί* do not cover every part of the body; yet does not this flatly contradict Galen's repeated assertion in passages 3 and 4 that *everything* must be in proportion to everything else?

[30] *Op. cit.* 200–8, 214–19.

[31] *Cf.* von Steuben's criticism of Schulz in *Der Kanon des Polyklet* 50–3; Galen's remark noted above (n. 29) points the same way.

[32] That sculptural canons did not always 'come to a *καιρός*' is implied by the criticism of Euphranor's preserved in Plin. *N.H.* xxxv 128.

That there can be no limit to the operation of the πολλοὶ ἀριθμοί is clear: the canon, in other words, is apparently at once both more rigid and more comprehensive than our twentieth-century preconceptions about artistic freedom will usually allow us to admit.[33]

To turn to the external evidence, of the recent developments in this field the most important has been the new lease of life accorded to an old suggestion of Diels (namely, the possibility of some kind of a link between Polykleitos and the Pythagoreans) by an article written some twenty-five years ago by J. E. Raven.[34] Raven's argument has force, though it concerns itself, at least on the face of it, only with the chance of Polykleitan influence on the Pythagoreans, and not *vice versa.* Yet a statement of Aëtius that Πυθαγόρας . . . πρῶτος φιλοσοφίαν τούτῳ τῷ ῥήματι προσαγορεύσας ἀρχὰς τοὺς ἀριθμοὺς καὶ τὰς συμμετρίας τὰς ἐν τούτοις, ἃς καὶ ἁρμονίας καλεῖ . . .,[35] if not anachronistic, reads almost like a gloss on passage [5] above (in all fairness, not known to Raven), and we know also that καιρός was highly esteemed by the Pythagoreans, being given the 'virginal' prime number 7.[36] The sheer number of correspondences here could point perhaps to a Pythagorean source for some of the sculptor's ideas—though the argument would be much stronger if we could be sure that Plutarch's note on καιρός came, directly or indirectly, from Polykleitos.

If all this is not fantasy it should, at least in principle, give us some leads as to the nature of the canon. Although a little guarded optimism does seem to be permissible on this score—of the possible lines of enquiry one will be investigated in the final section of this paper—the would-be researcher unfortunately again comes up against a problem here: the passage in Vitruvius that Raven sees as the key to the puzzle describes not one canon but two or perhaps even three, and without naming their authors.[37] These systems are as follows: one which expressed the major dimensions of the body as common fractions of its total height (though perhaps itself conflating a decimal and a duodecimal system);[38] another which sought to fit the body in various positions into simple geometric figures; and a third whereby the lengths of the various parts were collected and 'distributed' into the perfect number, the decad. Although various points of contact do exist between them, only this last (quoted below) can be thought of as decisively Pythagorean, though the second may have some relation to the preoccupation of early Greek mathematicians (including those of the School) with basic geometrical constructions such as circles and squares.

III. Some Possibilities and a Suggestion

The literary evidence, then, seems to be rather more helpful to the would-be restorer of the canon than the monumental, though by no means as informative and unequivocal as one would like. From it, and from stray remarks in later writers, we may make several assumptions as to the nature of Polykleitos' achievement; some may seem almost platitudinous, but, again, are all too

[33] *Cf.* here Iversen, *op. cit.* (n. 25) 69: 'it is curious to observe that the self-imposed restrictions of the canon had never hampered the creativeness of Egyptian artists or lowered the standard of their work. Rather the opposite would seem to have been the case, for the most rigorously canonical representations in Egyptian art are also as a rule those of the highest artistic perfection.'

[34] 'Polyclitus and Pythagoreanism' in *CQ* xlv (1951) 147–52; summary and discussion in Pollitt, *op. cit.* (no. 5) 14–22; the possibility was first raised by Diels, *AA* (1889) 10, and *Antike Technik* (1914) 15.

[35] Aët. i 3.8; DK[6] i 454 line 35. 'Pythagoras was the first to call philosophy by this name, [laying down] as its principles numbers and proportions in these things, which he also calls harmonies . . .'

