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Kouroi and Statistics

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Abstract

In a well-known series of articles, Eleanor Guralnick undertook statistical studies to compare the proportions of Greek archaic kouroi with one another and with the proportions of the Egyptian second canon; she concluded that Greek sculptors used the Egyptian canon sporadically for proportioning kouroi during most of the sixth century B.C.E. Here, we examine the results of Guralnick's analyses against the backdrop of current statistical method. While we do not believe that her analyses convincingly demonstrate any Greek use of the Egyptian system, we agree that the analyses do distribute the kouroi included in the studies into two main groups. We argue that this division results from the influence of regional styles, rather than from the use of standardized proportional systems. We also examine Guralnick's methodology in cluster, principal components, and z-score analyses and demonstrate that her studies do not provide statistically significant evidence for similarities among Greek kouroi or between kouroi and the Egyptian canon, in part because of the limitations of the statistical techniques employed and in part because of problems in her procedures and data. Thus, we disassociate archaic Greek kouroi from a dependence on the Egyptian standardized proportional schemes and argue instead that the development of regional styles best explains the proportional similarities documented by Guralnick.*

INTRODUCTION

The quest to establish that early Greek statues used the Egyptian system for proportioning human figures stems from a combination of two factors: (1) the approximate synchronism of the earliest Greek statues in stone and the resumption of direct contacts between Greece and Egypt around the middle of the seventh century B.C.E.; and (2) the visual resemblance between Greek kouroi and Egyptian statues. Standing male figures in both Greece and Egypt face forward, hold their arms alongside their thighs, and advance the left leg. These factors have suggested that Greeks learned sculptural techniques from the Egyptians; if so, one could expect to find Egyptian proportions in early Greek statues. Eleanor Guralnick's statistical studies of kouroi and korai are, in part, an attempt to demonstrate this hypothesis.[1] Guralnick concluded that "at least through the third quarter of the sixth century Greek sculptors made conscious use of the contemporary Egyptian canon without major modification."[2] For the last 30 years, Guralnick's studies have contributed significantly to a more or less orthodox view about the Egyptian origins of Greek sculpture.[3] However, a strong argument can be made that in the first instance, the Greeks adopted techniques and sculptural types from regions in the eastern Mediterranean, in particular from Syria-Palestine. That argument is well beyond the scope of this paper. Our purpose here is to show that while Guralnick's articles contain much that is valuable for the study of kouroi, they do not in fact demonstrate the likelihood that early Greek sculptors of kouroi used an Egyptian system of proportions. Thus, we hope to open the way for new discussion about archaic Greek statues and their origins.

The underlying premise of Guralnick's studies is that archaic Greek sculptors used one or more standardized proportioning schemes, and her numerous articles have served to reinforce this idea. We, on the contrary, doubt that early Greek statues embody any formal system of proportions.[4] Such proportional similarities as do exist among kouroi are best explained, we believe, by the evolution of regional styles and a consistent type of idealization embodied by virtually all kouroi.

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[1] Guralnick 1976, 1978, 1981, 1982, 1985, 1996a, 1996b, 2000.

[2] Guralnick 1985, 409.

[3] E.g., Osborne (1996, 209–11, 371) cites only Guralnick to support his statement that the "size and proportions [of kouroi] make it clear beyond doubt that they were directly inspired by Egyptian stone sculpture." Hurwit (2007, 274, 283 n. 27) likewise cites only Guralnick as evidence that the kouros type was invented "after Greeks had been exposed . . . to Egyptian techniques"; cf. the newest edition of Pedley's (2007, 148) widely used textbook: "computer studies have now confirmed the closeness of proportions between the earliest kouroi and Egyptian figurines."

[4] Cf. Boardman 2006, 12, 19–24.

We have not, therefore, attempted new measurements or pursued fresh statistical approaches with the aim of identifying one or more proportional schemes in Greek kouroi. In our opinion, the evidence published by Guralnick shows convincingly that archaic Greek statues of men and women exhibit a varied range of proportions and offers an explanation for the proportions of kouroi that does not depend on abstract proportional systems.

The Egyptian system has been documented almost entirely in two-dimensional works rather than in three-dimensional statues. Egyptian artists frequently employed guidelines for their preliminary sketches of human figures, and traces of their guidelines are sometimes preserved in unfinished reliefs or under painted surfaces. From this evidence, Egyptologists have shown that Egyptian artists in a given period consistently placed certain parts of the human anatomy at fixed points, thereby producing figures with fairly uniform proportions, regardless of their scale. Surviving guidelines show that a new system came into use in the 25th Dynasty (i.e., the late eighth century or early seventh century B.C.E.).[5] The new system, usually called the second canon,[6] was in use during the 26th Dynasty (664–525 B.C.E.), when, judging from archaeological and textual sources, Greeks began to visit Egypt again for the first time since the end of the Bronze Age.[7] At Theban Tomb 223, from the 26th Dynasty, preserves a good example of the second canon grid used to draw a standing male figure (fig. 1). From the baseline, the top of the eye is at 21 units, the mouth is at 20 units, the junction of neck and shoulder is at 19 units, the nipples are at 16 units, the navel (or the small of the back) is at 13 units, the bottom of the buttocks is at 11 units, the top of the knee is at 7 units, and the bottom of the knee is at 6 units.[8]

Guralnick's studies apply three different statistical methods. We emphasize that these studies contain valuable information for our understanding of Greek kouroi and korai. At the same time, statistical theory has progressed considerably in the last quarter-century, and important new work has been done on Egyptian proportioning techniques. First we look at what Guralnick's statistical analyses tell us about kouroi, then we examine some significant problems with her statistical methodology and her data.

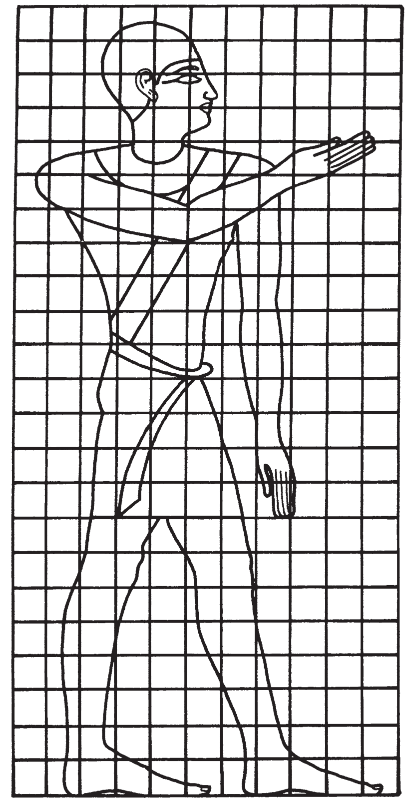

Fig. 1. An Egyptian standing male figure with original grid lines from Tomb 223 at Thebes, 26th Dynasty. This illustrates the so-called second canon or later grid (drawing by A. Fowler; Robins 1994, 161, fig. 7.2).

GURALNICK'S RESULTS FOR KOUROI

In her initial studies of kouroi, Guralnick employed cluster analysis to find similarities between the Egyptian canon and a group of 24 Greek kouroi.[9] For the cluster analyses, Guralnick relied primarily on two similar data sets (A and B) of measured dimensions.[10] Each dimension of each figure was expressed in terms of its proportion to the distance between the eyes and knee-tops of the figure; the ratios permitted comparisons of proportions among figures of different sizes. Table 1 shows Guralnick's results when the statistical software sorted the Egyptian second canon, 17 Greek kouroi, and the average dimensions of Greek, Turk-

[5] Robins 1994, 160.

[6] Robins (1994, 228, 258–59) shows clearly that the guidelines used by Egyptian artists did not always determine the proportions of their figures. E.g., the same grid system was used for the taller, more slender figures of the 19th and 20th Dynasties as had been used for the shorter and stockier figures of the 5th and 6th Dynasties. Robins thus correctly rejects the use of the term "canon" in reference to the Egyptian grids. Because "canon" is generally used for the Egyptian system, however, for convenience we do so here.

[7] Hdt. 2.152–54; Boardman 1999, 111–53.

[8] Robins 1994, 160–61, fig. 7.2.

[9] Guralnick 1976, 1978.

[10] Guralnick 1978, 464, fig. 2; 1996a, 41, fig. 4.1. Data set A comprised 11 dimensions: top of head to eyes, eyes to chin, chin to sternal notch, sternal notch to nipples, nipples to na-

Table 1. Results of Guralnick's Cluster Analysis with the Egyptian Second Canon, 17 Kouroi, and Average Greek, Turkish, and Italian Military Personnel Using Data Set A (modified from Guralnick 1978, fig. 3).

Object	No. of Clusters																	
	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3
Egyptian canon	–	–	–	–	–	–	–	–	–	–	F	F	F	F	F	F	F	F	F
New York	–	–	–	–	–	–	–	–	–	–	F	F	F	F	F	F	F	F	F
Ptoon 12	–	–	–	–	B	B	–	B	B	B	F	F	F	F	F	F	F	F	F
Tenea	–	–	–	B	B	B	B	B	B	B	B	F	F	F	F	F	F	F	F
Melos	–	–	–	B	B	B	B	B	B	B	B	C	C	C	C	C	F	F	F
Volomandra	–	–	–	–	–	–	–	–	–	B	B	C	C	C	C	C	F	F	F
Thebes 3	–	–	–	–	–	–	–	–	–	–	–	–	–	F	–	F	F	F	F
Ptoon 10	–	–	–	–	–	C	C	C	C	C	C	C	C	C	C	C	C	F	F
Florence	–	–	–	–	–	C	C	C	C	C	C	C	C	C	C	C	C	F	F
Dermys/Kitylos	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	C	F	F
Kleobis	–	–	–	–	–	–	–	–	E	E	E	E	E	E	E	E	E	E	E
Biton	–	–	–	–	–	–	–	–	E	E	E	E	E	E	E	E	E	E	E
Anavyssos	–	–	–	–	–	–	D	D	D	D	D	D	D	D	D	D	D	D	A
Munich	–	–	–	–	–	–	D	D	D	D	D	D	D	D	D	D	D	D	A
Kea	–	–	–	–	–	–	–	–	–	–	–	–	D	D	D	D	D	D	A
Paros	–	–	–	–	–	–	–	–	–	–	–	–	–	–	D	D	D	D	A
Sounion	–	–	–	–	–	–	–	–	–	–	–	–	–	–	D	D	D	D	A
Aristodikos	–	–	–	–	–	–	D	D	D	D	D	D	A	A	A	A	A	A	A
Greek men	–	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Turkish men	–	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Italian men	–	–	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

ish, and Italian military personnel into clusters using data set A.[11]

The cluster analysis begins with as many clusters as there are objects—in this case 21—and each object is assigned to its own cluster. A dash (–) in table 1 indicates that the object named in the left-hand column is the only object in its cluster. The analysis progressively sorts the objects into fewer clusters, and the objects whose proportions are most similar to one another are grouped together in one cluster (we explain more fully how this works below). In table 1, a cluster that contains more than one object is designated by a letter. Thus, the chart shows that when the number of clusters was reduced to 18, the Tenea kouros and the Melos kouros were placed together in cluster B. At this point, every other kouros was still the only object in its cluster. When the number of clusters was reduced to 17, the Ptoon 12 kouros also joined cluster B.[12]

The objects with the highest degree of similarity—always with respect to the variables in the data set—will be the ones that first begin to cluster together when there are a large number of clusters. Therefore, in the cluster analysis shown in table 1, the two most similar statues are the Tenea kouros and the Melos kouros.

vel, navel to top of knees, width of head, width of shoulders, width of chest, width of waist, and width of hips. Data set B increased the number of dimensions to 12 by subdividing the distance from navel to top of knees into two dimensions: navel to bottom of pubes and bottom of pubes to top of knees.