[36] Arist. *Metaph.* 985b30, 990a23, 1078b21; Philolaos *fr.* 20 (DK[6] i 416 line 8; 452 lines 5, 25; 456 line 36); on the significance of καιρός to the Pythagoreans see esp. W. Burkert, *Lore and Science in Ancient Pythagoreanism* (1972) 467.

[37] Vitr. iii 1.2–7. This passage forms the basis of Lorenzen's work (n. 5) further discussed in the following notes.

[38] Observed by F. W. Schlikker, *Hellenistische Vorstellungen von der Schönheit des Bauwerks nach Vitruv* (1940) 55 and 66. That Vitruvius's fractions are self-contradictory was recognised as early as Leonardo: only two of them in any sense fit the Doryphoros. Panofsky, *op. cit.* 67 n. 16, von Steuben, *op. cit.* 68–71, and Iversen, *op. cit.* (n. 25) 78–9 investigate the problem of possible textual corruption, all suggesting various emendations, and the last a general conformity with the later Egyptian canon. The enormous complexity of Lorenzen's system, involving no fewer than two sets each of two basic modules, each applicable to two further sets each of twenty or so 'flexible' scales, all apparently available to the sculptor of the classical period in any combination or permutation, enables him to circumvent such niceties of interpretation as these. It should perhaps also be remarked that, in the opinion of this writer at least, Iversen's work on the Egyptian canon *(op. cit.* 55–82 *passim)* has more-or-less invalidated many of Lorenzen's basic assumptions.

often forgotten in discussion, so worth stating explicitly. With these, we reach the limits of what we know or can directly infer from the sources, both written and monumental, that have survived; what follows them in the remainder of this section is thus entirely speculative and intended to provoke discussion, not to resolve it.

First, to judge by its immediate fame, swift conquest of the world of Peloponnesian sculpture and enormous prestige in later generations, it is reasonable to suppose that the canon represented a radical transformation of its predecessors in Archaic and Transitional sculpture, and not merely a refinement of them.[39]

Second, and by the same token, the chances are that it was rooted in a universal principle of some sort, probably mathematical in character, that particularly appealed to fifth-century Greek sensibilities.

Third, it was expressed in terms of ratios and contained many (whole?) numbers.[40]

Fourth, the implication of all the sources, backed by direct statements in passages 3–[5], is that it was unitary, completely comprehensive, and left nothing to chance or to optical illusion.[41]

Fifth, it was sufficiently flexible to accommodate the human body at different stages of its development and the differences between the sexes.[42]

Sixth, it was also apparently tractable enough to serve as the basis of the work of three generations of pupils without losing its normative character;[43] here it is the concept of what is **εὔκαιρος**, not the canon itself, that changes.

The argument thus seems to lead towards a mathematical progression or, more likely, a series of such progressions, all related to one another by a single well-defined formula, for only in this way can all six of these conditions be accommodated: the sculptor would substitute different numerical values for this formula according to the parts of the body under consideration, the age and sex of the subject tackled, and, in the case of the Polykleitan school, the individual artist's idea of what was appropriate. A modular or fractional system does not seem to be the answer: the former had been known in architecture (and, through Egyptian influence, apparently also in sculpture)[44] for a long time, and the latter *ipso facto* does not involve whole numbers and is not both fixed and adaptable in the way demanded above.

In considering the various formulae that Polykleitos could have used, it is fair to conjecture that he made his choice from what was available in the field of mathematics at the time, that is, around 450 B.C. In view of the points made in the first of the assumptions set down above, had he

[39] This would appear to militate against the improved modular system proposed by Ferri and Beschi (nn. 4 and 5) also Lorenzen's conclusion that Polykleitos returned to the older Egyptian canon (*op. cit.* 89–9).

[40] M. Lang, *Hesp.* xxvi (1957) 271–87 shows how the Greeks could manage abacus calculations of sums in the millions by Herodotus' day—but not always without error.