[11] We focus here on the cluster analyses using data set A because we do not believe that the position of the pubes, included in data set B, was ever fixed in the Egyptian system. The only Egyptian example of a nude male figure with preserved grid lines is a child, and here the bottom of the pubes does not correspond to a grid line (Guralnick 1976, 165, fig. 12).

[12] Guralnick (1978, 465, fig. 3) refers to three kouroi in the National Archaeological Museum in Athens (inv. nos. 10, 12, 20) as Athens 10, Athens 12, and Athens 20. All three are from the Ptoon sanctuary near Thebes, and we refer here to these statues as Ptoon 10, 12, and 20.

As the number of clusters is further decreased, some of the clusters must contain more and more objects. In table 1, when the objects were sorted into only three clusters, cluster F contained 10 objects, cluster E had 2 objects (the "twins" Kleobis and Biton), and cluster A had 9 objects. At a late stage in the analysis, the degree of similarity among the objects in each cluster may be quite low. For example, with only four clusters, the Dermys and Kitylos pair was assigned to cluster F, although the proportions of Dermys and Kitylos probably have little in common with any of the kouroi assigned to cluster F at that stage.

In this analysis, no kouros clustered with the Egyptian canon until the number of clusters was reduced to 11, about halfway between the maximum number of 21 clusters and the minimum of 1 cluster (see table 1). In the first half of the analysis—from 21 clusters to 12 clusters—the Egyptian canon was the only object in its cluster. With 11 clusters, the New York kouros and Ptoon 12 kouros were assigned to cluster F with the Egyptian canon. At the next stage—with 10 clusters—the Tenea kouros joined cluster F. When the clusters were reduced to 8, the Thebes 3 kouros entered cluster F, became again the sole member of its group with 7 clusters, then rejoined cluster F with the decrease to 6 clusters. With only 5 clusters, the Melos kouros and the Volomandra kouros also grouped with the Egyptian canon in cluster F.

The similarities indicated by the clusters are relative, not absolute. In general, objects that group together when there are many clusters are more alike than objects grouped together when the number of clusters is small. Objects very different from one another could be forced to group together as the number of clusters is decreased. At no point, however, does the analysis indicate the degree of similarity among clustered objects. It is also necessary to bear in mind that the choice of variables included in the data set can have considerable consequences in the results. For example, with 21 objects and data set A, the Ptoon 12 kouros first grouped with the Egyptian canon when the number of clusters was reduced to 11 (see table 1). However, using the same 21 objects and data set B, the Ptoon 12 kouros first grouped with the Egyptian canon much earlier, with 16 clusters.[13] In this case, the degree to which the Ptoon 12 kouros appears to be proportionally related to the Egyptian canon depends on which variables are included. Cluster analysis does not have an underlying theoretical model that permits the claim of statistically significant similarity among grouped objects.[14]

In the analysis with 17 kouroi using data set A, 3 kouroi (New York, Ptoon 12, and Tenea) clustered with the Egyptian canon when there were 10 clusters (see table 1). With the same 17 kouroi and data set B, the cluster analysis grouped together the Egyptian canon, these 3 kouroi, and the Melos kouros when there were 11 clusters.[15] Guralnick concluded that these 4 kouroi (New York, Melos, Tenea, and Ptoon 12) "closely resemble the Egyptian Second Canon in their proportions from the eyes to the top of the knees" (fig. 2).[16] In fact, we do not actually know how close the resemblance is between these kouroi and the Egyptian canon.[17] The analyses have only shown that, in relative terms, these 4 kouroi seem to be more similar to the Egyptian canon than the other 13 kouroi in terms of the data sets used. There is no basis for claiming statistically significant similarity among objects in any cluster. Indeed, the cluster analyses indicate that the Ptoon 12, Tenea, and Melos kouroi are more similar to one another than any kouros is to the Egyptian canon (in terms of data set A, see table 1), because these statues are already grouped with one another in cluster B when there are 17 clusters, six stages before any kouros groups with the Egyptian canon.

Moreover, it is important to remember that even if some method could establish significant proportional similarity between the Egyptian canon and certain Greek kouroi, different explanations could be proposed for the similarity. One hypothesis, put forward by Guralnick, could be that Greek sculptors sometimes used the Egyptian canon. We suggest that there is a

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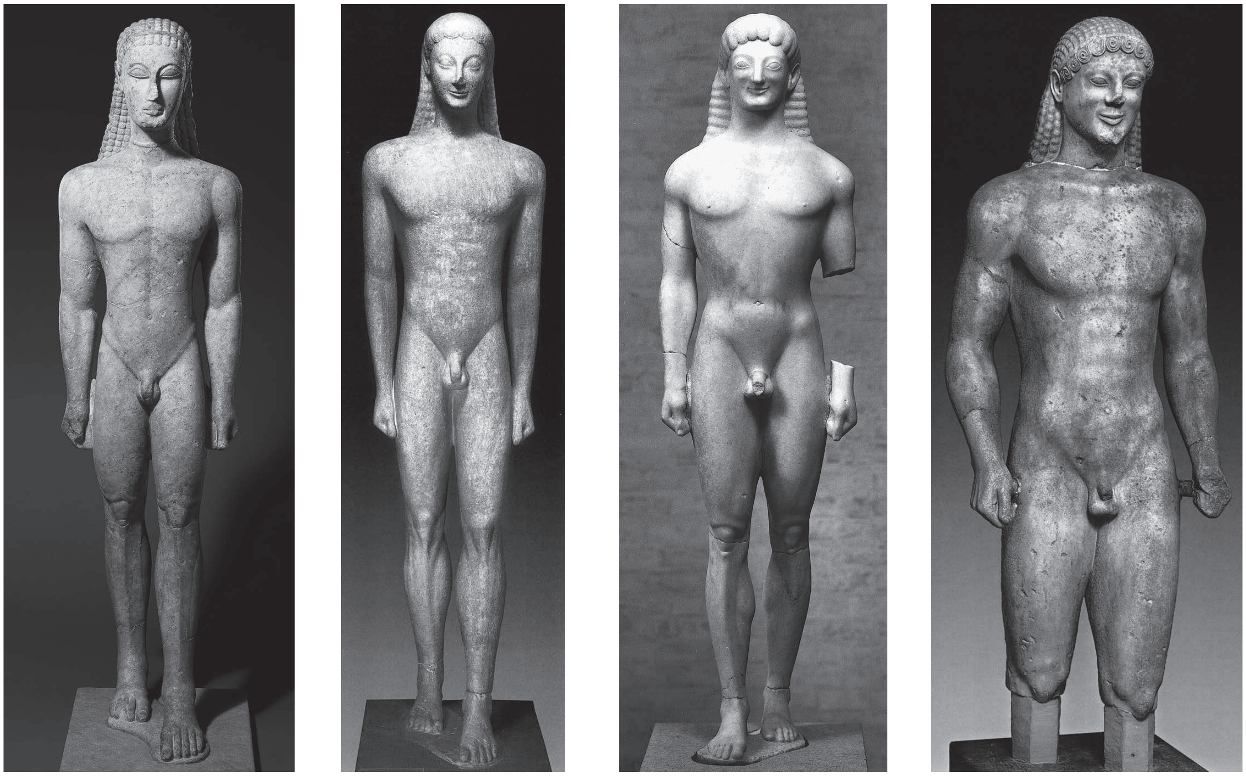
[13] Guralnick 1978, 465–66, figs. 3, 4.

[14] According to the Panel on Discriminant Analysis, Classification, and Clustering (1989, 35), the nature and composition of the clusters "appear to cause fundamental difficulties for formal statistical inference and distribution theory"; see also Punj and Stewart 1983, 136; Norušis 1985, 183; Shennan 1997, 254.

[15] Guralnick 1978, 466, fig. 4. Guralnick (1978, 467, fig. 5; 468–69) again used data set A in a cluster analysis with a total of 28 objects: 24 kouroi plus the Egyptian canon and the Greek, Turkish, and Italian men. In this case, the Ptoon 12 and the New York kouroi clustered with the Egyptian canon when the objects were sorted into 14 and 13 clusters, respectively. Guralnick (1978, fig. 5) does not show the results when the number of clusters was greater than 14. However, assuming that the chart documents the highest number of clusters at which a kouros and the Egyptian canon clustered together, then here, also, the New York and Ptoon 12 kouroi joined the Egyptian canon halfway between the maximum number of 28 clusters and the minimum of 1 cluster.

[16] Guralnick 1978, 466.

[17] As Guralnick (1978, 472) acknowledges, the cluster and principal components analyses "cannot determine . . . how closely the actual measurements of the statues conform to the proportional schemes."



a b c d

Fig. 2. Kouroi considered by Guralnick to be proportionally close to the Egyptian second canon: *a*, New York kouros, probably from Attica, Naxian marble, ca. 600–590 B.C.E. (© The Metropolitan Museum of Art; Fletcher Fund 1932, 32.11.1); *b*, Melos kouros, found on Melos in 1891, Naxian marble, ca. 550 B.C.E. Athens, National Archaeological Museum, inv. no. 1558 (C. Iosifidis and G. Moutevellis; Kaltsas 2002, cat. no. 48); *c*, Tenea kouros, found in cemetery of ancient Tenea in 1846, Parian marble, ca. 550 B.C.E. Munich, Staatliche Antikensammlungen und Glyptothek, inv. no. GL 168 (H. Koppermann; © Staatliche Antikensammlungen und Glyptothek, München); *d*, Ptoon 12 kouros, from the Sanctuary of Apollo at Ptoon in Boeotia, island marble, ca. 530–520 B.C.E. Athens, National Archaeological Museum, inv. no. 12 (G. Fafalis; Kaltsas 2002, cat. no. 80).

more probable explanation for proportional similarities that may exist between the Egyptian canon and certain Greek kouroi.

Guralnick tested her conclusion that four kouroi —New York, Melos, Tenea, and Ptoon 12 (see fig. 2)—"closely resemble" the Egyptian canon by using a technique known as principal components analysis with a larger group of 24 kouroi.[18] Guralnick illustrated these results with two graphs in which each object (kouroi, second canon, and Greek, Turkish, and Italian men) is represented by a point; circles are drawn around the points that seem to form groups.[19] Guralnick found agreement between the cluster analyses and the principal components analysies "in all essential conclusions"; in particular, she claims that the principal components analyses validate "the existence of a group of statues whose proportions are like those of the Egyptian canon."[20] This group consists of the four kouroi that were most closely associated with the Egyptian canon by the cluster analyses (New York, Melos, Tenea, and Ptoon 12) (see fig. 2) plus the Thera kouros (fig. 3). Guralnick adds that three more kouroi—Florence, Ptoon 10, and Volomandra—are also similar in proportions based on the principal components analyses.

Guralnick's graphs illustrating the principal components analyses do not appear to support these claims. In fact, there are a number of striking anomalies

[18] Guralnick 1978, 469.

[19] Guralnick 1978, 470, fig. 6 (using all the variables in her data set A); 471, fig. 7 (using the seven variables in data set A that were most alike in the 24 kouroi and the Egyptian canon).

[20] Guralnick 1978, 469.