[41] This excludes Tobin's solution from consideration, for here the entire head (!) does not fit the reconstructed canon (*op. cit.* 314–15, 321), and also does some damage to Lorenzen's (*op. cit.* 48–9: the top of the head is 3 cms lower than predicted) and to von Steuben's (*op. cit.* 51–2), where several measurements again do not come up to expectations. Tobin does not seem to have noticed that Pliny's remarks on Lysippos in *N.H.* xxxiv 55, which he quotes as supporting his case, specifically exclude the optically-based adjustments to the canon which he proposes. On this passage see further P. Moreno, *Testimonianze per la teoria artistica di Lisippo* (1973) 123–4, 133, 139–43.

[42] *Cf.* Plin. *N.H.* xxxiv 55: *Polyclitus . . . diadumenum fecit molliter iuvenem . . . et doryphorum uiriliter puerum [et] quem canona artifices uocant liniamenta artis ex eo petentes ueluti a lege quadam . . .*, also *ibid.* 53 on the Amazon and e.g. Paus. ii 17.4 on the Hera. The Baiae casts show how different his styles could be for male and female subjects.

[43] See Pliny's comment in the previous note, also, in gen., Arnold, *op. cit.* (n. 5) *passim*.

[44] See Panofsky, *op. cit.* 56–62 and fig. 1, with the references there cited, and also Diod. i 98; E. Iversen, 'The Egyptian origin of the archaic Greek canon' in *MDAI (Kairo)* xv (1957) 134–47; B. S. Ridgway, 'Greek Kouroi and Egyptian methods' in *AJA* lxx (1966) 68–70; *cf.* I. A. Richter's study in Brunn-Bruckmann, *Denkmäler Griechischer und Römischer Sculptur* cli (1934) 27, also *ead.*, 'The Archaic Apollo in the Metropolitan Museum', *Metr. Mus. Stud.* v (1934) 51–6; Lorenzen, *op. cit.* (n. 5) *passim;* D. Ahrens, 'Metrologische Beobachtungen am "Apoll von Tenea"', *JÖAI* xlix (1968–71) *Beibl.* 117–32; Carpenter, *Greek Sculpture* 94–5; Iversen, 'The Canonic tradition' in *The Legacy of Egypt* (1971) 55–82, with further bibliography; E. Guralnick, 'The proportions of some archaic Greek sculptured figures: A computer analysis' in *Computer and the Humanities* x 3 (1976) 153–69. One fairly firm piece of evidence for the use of the second Egyptian canon by the Greeks as late as the mid fifth century is the metrological relief in Oxford (A. Michaelis, *JHS* iv (1883) 335–50; Lorenzen, *op. cit.* 28–30, 39, 47–8, 60 ff. [but *cf.* n. 38]; Iversen, *op. cit.* 75)—though I am well aware that with the partial exception of those concerning the Oxford relief all these studies are still open to the objection stated on p. 122 above, that we still do not know the points considered significant by the Greeks. See, in gen., Ferri in *EAA* s.v. 'Canone' and 'Embater'.

invented something new, it would doubtless have become common coin fairly rapidly and would almost certainly have born his name, like Pythagoras's theorem in earlier days. This was, of course, not the case, so his achievement probably lay less in the field of pure invention than in the application of some already known theorem to the art of sculpture, thereby elevating his work to the plane of the universal. It follows that any suggestions as to the principles of the canon must take into account both the stage reached by Greek mathematics *c.* 450 and the philosophical significance and popular standing of whatever discoveries of this kind had been made by that time. One must also not forget the restrictions placed upon the sculptor by the problem of measurement that plagued all practical work in the ancient world where, as we are rightly reminded, it was simply not possible to go into a shop and buy an accurate ruler.[45]