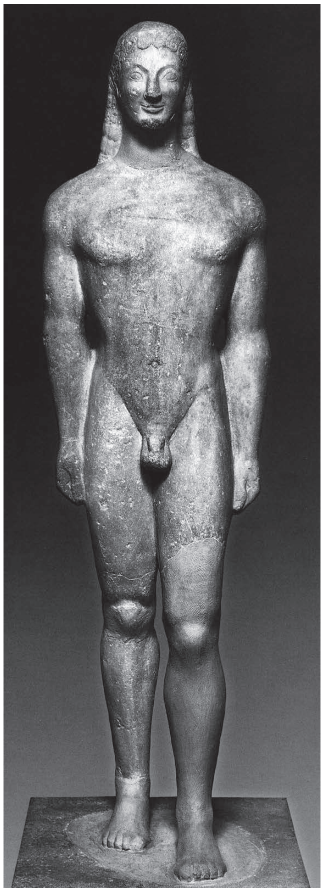


Fig. 3. The Thera kouros, found on Thera in 1836, Naxian marble, ca. 570–560 B.C.E. Athens, National Archaeological Museum, inv. no. 8 (G. Fafalis; Kaltsas 2002, cat. no. 22).

between the results of the cluster analyses and the principal components analyses:

1. The principal components analyses indicate a notably lower degree of similarity between the New York kouros and the Egyptian canon than the cluster analyses would lead us to expect.[21]
2. In the principal components analyses, the Melos kouros is very close to the Ptoon 12 kouros and seven examples of the Egyptian canon. However, in the cluster analyses with data set A, the Melos kouros does not cluster with the Egyptian canon until quite late in the analyses.[22]
3. Guralnick added the Thera kouros (see fig. 3) to the earlier group of four kouroi that she considered closest to the Egyptian canon (see fig. 2) because the Thera kouros appears inside the inner circle with seven examples of the Egyptian canon, Ptoon 12, and Melos in the second principal components graph. Yet, in the one cluster analysis that includes the Thera kouros, it does not group with the Egyptian canon until the final stage of the analysis.[23]
4. The Florence kouros, in both principal components analyses, is nearer the central core of Egyptian examples than several of the five kouroi that Guralnick associates most closely with the Egyptian canon. In the cluster analyses with data set A, however, the Florence kouros does not group with the Egyptian canon until the number of clusters is very small: at 4 clusters with 21 objects (see table 1) and at 5 clusters with 28 objects.[24]
5. In the first principal components graph, Italian men are closer to the central core of Egyptian examples than they are to Turkish and Greek men and closer to the Egyptian core than is the New York kouros. This conflicts with the results of the cluster analyses, where the Italian men group quickly with Turkish and Greek men when the number of clusters is still quite high and continue to do so as the number of clusters is reduced (see table 1).[25]

Given these and other discrepancies, it is difficult to accept that the principal components analyses corroborate the cluster analyses.

Interestingly, as Guralnick points out, the five kouroi she identifies as closely similar to the Egyptian

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[21] In the first principal components graph (Guralnick 1978, 470, fig. 6), the Aristodikos kouros (which never grouped with the Egyptian canon in the cluster analyses with data set A) is closer than the New York kouros to the inner circle drawn around six examples of the Egyptian canon. In the second graph (Guralnick 1978, 471, fig. 7), the Florence, Volomandra, and Athens 10 (Ptoon 10) kouroi are all closer than the New York kouros to the inner circle around seven examples of the Egyptian canon. By contrast, in the cluster analyses, the New York kouros groups with the Egyptian canon well before any of these kouroi (see table 1 herein) (Guralnick 1978, 465–67, figs. 3–5).

[22] Melos and the Egyptian canon cluster together when the number of clusters is reduced to 5, both in the analysis with 21 objects (see table 1 herein) and in the analysis with 28 objects (Guralnick 1978, 465, fig. 3; 467, fig. 5 [as extrapolated]).

[23] With 28 objects using data set A (Guralnick 1978, 467, fig. 5), Thera clustered with the Egyptian canon only when the analysis was extended to five groups by extrapolation.

[24] Cluster analyses: Guralnick 1978, 465, fig. 3; 467, fig. 5. Using data set B (Guralnick 1978, 466, fig. 4), the Florence kouros groups with the Egyptian canon with six clusters but not with more or fewer.

[25] With data set A and 21 objects, Italians group with Turks and Greeks when the number of clusters is 19 (see table 1 herein); with data set B and 21 objects, the men group together when the number of clusters is 17 (Guralnick 1978, 466, fig. 4). With data set A and 28 objects, Italians, Turks, Greeks,

canon (New York, Melos, Tenea, Ptoon 12, and Thera) (see figs. 2, 3) do not represent either a chronological or a geographical group as one might have expected them to do.[26] Instead, the five statues span most of the sixth century, with the New York kouros (600–590 B.C.E.) and the Ptoon 12 kouros (530–520 B.C.E.) at opposite ends of this time span.[27] The geographical distribution of the five statues is equally wide: one from Athens (the New York kouros), two from the Cyclades (Thera and Melos), one from near Corinth (Tenea), and one found at the Ptoon sanctuary in Boeotia (Ptoon 12). By contrast, the New York kouros and the Sounion kouros, both made in Attica and probably within a decade of each other, did not cluster together using data set A even at the lowest threshold of similarity when the statues were divided into three clusters (see table 1).[28]

Guralnick first explains this seemingly random distribution of the five kouroi in space and time as the result of sporadic trips by Greek sculptors to study in Egypt; only sculptors "who had learned the system under a master would apply it."[29] This explanation does not fit well with what we know of Greek kouroi in general. During much of the sixth century, for example, kouroi that are from the same region and approximately contemporary are also visually similar. Apparently, sculptors working near one another did share technical and aesthetic preferences. Guralnick argues that similar treatments of the surfaces of statues may obscure the underlying proportional differences revealed by her statistical studies.[30] However, there is no obvious reason that sculptors working in the same region would intentionally produce statues that were superficially similar but quite different proportionally. Regional similarities should apply equally to both underlying proportions and surface treatment. If visually similar statues produced in the same region within a time frame of 10 or 15 years do not have similar proportions, the simplest explanation is that their sculptors did not use a standardized proportional system.

Guralnick also suggests that pattern books might have circulated among archaic sculptors and might have contained "copies of or adaptations from" the Egyptian system.[31] There is no evidence that sculptors used pattern books in the Archaic period or later. We know of no treatise or technical work about statues until the *Canon* of Polykleitos in the second half of the fifth century B.C.E.,[32] and a book by one sculptor about his own work is not the same thing as a pattern book with a variety of proportional systems. If such pattern books had been widely used by early Greek sculptors, we would expect a mixture of different styles, both visually and proportionally, to appear contemporaneously in various regions. Instead, regional sculptural styles dominate at least through the first half of the sixth century.

If neither sporadic study trips to Egypt by Greek sculptors nor pattern books convince, how can we explain some proportional similarity between the five kouroi (see figs. 2, 3) and the Egyptian canon? Let us repeat that cluster analyses do not indicate the degree of similarity among objects clustered together. Let us also remember that these kouroi did not all group with the Egyptian canon until far along in the analy-

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and the Strangford kouros consistently form one group for all the stages represented in the graph—14 clusters down to 5 clusters (Guralnick 1978, 467, fig. 5). The Greeks, Turks, and Italians only group with the Egyptian canon in the cluster analysis using data set B and only when the number of clusters is reduced to 3 (Guralnick 1978, 466, fig. 4).

[26] Guralnick 1978, 470. Illustrations and extensive bibliography for these kouroi can be found as follows. New York (Metropolitan Museum of Art, inv. no. 32.11.1, ht. 1.85 m): Richter 1970, 41–2, no. 1, figs. 25–32, 60–2; Boardman 1978, fig. 63; Floren 1987, 252 n. 6; Stewart 1990, 108–9, 111–12, figs. 49–55; Vorster 2002, 120–22, 304, fig. 190a–e. Thera (Athens, National Archaeological Museum, inv. no. 8, preserved ht. 1.24 m): Richter 1970, 69–70, no. 49, figs. 178–83; Boardman 1978, fig. 101; Floren 1987, 177 n. 7, pl. 13.2; Kreikenbom 2002, 147–48, 308, fig. 218a–d; Kaltsas 2002, 41, no. 22. Melos (Athens, National Archaeological Museum, inv. no. 1558, ht. 2.14 m): Richter 1970, 96–7, no. 86, figs. 273–79; Boardman 1978, fig. 102; Floren 1987, 178 n. 5, pl. 13.3; Stewart 1990, 119, fig. 117; Karanastassis 2002, 180–81, 312, fig. 253a, b; Kaltsas 2002, 50, no. 48. Tenea (Munich, Staatliche Antikensammlungen und Glyptothek, inv. no. 168, ht. 1.53 m): Richter 1970, 84–5, no. 73, figs. 245–50; Boardman 1978, fig. 121; Stewart 1986; Floren 1987, 188 n. 12, pls. 14.2, 15.1; Karanastassis 2002, 184–85, 313, fig. 262a–d. Ptoon 12 (Athens, National Archaeological Museum, inv. no. 12, preserved ht. 1.60 m): Richter 1970, 122–23, no. 145, figs. 425–29, 437; Ducat 1971, 346–51, no. 197, pls. 112–14; Boardman 1978, fig. 179; Floren 1987, 315 n. 41; Stewart 1990, 126, fig. 170; Maderna-Lauter 2002, 230–32, 319, fig. 309a–d; Kaltsas 2002, 62, no. 80.

[27] For the sake of consistency, dates of statues are taken from Boardman (1978) whenever possible.

[28] Data set A: Guralnick 1978, 465, fig. 3; 467, fig. 5. With data set B, 9 out of 17 kouroi, including the New York and the Sounion kouroi, did cluster with the Egyptian canon when the number of clusters was reduced to 3 (Guralnick 1978, 466, fig. 4).

[29] Guralnick 1978, 471.

[30] Guralnick 1978, 469.

[31] Guralnick 1978, 471.

[32] Gal. *De placitis Hippocratis et Platonis* 5; Plin. *HN* 34.55. Similarly, according to Vitruvius (*De arch.* 7, pref. 12), in the sixth century B.C.E., the architects Rhoikos and Theodoros wrote a book about their Temple of Hera on Samos, and Chersiphron and Metagenes likewise wrote about their Temple of Artemis at Ephesos.

ses (see table 1),[33] which suggests that no very strong proportional similarity does, in fact, exist among these kouroi and the Egyptian canon. Still, the combined results of the cluster and principal components analyses do appear to identify some degree of proportional similarity among these objects, and there must be a reason for this.

We cannot tell which proportioned dimensions in the data sets caused the cluster and principal components analyses to group these objects together. In 1985, Guralnick used a third method, z-score profile analysis (fig. 4),[34] to examine the proportions of kouroi. What the z-scores offer, and the other methods do not, is a visualization of the proportional dimensions. Using the z-scores, we are able to suggest what factors caused the earlier analyses to produce the groups they did.

Z-scores show how an object relates to the average (mean) of its class; the z-score is the distance of the object from the mean, measured in standard deviations, for each proportioned variable. In figure 4, the straight horizontal axis, centered at zero, represents the proportioned dimensions of the average Greek man,[35] and the vertical y-axis of the chart is marked in plus and minus standard deviations (SD) from this average man. If human males represent a statistically "normal" distribution, as is assumed, then the proportions of 68% of all human males will be between +1 and –1 SD from the average, 95% will be between +2 and –2 SD, and 99.7% will be between +3 and –3 SD. Basically, then, proportions that fall outside the area of +1 to –1 SD begin to be unusual, and a proportion that falls outside +3 to –3 SD can be expected to occur only once in 357 men. The mean and standard deviations for the average man as computed by Guralnick are not statistically comparable to the proportions of the kouroi (see below, under "Z-Score Profiles"). However, the average man used by Guralnick does provide a fixed paradigm against which other objects (Greek statues and the Egyptian canon) are compared, and this provides useful information about how the objects relate to one another.