Together, these conditions ought to rule out the Golden Section as a possibility.[46] It is arithmetically irrational (1 : 1·6180339 . . .) and thus to the Greeks not expressible in terms of number; its exact formulation depends upon the construction of the star-pentagon or pentagram which (even despite the figure being the Pythagorean recognition sign *par excellence*) was apparently not achieved until the late fifth century and not proved until the fourth, by Plato and Eudoxus;[47] and, finally, its closest approximation, the so-called Fibonacci series (a + b = c; i.e. 3, 5, 8, 13 . . .) was not added to the list of known progressions or 'means' (μεσότητες) until about this latter date, by the Pythagoreans Myonides and Euphranor.[48]

In fact, of the ten 'means' found in later mathematicians, only three were known to the fifth century, as a fragment of Archytas's treatise *On Music* makes clear.[49] These were as follows:

(1) The arithmetic: of three terms a, b, and c, the third exceeds the second by the same amount as the second exceeds the first, i.e. $a+c=2b$ (example: 2, 3, 4 . . .).

(2) The geometric: of three terms, the first is to the second as the second is to the third, i.e. $ac=b^2$ (example: 2, 4, 8).

(3) The subcontrary (renamed by Archytas the harmonic): of three terms, by whatever part of itself the third exceeds the second, the second exceeds the first by the same part of the first, i.e. $\frac{1}{a}+\frac{1}{c}=\frac{2}{b}$ (example: 6, 8, 12 . . .).

The second of these is that favoured by von Steuben, though he gives no justification for his view other than that of the monumental evidence: as he himself admits, his system and the so-called 'Pheidonian' only coincide very roughly[50]—and the canon was nothing if not absolutely exact. Nevertheless, although we have no real information about the use of this or the subcontrary, or about their significance in more general terms to the Greeks, pending further evidence one way or the other both must clearly remain in the list of possibilities.

To turn, finally, to the arithmetic mean: one case of this is, of course, the 'Pythagorean series' implicit in Vitruvius's passage on sculptors' canons discussed by Raven.[51] The relevant sentence deserves quotation:

Nec minus mensuram rationes, quae in omnibus operibus uidentur necessariae esse, ex

[45] P. E. Corbett, *JHS* lxxxvi (1966) 275–6; *cf.* J. J. Coulton, *BSA* lxx (1975) 59–99, esp. 89–98.

[46] Proposed by M. Bieber in Thieme-Becker, *Allgemeines Lexikon der bildenden Künstler* (1933) s.v. 'Polykleitos' 225; *AJA* lxvi (1962) 242; *ibid.* lxxiv (1970) 90; Gordon and Cunningham, *op. cit.* (n. 5) *passim*.

[47] Proclus on Eucl. i p. 67, 6; cf. *ibid.* p. 60, 16–19: 'common to both sciences [geometry and arithmetic] are the theorems regarding sections . . . with the exception of the division of a line in extreme and mean ratio'. See T. Heath, *A History of Greek Mathematics* (1921) 87, 160, 304, 324–5; *id.*, *Euclid*[2] (1926) i 137; ii 97–101—though the present tendency, following Heidel's fundamental 'The Pythagoreans and Greek Mathematics' (*AJP* lxi [1940] 1–33) is to downgrade the Pythagorean contribution to the science, and to down-date it as well: *cf.* J. A. Philip, *Pythagoras and Early Pythagoreanism* (1966) 204–5, and esp. Burkert, *op. cit.* 401 ff., and in particular pp. 452–3; this is the stance adopted in the present study.

[48] Nicom. *Ar.* 2. 28; Papp. p. 102; Iamb. *in Nic.* p. 116, 4–6 (DK[6] i 445 line 3): *cf.* Heath, *History of Greek Mathematics* 87. Tobin's canon, based on the ratio of $1=\sqrt{2}$ (1 : 1·4142136 . . . : *cf.* Heath, *op. cit.* 90–1, 154–7), is open to several of the objections already levelled at the Golden Section, plus the additional one that if there is anything at all in the postulated connection between Polykleitos and the Pythagoreans, the latter could not for a moment have entertained a canon grounded in the ultimate in irrationals, the one, in fact, that was eventually to contribute much to bringing down their entire world system.

[49] Archyt. ap. Porph. *in Harm.* p. 92 (DK[6] i 435–6); Heath, *op. cit.* 85–6.