The proportioned dimensions that are being compared to the average man are located at fixed points on the horizontal x-axis and labeled at the bottom of the graph (see fig. 4). Again, Guralnick has considered the measurements as ratios (each dimension of an object is divided by its height from the top of the knee to the top of the head). For each proportioned dimension, a point is charted at the appropriate place for that dimension on the x-axis and at a point on the vertical y-axis showing its distance from the average man. The distance on the vertical axis is measured in units that should correspond to the SD for that proportional dimension in the population of all men. For example, in figure 4, the proportional shoulder width of the New York kouros is charted at a little less than +1 SD from the average man. Thus, for that proportional dimension, the New York kouros should be within 68% of a normal population of men. The charted points are then connected, creating the irregular zigzag profile.

The chart (see fig. 4) shows that two kouroi (New York and Ptoon 12) and the Egyptian canon have, proportionally, shoulders that are a little wider than those of the average man and very slim waists. Three vertical dimensions—knee to navel, knee to nipples, and knee to sternum—in both kouroi and the Egyptian canon are, proportionally, quite similar to those of the average man and to one another; all are slightly less than those of an average man and are within less than 0.9 SD from one another. The head of the Ptoon 12 kouros is somewhat on the large side, and the head of the New York kouros is enormously large.

The similarity in the proportions of the five kouroi that Guralnick associated most closely with the Egyptian canon can be seen clearly in a column chart (fig. 5). Again, the average man is represented by the horizontal axis. All five statues and the Egyptian canon have slightly wide shoulders (except the Melos kouros), very narrow waists, narrow hips, and vertical dimensions from knee to sternum that are quite close to those of the average man. The head heights tend to be greater than the average man's.

In fact, as Guralnick's z-score profiles show, most kouroi follow this pattern; they have shoulders that are proportionately quite broad in relation to the waists and hips, and they have vertical dimensions from knee to sternum that are proportionately quite similar to one another and to those of the average man. Since all kouroi seem to have average proportions from knee to sternum that are close to the proportions of an aver-

[33] Using data set A with 21 objects (not including Thera), the 4 kouroi grouped with the Egyptian canon when the clusters were reduced to 8, about two-thirds of the way through the analysis (Guralnick 1978, 465, fig. 3). With data set A and 28 objects, the 5 kouroi did not all group with the Egyptian canon until the analysis was extended by extrapolation to 5 clusters (Guralnick 1978, 467, fig. 5). Using data set B with 21 objects (not including Thera), the 4 kouroi grouped with the Egyptian canon when the clusters were reduced from 21 to 11 (Guralnick 1978, 466, fig. 4).

[34] Guralnick's z-score charts place the anatomical dimensions on the vertical axis and the standard deviations on the horizontal axis; the orientation is reversed here.

[35] Guralnick 1982, 174 n. 7; 1985, 400.

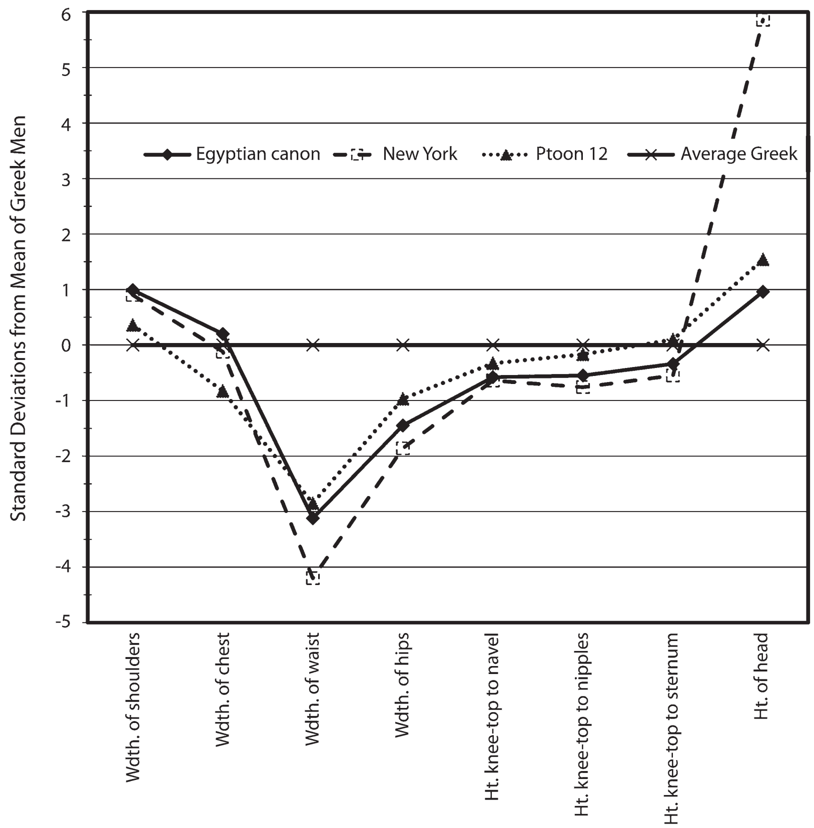

Fig. 4. Z-score profiles for the Egyptian second canon, the New York kouros, and the Ptoon 12 kouros, showing their proportioned dimensions in terms of standard deviations from an average Greek male. Dimensions are considered in proportion to the distance from the top of the knee to the top of the head for each object. The standard deviations are measured from Guralnick 1985, fig. 4. Guralnick's z-score charts place the anatomical dimensions on the vertical axis and the standard deviations on the horizontal axis; the orientation is reversed here.

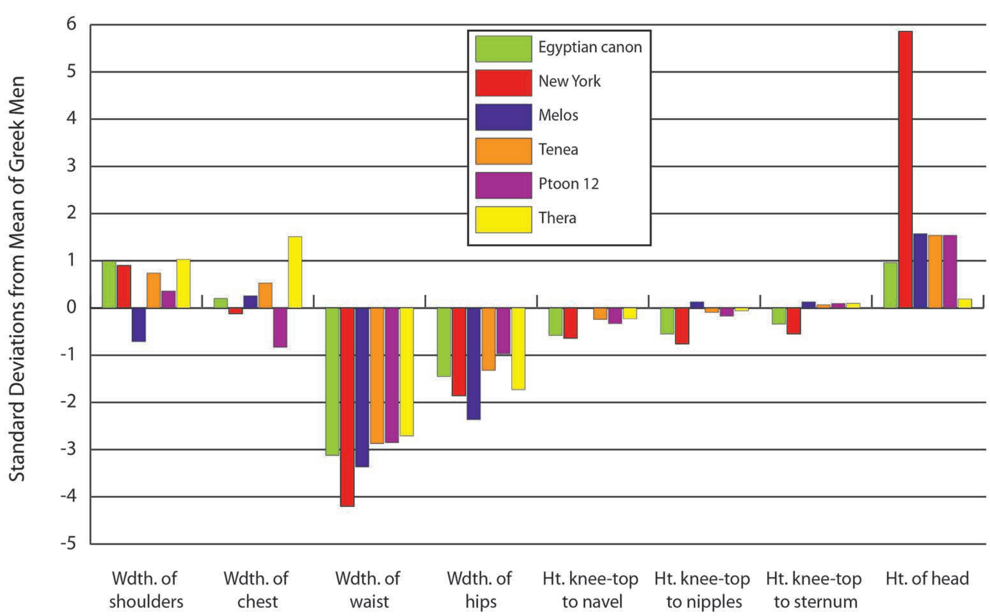

Fig. 5. Column chart showing the z-scores for the Egyptian second canon and the five kouroi that Guralnick found to resemble most closely the proportions of the Egyptian second canon. The horizontal axis of the graph at zero standard deviations represents the proportioned dimensions of an average Greek man. The z-score values are measured from Guralnick 1985, figs. 4, 5.

age man, it is primarily the non average proportions that differentiate the kouroi and are most influential in grouping certain kouroi as proportionally similar. One important non average factor is the difference between the proportional width of the shoulders and the proportional width of the waist relative to these dimensions for the average man. In these five kouroi, the shoulders are a little broader than average (except Melos), while the waists are a good deal more slender than average. Other kouroi show a strong proportional exaggeration of the width of the shoulders as well as the slimness of the waist. The Sounion and Munich kouroi, for example, are alike in having very broad shoulders (+2.62 and +2.55 SD, respectively) and very narrow waists (–2.04 SD for both).[36] In a group of late kouroi (Ptoon 20, Aristodikos, Strangford, and the Kritios Boy), a lesser but still notable difference between shoulders and waist is realized by shoulders that are proportionally broader than average and waists that are narrower than average but with less exaggeration of either dimension (table 2).[37]

There was thus a preferred idealization of the male physique in the sixth century B.C.E. that favored a greater-than-average proportional difference between the width of the shoulders and the width of the waist and close-to-average vertical proportions between knees and sternum. In addition, most kouroi have proportionally large heads, long lower legs, and tall total height.[38] Kouroi may be relatively slender or relatively thickset and still fit this general description. A regional preference for stockier proportions explains why, for example, the Munich and Anavyssos kouroi—which are both Attic and both dated to the third quarter of the sixth century B.C.E.—are associated by multivariate analyses (see table 1).[39]

This pattern, indeed, caused Guralnick to wonder whether all kouroi embody a single proportional ideal. She noted the same variations we have just described, namely, that the same basic proportional ideal occurs both in more slender kouroi and in broader kouroi for much of the sixth century and again in more naturalistic kouroi toward the end of the series.[40] She concluded that "the proportional patterns . . . most likely came from a widely accepted approach to idealization which individual sculptors felt free to modify in detail, if not in basic lines."[41] This seems entirely reasonable. Within this generally preferred idealization, however, Guralnick hypothesized that proportional similarities between any two kouroi are the result of the deliberate use of the same proportional scheme. She suggests, for example, that the Sounion kouros from Attica (ca. 590–580 B.C.E.) and the Ptoon 20 kouros from the Apollo Ptoon sanctuary at Thebes (ca. 510–500 B.C.E.) may have grouped together early in cluster analyses because both conform to a (non-Egyptian) canon "infrequently used but long known."[42] We, by contrast, believe that regional styles, operating within the generally preferred idealization, are a better ex-

[36] Measured from Guralnick 1985, 400, fig. 1; 406, fig. 7. The main proportional difference between these two kouroi is the width of the hips (Sounion: –0.75 SD; Munich: +0.33 SD). Sounion (Athens, National Archaeological Museum, inv. no. 2720, ht. 3.05 m, ca. 590–580 B.C.E.): Richter 1970, 42–4, no. 2, figs. 33–9; Boardman 1978, fig. 64; Floren 1987, 252 n. 9, pl. 20.1; Stewart 1990, 111–12, figs. 44, 45; Kaltsas 2002, 39, no. 17; Vorster 2002, 123–25, 305, fig. 193a–e. Munich (Munich, Glyptothek, inv. no. 169, ht. 2.08 m, ca. 540–530 B.C.E.): Richter 1970, 118, no. 135, figs. 391–94; Boardman 1978, fig. 106; Floren 1987, 256 n. 22, pl. 20.4; Karanastassis 2002, 175–77, 312, fig. 251a–d.