[50] Von Steuben, *op. cit.* 16–20.

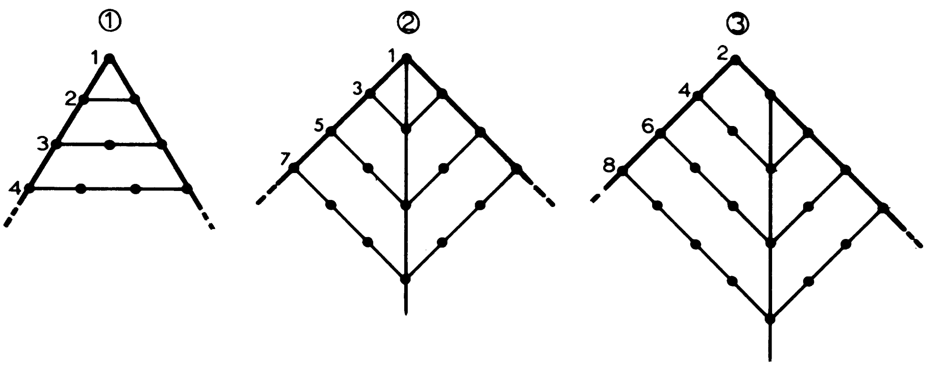
[51] *Op. cit.* (n. 34) 150–1.

corporis membris collegerunt, uti digitum, palmum, pedem, cubitum, et eas distribuerunt in perfectum numerum, quem Graeci *τελεῖον* dicunt, perfectum autem antiqui instituerunt numerum qui decem dicitur.[52]

(iii 1.7)

As Raven notes, the similarities between this, the Galen passage quoted above (no. 4) and other fragments of Pythagorean writing on the subject of proportion, are remarkable. Linking these with the newly discovered fragment embedded in the *Moralia* [5], itself already seen to be persuasively Pythagorean in character, we are confronted with a nexus of evidence that goes a certain way towards weighting the balance in favour of the arithmetic mean, if any, as the basis of the Polykleitan canon.

Apart from its simplicity, the formula in question would also have had one other distinct advantage in sculpture over its rivals, for by applying it to geometry one can construct series of equilateral triangles, squares and rectangles of any desired size and, in the first two cases, in fixed proportion to one another, thus:[53]



—a practical application of the *πολλοὶ ἀριθμοί* that would, one imagines, have been very useful to the sculptor (or architect) in formulating his design, and one easily put into service with the aid of a measuring rod or string. Evidence for the use of such 'gnomonic' numbers in architecture (as well as the 3 : 4 : 5 triangle and its derivations) goes back to second millennium Babylonia, whence, as we are explicitly told by Herodotus, the gnomon was introduced to Greece, perhaps by Anaximander;[54] other authorities testify to the indebtedness of early Greek mathematics and engineering to the same source,[55] where, significantly, both Greek masons and Greek sculptors were working from around 550 onwards.[56] As for the wider significance of the arithmetic mean, there is no need to elaborate upon the special importance of the series 1, 2, 3, 4 as the basis of the musical scale and, to the Pythagoreans, as the governing principle of the universe. How far any of this would hold generally, for non-Pythagoreans, we cannot tell, yet, as one modern writer has recently observed, the 3 : 4 : 5 triangle still has one significance that no other geometrical figure possesses: it remains the 'fundamental characterisation of the space in which we move'.[57]

Of course, none of this by any means permits us to conclude that Polykleitos and his followers were in any sense Pythagoreans: if this had been the case such a coup would hardly have passed

[52] 'Moreover they collected from the members of the human body the proportionate dimensions which appear necessary in all building operations: the finger [inch] the palm, the foot, the cubit. These they distributed into the perfect number, which the Greeks call *teleon*, for the ancients determined as perfect the number which is called ten.'

[53] Heath, *op. cit.* 78–9.