[37] The information in table 2 is measured from Guralnick 1985, 407, fig. 8; dates are from Boardman 1978, figs. 180, 182, 145, 147. Ptoon 20 (Athens, National Archaeological Museum, inv. no. 20, ht. 1.03 m, ca. 510–500 B.C.E.): Richter 1970, 134, no. 155, figs. 450–57; Ducat 1971, 355–62, no. 202, pls. 117–19; Boardman 1978, fig. 180; Floren 1987, 315 n. 41; Stewart 1990, 126, fig. 180; Kaltsas 2002, 71–2, no. 102; Maderna-Lauter 2002, 232, 319, fig. 310a–c. Attic style of Ptoon 20: Boardman 1978, 88; Stewart 1990, 124; Maderna-Lauter 2002, 232. Aristodikos (Athens, National Archaeological Museum, inv. no. 3938, ht. 1.95 m, ca. 510–500 B.C.E.): Richter 1970, 139, no. 165, figs. 492, 493; Boardman 1978, fig. 145; Floren 1987, 258 n. 31, pl. 20.5; Stewart 1990, 133, fig. 218; Kaltsas 2002, 66, no. 94; Maderna-Lauter 2002, 227–29, 319, fig. 307a–e. Strangford (London, British Museum, inv. no. B 475, ht. 1.01 m, ca. 510–500 B.C.E.): Richter 1970, 136, no. 159, figs. 461–63; Boardman 1978, fig. 182. Kritios Boy (Athens, Acropolis Museum, inv. no. 698, ht. 0.86, ca. 490–480 B.C.E.): Richter 1970, 149, no. 190, figs. 564–69; Boardman 1978, fig. 147; Stewart 1990, 133–35, figs. 219, 220; Kaltsas 2002, 58, no. 69.

[38] Of the 23 statues charted in z-scores (Guralnick 1985), 19 have heads that are proportionally greater in height than the head of an average man by more than +1 SD. Of the 11 complete kouroi charted in z-scores by Guralnick (1985), 8 are proportionally taller by more than +1 SD from baseline to knee-top than is an average man, and 9 are proportionally taller in total height than an average man (though only 3 are taller by more than +1 SD).

[39] See also the z-scores for these two statues (Guralnick 1985, 406, fig. 7). Both statues have wide shoulders, narrow waists, and wider-than-average hips. Kroisos from Anavyssos (Athens, National Archaeological Museum, inv. no. 3851, ht. 1.94 m, ca. 530 B.C.E.): Richter 1970, 118–19, no. 136, figs. 395–98; Boardman 1978, fig. 107; Floren 1987, 255 n. 21, pl. 20.3; Stewart 1990, 122, figs. 132, 134; Kaltsas 2002, 58, no. 69; Karanastassis 2002, 177–79, 312, fig. 252a–d.

[40] Guralnick 1985, 404–7.

[41] Guralnick 1985, 407.

[42] Guralnick 1978, 467, fig. 5; 469.

Table 2. Proportioned Dimensions of Four Late Archaic Kouroi in Standard Deviations from an Average Human Male (adapted from Guralnick 1985, fig. 8).[a]

Kouros	Width of Shoulders	Width of Waist	Height from Knee-Top to Navel	Height from Knee-Top to Nipple	Height from Knee-Top to Sternum
Ptoon 20 (ca. 510–500 B.C.E.)	+2.08	–0.73	–0.44	–0.09	–0.21
Strangford (ca. 510–500 B.C.E.)	+1.86	–1.46	–0.13	–0.29	–0.21
Aristodikos (ca. 510–500 B.C.E.)	+1.33	–1.14	+0.27	+0.38	+0.04
Kritios Boy (ca. 490–480 B.C.E.)	+2.37	–0.65	–0.12	–0.09	–0.01

[a] Guralnick presents this information as a z-score chart; the values shown here were obtained by measuring the distances on Guralnick's chart and converting the distances to standard deviations. Each dimension was considered as a proportion of the statue's height from the top of the knee to the top of the head.

planation for the proportional similarities that may exist among kouroi than are standardized proportional systems used sporadically in different places at different times.

It is probably the influence of regional style that best accounts for the seemingly random collection of five kouroi that Guralnick considered closest to the Egyptian canon (see figs. 2, 3). These five are all slender kouroi that share idealizing proportions of modestly wider-than-average shoulders, very narrow waists, and close-to-average heights from sternum to knee-top. All five have been associated with a style of sculpture that appears to have originated on Naxos and exercised notable influence on other Cycladic islands and the mainland. The New York kouros, which belongs to the earliest group of kouroi known from Attica, is carved from Naxian marble; Attic sculptors probably adopted the kouros type from Naxos and with it a Naxian preference for slender stature and linear surface patterning.[43] The Thera kouros (ca. 570–560 B.C.E.) is also made of Naxian marble. Boardman noted similarities between the head of this kouros, the head of the Melos kouros, and the head of a probably Naxian kore from the Athenian Acropolis (Athens, Acropolis Museum, inv. no. 677); recently, Kreikenbom has described the Thera kouros as a somewhat inept imitation of Naxian and Parian sculpture by a local Theran carver.[44] The Melos kouros (ca. 550 B.C.E.), also of Naxian marble, is universally considered to be the work of either a Naxian sculptor or a sculptor under strong Naxian influence.[45] The Tenea kouros (ca. 550 B.C.E.), from near Corinth, is sculpted from Parian marble. While there is general agreement about the Cycladic connections of this statue, scholars have tended to associate it more with Paros than Naxos, in part because of the relatively smooth carving of the torso.[46] Finally, Ptoon 12 (ca. 530–520 B.C.E., of "island marble"), found in the Ptoon sanctuary in Boeotia, belongs to what Ridgway has called the International Style.[47] Ridgway sees the regional schools of the earlier sixth century beginning to merge in the decade 540–530 B.C.E.; she believes that local styles cannot be distinguished after 530. At the Ptoon sanctuary, the local style came under Cycladic influence from Naxos and Paros in the decades between ca. 550 and 530 B.C.E.; Naxian sculptors may have migrated to the mainland when Lygdamis became tyrant on Naxos and confiscated unfinished works for resale ca. 540 B.C.E. (Arist. [*Oec.*] 2.2.2, lines 1346b9–13).[48] Parian and East Greek kouroi generally appear heavier than their Naxian counterparts, with fluid modeling of the surface. Attic kouroi become more thickset in the third quarter of the sixth century B.C.E., perhaps under Parian influence, but they continue the modeled athletic musculature of Attic kouroi from the second quarter of the sixth century. After ca. 530 B.C.E., some Ptoon statues begin to resemble the International Style of contemporary Attic kouroi. The well-muscled style of Ptoon 12 thus blends Cycladic

[43] Stewart 1990, 111; Ridgway 1993, 88.

[44] Naxian marble: Kaltsas 2002, 41, no. 22; see also Boardman 1978, 71; Kreikenbom 2002, 148.

[45] Pedley 1976, 35–6; Boardman 1978, 71; Floren 1987, 178; Stewart 1990, 119; Ridgway 1993, 85; Karanastassis 2002, 181.

[46] Stewart 1986, 61 (Paros-trained sculptor); Floren 1987, 188–89 (a Corinthian sculptor inspired by both Parian and Naxian kouroi); Martini 1990, 213 (more Parian than Naxian); Sturgeon 2006, 47 (closest to sculptures from Paros and Attica).

[47] Ridgway 1993, 80, 84–5.

[48] Stewart 1986, 119.

and Attic traits. However, the statue retains a Naxian slenderness that contrasts with the heavier proportions of contemporary Parian and Attic kouroi.[49]

Stylistic trends emanating from Naxos could explain the proportional similarities of these five kouroi. With the partial exception of the Tenea kouros, the connections of these statues to Naxian-related sculpture are fairly clear. The evolution of regional styles in the second quarter of the sixth century B.C.E. may also explain the proportional similarities of the Florence and Ptoon 10 kouroi (fig. 6). The Florence kouros (ca. 560 B.C.E., island marble) was probably carved by an Attic sculptor, while the sculptor of the Ptoon 10 kouros (ca. 550 B.C.E., Naxian marble), from the Ptoon sanctuary in Boeotia, was probably working under Naxian influence.[50] The clearly defined musculature and large head of the Florence kouros distinguish it immediately from the soft forms and fluid transitions of Ptoon 10. Yet, in Guralnick's cluster analysis using data set B, these two statues are linked more closely at the third stage of the analysis than any other statues are associated either with each other or with the Egyptian canon.[51] Relative to other kouroi, the Florence and Ptoon 10 kouroi are proportionally similar in that both have modest shoulder widths (+0.3 SD and –0.84 SD, respectively), extremely narrow waists (–4.03 SD and –3.31 SD, respectively), very narrow hips (–2.47 SD and –2.53 SD, respectively), and vertical dimensions from knee-top to sternum that are very close to those of the average man (–0.12 SD and +0.1 SD, respectively).[52] Attic kouroi in the second quarter of the sixth century begin to transform the earlier linear patterning of the surface into plastic modeling of anatomical structures, but they preserve the slender stature of the first generation of Attic kouroi (e.g., the New York kouros). The slender Ptoon 10 kouros has also relinquished surface patterning but—in contrast to Attic kouroi—in favor of smoothly modeled forms (more like Parian and East Greek statues). Both Florence and Ptoon 10, then, can be seen as embodying the slender proportions of the broadly defined Naxian style while developing different surface treatments. It is no surprise that Guralnick's analyses grouped the Volomandra kouros (ca. 570–560 B.C.E., Parian marble) with the five kouroi considered most like the Egyptian canon (see figs. 2, 3) and with the Florence and Ptoon 10 kouroi (see fig. 6).[53] The Volomandra kouros is a slender Attic funerary monument with flamelike hair and anatomical modeling similar to that of the Florence kouros.

Indeed, Guralnick's analyses appear to distinguish what could, in broad terms, be called a Naxian/Attic strain of kouroi that begins early and lasts into the third quarter of the sixth century (New York, Thera, Volomandra, Florence, Thebes 3, Melos, Ptoon 10, Tenea, Ptoon 12) and a Parian/Attic strain that begins later and continues longer (Paros, Keratea, Munich, Anavyssos, Kea, Ptoon 20, Aristodikos, Piombino, Kritios Boy).[54] These two principal proportional types can be illustrated by comparing the z-scores of the New

[49] Ducat 1971, 351 (the style of Ptoon 12 can be considered Naxian by process of elimination, but this is hypothetical because nothing is known about Naxian sculpture during this period); Boardman 1978, 88 (Ptoon 12 does not have contemporary Attic "clear grasp of form and features"); Floren 1987, 315 (only to be separated from Attic kouroi in stiff facial features); Maderna-Lauter 2002, 231–32 (Ptoon 12 resembles the Attic Anavyssos kouros, but compared with Attic kouroi, it is slender, almost delicate).

[50] Florence kouros (Florence, Archaeological Museum, ht. 1.39 m, ca. 560 B.C.E.): Richter 1970, 83–4, no. 70, figs. 239–44 (island marble); Boardman 1978, fig. 105; Floren 1987, 254 n. 13; Ridgway 1993, 89 (probably Athenian); Karanastassis 2002, 173–74, 312, fig. 250a–d. Ptoon 10 kouros (Athens, National Archaeological Museum, inv. no. 10, ht. 1.30 m, ca. 550 B.C.E.): Richter 1970, 100, no. 95, figs. 306–11; Ducat 1971, 271–78 (the Naxian origin of Ptoon 10 is "pratiquement sûre"), no. 147, pls. 78–80; Floren 1987, 315 n. 31 (related to Naxian sculpture); Kaltsas 2002, 47, no. 44 (mid sixth century B.C.E., Naxian marble, a Cycladic, perhaps Melian, workshop).

[51] Guralnick 1978, 466, fig. 4 (using data set B). The Florence and Ptoon 10 kouroi are also very closely associated in cluster analyses using data set A (see table 1 herein; Guralnick 1978, 467, fig. 5), principal components analyses (Guralnick 1978, 470–71, figs. 6, 7), and z-score analysis (Guralnick 1985, 405, fig. 6).

[52] Standard deviations measured from Guralnick 1985, 405, fig. 6.

[53] Volomandra (Athens, National Archaeological Museum, inv. no. 1906, ht. 1.79 m, ca. 570–560 B.C.E.): Richter 1970, 80–1, no. 63, figs. 208–16; Boardman 1978, fig. 104; Floren 1987, 253 n. 11, pl. 20.2; Stewart 1990, 119, fig. 120; Kaltsas 2002, 50, no. 47; Karanastassis 2002, 312, fig. 249a–e. For the proportional similarity between Volomandra and kouroi similar to Egyptian canon, see Guralnick 1978, 467, fig. 5; 468 (cluster analysis with data set A); 1985, 402, 404, fig. 5 (z-scores). For Volomandra grouped with Florence and Ptoon 10, see Guralnick 1978, 466, fig. 4; 469 (cluster analysis with data set B and principal components analysis).

[54] The only apparent anomaly in Guralnick's results is the Sounion kouros. As an Attic statue of the first quarter of the sixth century B.C.E., it should belong to the Naxian/Attic group. However, in the cluster analysis with 28 objects, Sounion groups with Ptoon 20 and the Kritios Boy when there are 14 clusters and with all the Parian/Attic statues when there are 7 clusters (Guralnick 1978, 467, fig. 5). The Sounion kouros also finally joins with the Parian/Attic kouroi in both cluster analyses with 21 objects (Guralnick 1978, 465–66, figs. 3, 4) and is quite close to Paros, Kritios Boy, and Piombino in the principal components analyses (Guralnick 1978, 470–71, figs. 6, 7). Sounion may be something of an outlier; in both cluster analyses with 21 objects, Sounion is the only object in its cluster until the number of clusters is reduced to 7. A com-

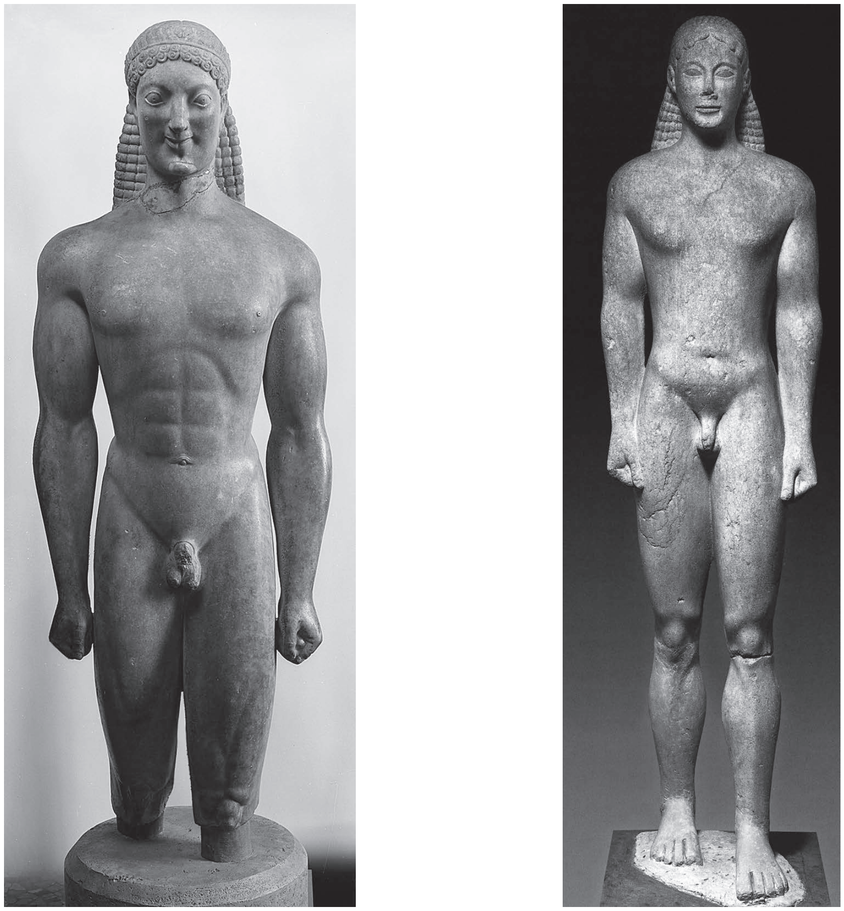

Fig. 6. Kouroi considered proportionally similar by Guralnick: *left*, Florence kouros (also known as the Milani kouros), provenance uncertain, island marble, ca. 560 B.C.E. Florence, Florence Archaeological Museum (H. Koppermann; © DAI Rome, neg. 1962.0001); *right*, Ptoon 10 kouros, from the Ptoon sanctuary in Boeotia, Naxian marble, ca. 550 B.C.E. Athens, National Archaeological Museum, inv. no. 10 (G. Fafalis; Kaltsas 2002, cat. no. 44).

York and Ptoon 12 kouroi to those of the Munich kouros and the three-times-life-sized statue of Isches from Samos (fig. 7). Made of local Samian marble and dated ca. 590–580 B.C.E., the Isches kouros provides a good example of the heavy physique and soft modeling of East Greek kouroi.[55] We would expect Isches to be more like the Parian/Attic proportional type than the Naxian/Attic. The z-scores of Isches suggest that this is the case (fig. 8); like the Munich kouros, he has notably wide shoulders, narrow waist, and vertical dimensions from knee to sternum that are a little greater than those of an average man.[56] By contrast, the New York and Ptoon 12 kouroi are consistently more narrow and not as tall (heads excluded) in their vertical dimensions.

Guralnick noted the same two basic proportional types and observed that the first group may have "a general proportional configuration related to that of the Egyptian canon."[57] This characterization, however, suggests a causal relationship that is not warranted. A visual examination of all these statues shows immediately that the statues of the Naxian/Attic group have

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parison of the z-scores of Sounion and New York (Guralnick 1985, 401, fig. 2) shows similar profiles, but Sounion has overall wider horizontal dimensions than New York.

[55] Kyrieleis (1986, 38) first dated Isches to ca. 580–570 B.C.E. but later (Kyrieleis 1996, 57) revised the date to ca. 600–580 B.C.E. The statue is now in the Vathy Museum on Samos (ht. as restored 4.78 m). For bibliography, see Kyrieleis 1986, 35–41, pls. 14–19; 1996; Floren 1987, 350 n. 31, pl. 30.5; Kreikenbom 2002, 144, 309, fig. 229a–c.

[56] Munich z-scores are measured from Guralnick 1985, 406, fig. 7; z-scores of Isches are taken from Guralnick 1996b, 521, table 1.

[57] Guralnick 1978, 466.

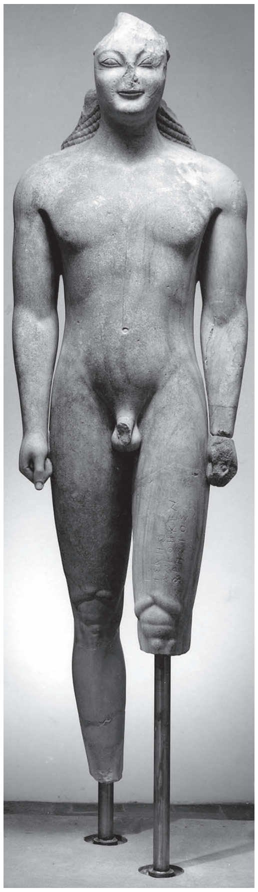

Fig. 7. Kouros dedicated by Isches in the Sanctuary of Hera on Samos, Samian marble, ca. 590–580 B.C.E. (E. Gehnen; © DAI Athens, neg. 1988/363).

relatively slender proportions, while the statues of the Parian/Attic group have relatively more thickset proportions. These resemblances are very general; they probably do reflect the influence of regional styles, but they lack the specificity that might imply an intentional use of standardized proportional schemes. The Egyptian canon describes a relatively slender figure, and so it is more like the slender group of kouroi, but this does not mean that these kouroi were proportioned according to the Egyptian scheme.

According to z-scores (see fig. 4), the Egyptian canon conforms to the same preferred idealization shown by kouroi: it has proportionally wider-than-average shoulders, a very narrow waist, narrower-than-average hips, close-to-average vertical dimensions between knees and sternum, and taller-than-average head, lower legs, and total height. Nine of the 13 proportions of the Egyptian canon charted by Guralnick fall within 68% of average men (i.e., within ±1 SD). The Egyptian proportions that depart from the majority of men are the very thin and slender waist (–2.97 and –3.12 SD), the slender hips (–1.45 SD), and the tall height of the knees from the baseline (+2.72 SD).[58] This is not an unusual kind of masculine ideal. Exaggerations of these proportions are common to idealized male figures of many eras and cultures, including modern western culture. The triangular torso of male figures on Greek geometric vases is an extreme case of this stylization.[59] Less obvious, perhaps, is the long lower leg, but this elongation, too, was a frequent characteristic in Greek and Roman art and in classicizing figures thereafter.[60] Greek geometric bronze figurines and painted male figures generally have elongated legs, and frequently the lower leg is (contrary to nature) longer than the thigh.[61] Since these exaggerated dimensions were at home in Greek art before the first kouroi, there is no reason that Greek sculptors need have imitated these idealizing proportions from Egyptian models.

Guralnick's studies also demonstrate how the proportions of kouroi evolve toward greater naturalism. If we look at the absolute distance (in SD from the average male) between the proportional widths of shoulders and waist for all the kouroi included in the z-score profiles, we can see how the relation between proportional shoulder and waist width changes over time (table 3).[62] The sum (i.e., the absolute distance) tends to diminish, though unevenly, over the course of the sixth century, regardless of regional preferences for slender figures (e.g., Melos, Ptoon 10) or for stockier figures (e.g., Kea, Aristodikos). As the sum shrinks, the statues become more like the average man, since, by definition, all proportions of the average man have the value of zero standard deviations. Even at the end of the series, however, the absolute distance remains unusually large, only once slipping below two standard deviations (with the Kea kouros). Even the more naturalistic kouroi continue the generally preferred idealization.

Guralnick's Methodology for Kouroi

The Statistical Techniques Used in Guralnick's Studies

In the previous section, we accepted the validity of Guralnick's published results and examined her interpretations of those results. We now look at her method-

[58] Measured from Guralnick 1985, 403, fig. 4.
[59] Cf. Boardman 2006, 20.
[60] Hollander 1978, 98–9.
[61] For geometric bronze male figures, see, e.g., Schweitzer 1971, pls. 130, 131, 136–39, 164, 165, 182–84, 185. For geometric vases, see, e.g., Schweitzer 1971, pls. 35, 36, 40, 69, 72.
[62] The z-scores are measured from charts in Guralnick 1985; date of the Isches kouros: Kyrieleis 1996, 57; date of Paros kouros: Stewart 1990, pls. 118, 119; date of Ptoon 10: Kaltsas 2002, 47, no. 44; all other dates: Boardman 1978.