[54] Hdt. ii 109; *Souda*, s.v. '*γνώμων*'. Gnomons (builders' set squares in the form of a cross) are illustrated on red-figured vases from *c.* 490 onwards: J. D. Beazley, *Attic Red-figure Vase-painters*² (1963) 348/3, 431–2/48, 892/7; (E. Pottier, *Vases Antiques du Louvre* [1897–1922] pl. 135; F. A. G. Beck, *Greek Education, 450–350 B.C.* [1964] pls. 4, 8): *cf.* Heath, *loc. cit.*; Burkert, *op. cit.* 33 n. 27, 274 n. 172, 419 n. 104 (with references). For a sample of technical terms in geometry and mensuration in use at the beginning of the fifth century *cf.* Simon. *fr.* 542. 3 (Page); Thgn. 805; Plin. *N.H.* vii 198; Coulton *op. cit.* (n. 45) *passim*.

[55] Collections of sources and discussion in Heidel, *op. cit.* 16–17, 30–3; Burkert, *op. cit.* 407–20, 429, 433, 442; on Babylonian science see esp. O. Neugebauer, *The Exact Sciences in Antiquity* (1957) 29–52, and 157 ff. for its influence on Greece.

[56] Richter, 'Greeks in Persia', *AJA* l (1946) 15–30.

[57] J. Bronowski, *The Ascent of Man* (1973) 161; N.B. that at least one fifth-century non-Pythagorean used the term *κανών* to describe the musical scale: Porph. *V.P.* 3 (DK⁶ i 444 lines 33–445): Burkert, *op. cit.* 455 n. 40.

unnoticed in the ancient literature, and in particular in Pythagorean writing and propaganda. More promising than this rather unpropitious line of inquiry is the less far-reaching possibility that some acquaintance with a Pythagorean source may have led the sculptor to begin thinking about number in terms of such concepts as ***συμμετρία, ἁρμονία*** and perhaps also ***εὐκαιρία***; this is I think worthy of further study. As for the other side of the coin, at this stage all one can do is to infer, with Raven, that 'the canon was mentioned, and probably summarised, in some Pythagorean source known to Vitruvius and to Galen'[58] (and, one might add, possibly to Plutarch as well), and to proffer the suggestion that if this was indeed the case, this source extracted from it what was most congenial to Pythagorean thinking, namely the doctrine of commensurability of parts and that special case of the arithmetic mean whose first few terms were the numbers 1, 2, 3 and 4, the elements of the decad.

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Postscript

The translation of *μετακάρπιον, καρπός* and *βραχίων* as given in footnotes 23 and 25 is erroneous. At the time of writing, I was unaware of the existence of W. F. Richardson's *Some Greek and Latin Anatomical Terms* (diss. Auckland, 1977), which solves the problems discussed there. I quote an opinion from Dr Richardson:

'The author here splits the upper limb into four sections:

(a) fingers: *δάκτυλοι*
(b) hand: *μετακάρπιον και καρπός*
(c) forearm: *πῆχυς*
(d) upperarm: *βραχίων*

He is concerned with lengths, not joints; hence there is no reference to the elbow, and *καρπός* does not mean wrist. So far as I am aware Greek has no term which specifically denotes the hand from the wrist to the base of the fingers; and so the author here, rejecting *χείρ* as too vague, has referred to that area by linking as a pair two medical technical terms which are still used, metacarpus (roughly 'palm', the concave part containing the metacarpal bones) and carpus (not 'wrist', but the convex part containing the carpal bones).

'*Βραχίων* refers specifically to the upper arm. This is the usual meaning of the word in technical and medical authors, especially when paired with *πῆχυς*: *cf.* Xen. *Eq.* xii 5; Hp. *Ep.* iii 4 etc.'

The relevant section of n. 23 should thus read: '. . . such as for example that of finger to finger and all these to the palm and base of the hand, of those to the forearm, of the forearm to the upper arm and of everything to everything else, just as described in the Canon of Polykleitos.' The proportions employed by Polykleitos were thus a:b, b:c . . . etc.

A.F.S.

[58] *Op. cit.* (n. 34) 151–2.