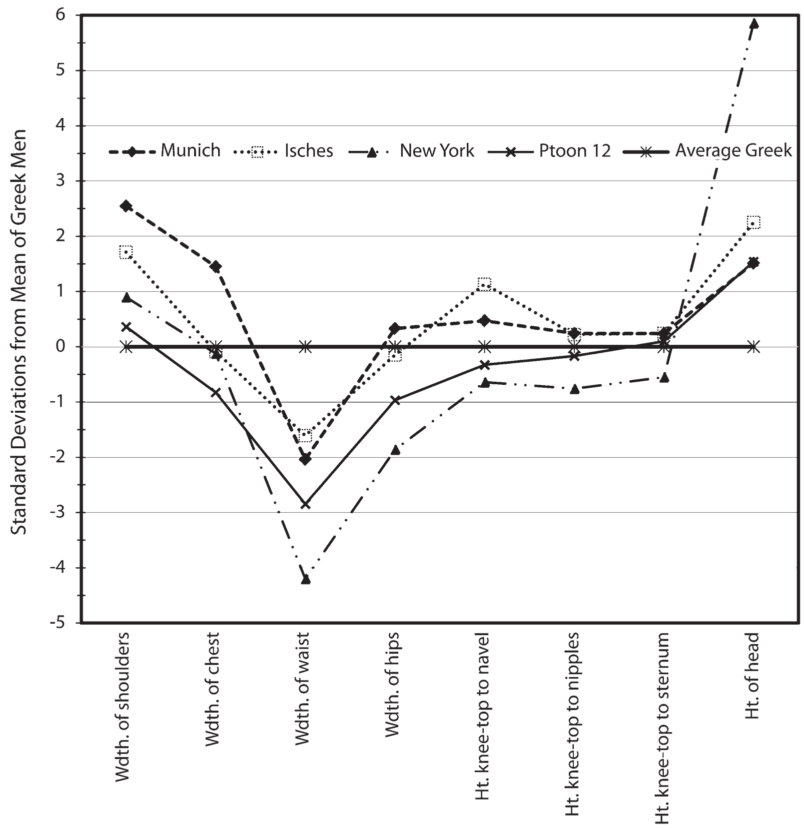

Fig. 8. Z-score profiles for the New York kouros, the Ptoon 12 kouros, the Munich kouros, and the Isches kouros showing their proportioned dimensions in terms of standard deviations from an average Greek male. Dimensions are considered in proportion to the distance from the top of the knee to the top of the head for each object. The standard deviations for the New York, Athens 12, and Munich kouroi are measured from Guralnick 1985, figs. 4, 7; the standard deviations for Isches are from Guralnick 1996b, tables 1, 2. Guralnick's z-score charts place the anatomical dimensions on the vertical axis and the standard deviations on the horizontal axis; the orientation is reversed here.

ology. First, we discuss each of the three techniques she used; then, we consider the data used in the analyses.

Cluster Analysis. Cluster analysis works by continually grouping objects into clusters with which they are most similar.[63] In fact, the exact algorithm by which the clustering proceeds depends on the particular method of clustering employed. Many possibilities exist.[64] Guralnick used the CLUS program from IBM, which produces clusters by minimizing trace W, where W is the pooled within-cluster covariance matrix.[65] In essence, each analysis with CLUS divides the data into a predetermined number of clusters so that the sum of the variances of the clusters is minimized. For example, if three clusters are created, the variance within each cluster would be computed in the standard manner.[66] Then the variances of the three clusters would be added together to compute the total variance of all the clusters. The CLUS algorithm moves objects among the clusters until the total variance of all the clusters is minimized.

It is therefore a simplification to say that similar objects group together. Since the CLUS method minimizes the sum of the variances of the clusters, an object could be in one cluster but actually be more similar to an object in another cluster. Where an object will go depends not only on the values of that object but also on the average values of the individual clusters. For example, in the cluster analysis with 28 objects,[67] the Munich kouros is grouped with the Keratea and Paros kouroi in cluster E when there are 14, 12, and 11 clus-

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[63] For cluster analysis in archaeology, see Baxter 1994, 140–84; 2003, 90–104; Shennan 1997, 216–60. For cluster analysis in general, see Everitt et al. 2001.

[64] Punj and Stewart 1983; Baxter 2003, 90–104.

[65] Guralnick 1976, 155; Punj and Stewart 1983, 139, tables 2, 3; Friedman and Rubin 1967.

[66] I.e., variance = (sum of the squared distances of each point from the average of the group)/(the number of points in the group minus 1).

[67] Guralnick 1978, 467, fig. 5.

Table 3. Sums of the Absolute Z-Scores of the Proportioned Widths of Shoulders and Waists of the Egyptian Second Canon and Greek Kouroi (adapted from Guralnick 1985, figs. 1, 3–8; 1996b, table 1).

Object	Date (B.C.E.)	Z-Score for Width of Shoulders[a]	Z-Score for Width of Waist[a]	Sum of Absolute Standard Deviations of Shoulders and Waist
Egyptian canon	–	+0.99	–3.12	4.11
New York	ca. 600–590	+0.90	–4.20	5.10
Sounion	ca. 590–580	+2.62	–2.04	4.66
Isches	ca. 590–580	+1.71	–1.61	3.32
Ram-bearer	ca. 580	+1.39	–2.09	3.48
Kleobis	ca. 580	+4.32	–1.11	5.43
Biton	ca. 580	+3.55	–1.44	4.99
Thera	ca. 570–560	+1.03	–2.71	3.74
Volomandra	ca. 570–560	+0.74	–3.43	4.17
Florence	ca. 560	+0.30	–4.03	4.33
Thebes 3	ca. 550	+0.67	–2.69	3.36
Melos	ca. 550	–0.71	–3.36	2.65
Paros	ca. 550	+1.10	–2.25	3.35
Keratea	ca. 550	4.74	–1.07	5.81
Ptoon 10	ca. 550	–0.84	–3.31	2.47
Tenea	ca. 550	+0.74	–2.87	3.61
Munich	ca. 540–530	+2.55	–2.06	4.61
Anavyssos	ca. 530	+2.15	–1.2	3.35
Kea	ca. 530	+0.12	–1.42	1.54
Ptoon 12	ca. 530–520	+0.36	–2.85	3.21
Ptoon 20	ca. 510–500	+2.08	–1.05	3.13
Strangford	ca. 510–500	+1.86	–1.46	3.32
Aristodikos	ca. 510–500	+1.33	–1.16	2.49
Kritios Boy	ca. 490–480	+2.37	–0.65	3.02

[a] The z-scores are expressed in standard deviations for average human males. For all kouroi except Isches, Guralnick presents this information only in z-score charts; the values shown here were obtained by measuring the distances on Guralnick's charts and converting the distances to standard deviations.

ters, but it joins cluster F with the Anavyssos, Kea, and Aristodikos kouroi when there are 13 clusters. A first response might be to conclude that Munich is more similar to Keratea and Paros than to Anavyssos, Kea, and Aristodikos, since it first groups in cluster E with Keratea and Paros with a larger number of clusters (14 clusters) and then returns to E with 12 and 11 clusters. However, this is probably not true, since the Munich kouros groups soon and consistently with the Anavyssos kouros in the two other cluster analyses and is close to Anavyssos and Kea in the principal components charts. Thus, one should interpret Guralnick's clusters as implying that for a predetermined number of clusters, groups of objects are most similar as aggregates; one should not conclude that an individual object in one group is more similar to other individual objects in the same group than to any other object in another group. (The exception to this would be at the early stage of analysis when clusters have only two objects in them. In this case, the objects that are most similar to each other will most likely pair together.)

Guralnick might have chosen another similarity measure to cluster the objects rather than minimizing the trace of W. There were a number of different algorithms available in the 1970s and 1980s, and each algorithm used one of several different similarity measures and a particular method to minimize the similarity measure used. Studies have shown that analyses of the same data set by different algorithms and different similarity measures produce different results.[68] Given a particular set of variables, some methods perform better than others. For example, minimizing the determinant of W or maximizing the trace of BW^{-1} (where B is the between-cluster covariance matrix) has the advantage of accounting for covariance in the data (which very likely existed in Guralnick's data sets). The primary advantage of the trace W measure is the ease with which it can be computed; the capacity of a computer to perform the algorithm was an important consideration in the 1970s (and is a far lesser concern today).[69] For our purposes, it is important to note that other algorithms using different similarity measures or different minimization methods might have produced different groupings than Guralnick's analyses did. Furthermore, it is not possible to know a priori which method will work best for a given data set, and, when the classification of the objects is not known beforehand (as was the case with Guralnick's studies), it would not be possible to determine which results are better even after several methods had been used.[70]

Another important consideration is the robustness of cluster analysis to the particular values in the data set. For example, it is well known that the method is sensitive to outliers, the presence of which can distort the model results.[71] The sample of kouroi certainly includes outliers such as the Dermys and Kitylos pair and the Kleobis and Biton pair. The Dermys and Kitylos pair is so different from other kouroi that if it were put in a cluster with other kouroi, the variance of that cluster would increase dramatically. Thus, the program avoids putting the Dermys and Kitylos outlier into a cluster as long as it can (see table 1 [the Dermys and Kitylos pair formed its own cluster until the number of clusters was reduced to five]). In order to keep Dermys and Kitylos isolated, however, the program is forced to group together other objects that may not actually have a high degree of similarity.

Cluster analysis is also sensitive to the exact values of data. Small changes in the value of a variable can move the data point from one cluster to another.[72] The results of Guralnick's cluster analyses thus depend on the reliability of the exact values of the data she has used for the kouroi and the Egyptian canon. Guralnick first measured kouroi in 1968 for her doctoral dissertation. For this project, which did not use statistical analyses, she included eight life-sized, completely preserved kouroi; of these, she herself measured six, and she used previously published dimensions for the other two.[73] Guralnick adopted the measurements of these kouroi from her dissertation for her statistical studies, adding measurements of additional kouroi taken in 1974.[74] The tables in her dissertation that record the dimensions of the initial eight kouroi report the "averages of actual dimensions."[75] This indicates that Guralnick took several measurements and then used the average value for her study. By the central limit theorem, one expects that the greater the number of measurements taken and averaged, the more accurately and precisely the actual dimension can be estimated. The amount of precision in the estimate is measured by the deviations of the measurements from their mean. Guralnick does not provide these deviations or the number of measurements taken, so we cannot estimate this uncertainty; but the fact that she used averages implies that there was measurement error of unknown magnitude in the data. While the amount of deviation in Guralnick's data might have been small, it is nevertheless likely to have affected the clustering.

The data used for the Egyptian canon present more serious problems with respect to exact values because Egyptian figures do not conform exactly and consistently to surviving or restored grids. Guralnick remarks on this in her dissertation. There she gives a range of values for the shoulder width (6 to 7 units) and waist width (2.5 to 3 units) of the second canon.[76] For the cluster analyses and the z-score profiles, however, Guralnick used a single set of values for the dimensions of the Egyptian canon, which means that she must have either used an average value or selected one value within the range shown by Egyptian figures on some other basis. If somewhat different values for the Egyptian canon had been used in the analyses, we would

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[68] Friedman and Rubin 1967; Everitt et al. 2001, 65–7, 94–9; Baxter 2003, 103–4.

[69] Seber 1984, 383. It is possible, for example, that Guralnick extrapolated the division into five clusters in her cluster analyses with 28 objects because this task exceeded the capacity of the computer (Guralnick 1978, 467, fig. 5).

[70] Shennan 1997, 254.

[71] Punj and Stewart 1983, 143–44; Baxter 1994, 165–66; Baxter 2003, 102. Principal components analysis is also sensitive to outliers (James and McCulloch 1990, 142; Baxter 1994, 79–80).

[72] Morrison 1990, 385: "small perturbations in the data might lead to very different clusters."

[73] Guralnick 1970, 3, 40. Guralnick measured Dermys and Kitylos, and the Tenea, Volomandra, Melos, Anavyssos, and Munich kouroi. She used previously published measurements for the New York and Aristodikos kouroi.

[74] Guralnick 1978, 461.

[75] Guralnick 1970, 108–24, tables 1–8.

[76] Guralnick 1970, 41–2, 127, table 10. Guralnick also gives a range of 1.75 to 2.25 units for the height of the face.

expect the results to have been different. The range of values reported in Guralnick's dissertation for the width of shoulders and waists in the second canon has particular importance, as we have identified the proportional widths of shoulders and waists as critical factors in identifying similarities among the kouroi and the Egyptian canon.

As discussed above, cluster analysis cannot produce measures of statistical significance. For this reason, an essential aspect of cluster analysis is its function as an exploratory data tool.[77] It should be used to suggest hypotheses, not confirm them. As James and McCulloch note, "cluster analysis produces clusters whether or not natural groupings exist"; they warn that the results are "frequently overinterpreted."[78] Guralnick did use principal components analysis to provide validation for the cluster analyses, but, as noted above, there are serious incongruities in the two sets of results.

Principal Components Analysis. Typically, principal components graphs show the value of the first principal component on the horizontal axis and the second principal component on the vertical axis.[79] Principal components are created from linear transformations of the data so that each principal component is orthogonal to all others. The original data points may then be graphed with respect to each principal component. With 11 variables in data set A, there are 11 principal components. Each principal component explains a portion of the total variance of the data set. The first principal component explains the greatest amount of the total variance.[80]

Points (in this case, the points represent the individual statues, men, and the Egyptian canon) are plotted in this x-y space, and one may visually inspect the plot to see if any obvious clustering can be detected. Guralnick's graphs include several circles around various groups of points.[81] The purpose and justification for the circles are not explained. Such circles are not a standard technique, and one assumes that they were meant to help visualize distances between points considered central to the analysis (e.g., the points representing the Egyptian canon). When the circles are removed from the graphs, obvious clustering is not visible, except possibly for a group with seven Egyptian examples and the Ptoon 12, Melos, and Thera kouroi. It is also noteworthy that such graphs are not considered useful unless most of the variance of the data set is explained by the first two principal components.[82] However, no statistical results were provided to show what proportion of the total variance is contained in the first two components.

Z-Score Profiles. As Guralnick explains, the z-score method is based on the idea that there is a distribution of human proportions (with a shape similar to a bell curve) so that for a given proportion, one can find its average value and standard deviation (a measure of the spread of values around the average).[83] A person possessing this average value would be labeled "perfectly average" by Guralnick. As noted above, 99.7% of humans should fall within three standard deviations on either side of the average value. Guralnick used the anthropometric survey of air force personnel done by NATO to arrive at the mean and distributions of proportioned dimensions for real men.[84] Following standard statistical practice, the distributions are characterized by an average value of zero and a standard deviation. They are assumed to describe normal random variables (i.e., the proportions are assumed to be normal random variables). The analysis then proceeds by comparing the proportioned dimensions of kouroi to these distributions, and claims are made regarding the unlikeliness of a proportion being three or more standard deviations from the average.[85]

For these comparisons to be valid, however, it is essential that the average proportion and the accompanying standard deviation be computed correctly. For most of her z-score charts, Guralnick considered each dimension in proportion to the height of the figure from top of knee to top of head. The correct way to compute the mean and standard deviation for each proportioned dimension of real men would have been to compute the ratio between each dimension and the knee-top to head-top distance for every individual man. After doing this with all the men in the NATO study, then, for each dimension, a plot could be made of the ratios obtained vs. the number of times each ratio ap-

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[77] Punj and Stewart 1983, 146; Shennan 1997, 255.

[78] James and McCulloch 1990, 148. James and McCulloch (1990, 136, 158) point out that overinterpretation leads to "the unjustified assignment of causation in the absence of experimentation"; see also Punj and Stewart 1983, 145–46. Baxter (2003, 27, 103–4) provides an example of the pitfalls of cluster analysis using 494 artifacts at the Mask Site (an Inuit camp site); cluster analysis clearly identified a seven-cluster solution that "archaeologically . . . does not make sense"; cf. Gordon 1999, 6, 183–84.

[79] For principal components analysis in archaeology, see Baxter 1994, 48–99; 2003, 73–98; Shennan 1997, 265–305.

[80] Morrison 1990, 312–42. Shennan (1997, 288–97) gives a useful illustration.

[81] Guralnick 1978, 470–71, figs. 6, 7.

[82] Dunteman 1989, 78.

[83] For z-score analysis in archaeology, see Shennan 1997, 74–7; see also Guralnick 1982, 174–75.

[84] Herzberg et al. 1963; Guralnick 1978, 463 n. 22. The same NATO study was used for the cluster and principal components analyses.

[85] E.g., Guralnick 1985, 401–2.

peared. The result would be similar to a bell-shaped curve from which the mean and standard deviation for each proportional ratio could be computed.

However, Guralnick could not have plotted a bell-shaped curve in this way because the NATO publication does not provide these data for all the individual men in the study. Rather, the NATO publication reports only the mean and standard deviation for each dimension of the men. The authors were interested in actual dimensions of real men, not proportional relationships. By contrast, Guralnick's project involved representations of human figures, some life-sized and some larger or smaller than life-sized. She therefore compared kouroi using proportional ratios rather than actual dimensions, and this means that she needed the mean and standard deviation for each proportional ratio of real men, rather than for each dimension, to compare with the kouroi.

A hypothetical example may be helpful here. Suppose we wanted to compute the "perfectly average" university nationwide with respect to student-faculty ratios. The correct way to do this is to find the ratio for each school in the nation, sum the ratios together, and then divide by the number of schools to get the average student-faculty ratio for a U.S. university. This method is equivalent to measuring the NATO men, expressing the dimensions of each man as a ratio, and then computing the average value of all the ratios.

In contrast, one could divide the total number of students attending all U.S. universities by the number of universities to get the average number of students per school (call this S). Then one could divide the total number of university faculty in all U.S. universities by the number of universities to get the average number of faculty per school (call this F). Finally, one could divide the average number of students per school (S) by the average number of faculty per school (F) to find the ratio of students to faculty across the country (S/F). This method, which is equivalent to the method that Guralnick used, does not give the average student-faculty ratio for U.S. universities but rather is simply a ratio of two averages, S and F.

The two methods will not yield the same result.[86] For our purposes, the important difference is that the second method does not produce a random variable similar in kind to the ratio obtained from averaging the ratios of the individual schools (which were computed from the number of students and faculty at each individual institution). Hence, the value obtained by the first method is not comparable to the value computed by the second method.

Guralnick does not explain the method she used to chart the z-scores of kouroi and korai in her articles of 1982 and 1985; however, in her more recent study of the colossal Isches kouros from Samos (see fig. 7), she does provide enough information to permit a reconstruction of her procedure. Here, in addition to a z-score profile that compares proportions of the Isches kouros with those of an average Greek man, Guralnick includes a table showing the values used to create the z-score profile;[87] the information is given in table 4. The columns show (left to right) the actual dimensions (in cm) of the Isches kouros, the mean and standard deviations for dimensions of Greek men as reported by the NATO study,[88] and the z-scores for the Isches kouros using the distance from knee-top to head-top as the proportioning base. The standard deviations for Greek men are given in centimeters, indicating the spread of values around the mean value of the dimensions of Greek men. However, Guralnick's data do not include the measures of interest for comparing the proportions of Isches to those of real men, that is, the mean and standard deviations of the ratios between the dimensions and the proportioning base (which, as ratios, would not be expressed in any unit of measurement).

Guralnick apparently proceeds as follows. Each dimension of the Isches kouros is divided by the height of the statue from knee-top to head-top (329.1 cm). This ratio is then used to compute what the dimensions of Isches would be if the statue had the same height from knee-top to head-top as the average Greek man.[89] Then the difference between each converted dimension of the kouros and the mean dimension for Greek men is expressed in terms of the standard deviation for that (unproportioned) dimension. Thus the ratio of shoulder width to knee-top-to-head-top height for Isches is 131.9 cm/329.1 cm (see table 4).

[86] Suppose one school has 300 students and 50 faculty members, another has 600 students and 20 faculty, another has 700 students and 100 faculty, and another has 300 students and 40 faculty. Using the first procedure, the average value of the student-teacher ratio is 12.6 students per faculty member. Using the alternative procedure, the average number of students per school (475 students) is divided by the average number of faculty per school (52.5 faculty), and the overall ratio is computed as 9.0 students per faculty member.

[87] Guralnick 1996b, 512, fig. 1 (z-score profile); 521, table 1 (data used for the profile).

[88] Herzberg et al. 1963, 153 (shoulder wdth.), 154 (chest wdth.), 156 (waist wdth.), 157 (hip wdth.), 128 (ht. of sternum), 129 (ht. of nipples), 130 (ht. of navel), 135 (ht. of knee-top).

[89] E.g., let x = the shoulder width of Isches if the statue were the same height as an average man. Then x/knee-top to head-top distance of the average man = shoulder width of Isches/knee-top to head-top distance of Isches.

Table 4. Dimensions of Isches Kouros, Average Dimensions and Standard Deviations of Greek Men, and Z-Scores for Dimensions of the Isches Kouros (after Guralnick 1996b, tables 1, 2; fig. 1).

Variable	Isches (cm)	Average Greek Man (cm)	Standard Deviation of the Variable for Greek Men (cm)	Z-Score of Isches for Variables Proportioned to Isches' Height from Knee-Top to Head-Top
Wdth. of shoulders	131.9	44.69	2.25	+1.71
Wdth. of chest	83.6	30.94	1.97	–0.09
Wdth. of waist	71.5	29.27	1.84	–1.61
Wdth. of hips	90.7	33.62	1.62	–0.15
Ht. knee-top to navel	149.4	51.05	3.47	+1.13
Ht. knee-top to nipples	204.2	74.35	3.64	+0.22
Ht. knee-top to sternum	243.7	88.75	3.86	+0.24
Ht. of head	66.9	22.64	0.88	+2.25
Ht. knee-top to head-top	329.1	121.10	4.16	0.00

If the kouros had the same height from knee-top to head-top as the average Greek man (121.1 cm), then its shoulder width would be 48.54 cm, or 3.85 cm more than the shoulder width of the average Greek (44.69 cm). Expressed as a z-score (i.e., in terms of the standard deviation of 2.25 cm for the shoulder width of Greek men), the shoulder width of Isches is +1.71 (i.e., 3.85/2.25).[90] Guralnick uses the z-scores computed in this way to create z-score profiles of the Isches kouros.[91]

This is not a valid procedure because it does not compare the proportional value of Isches' shoulder width relative to his knee-top-to-head-top height with the computed mean and SD of this proportional value for the average Greek. We would have to begin by computing the proportional value of the shoulder width to the height from knee-top to head-top for every Greek man in the NATO sample. But, as noted previously, the NATO study does not give the individual dimensions of each man measured, only the average value and standard deviation for each dimension. Guralnick, therefore, could not have produced a random variable and an associated SD for the proportional values of the men that would be statistically comparable to the proportional values of the statue. Hence, we must conclude that the z-score profiles in which the dimensions of the Isches kouros are compared to the average Greek man have little or no statistical meaning. The same must be true of the z-score profiles in Guralnick's earlier studies of kouroi and korai. They do not show statistically meaningful comparisons between the kouroi (or the Egyptian canon) and an average man, and the profiles would have different shapes if they were charted with z-scores for proportional values.

Measuring the Egyptian Canon

Guralnick seems, for the most part, to consider the Egyptian second canon as an invariable and comprehensive proportional system.[92] The surviving evidence for the Egyptian system, however, indicates that it was neither as fixed nor as comprehensive as her studies imply.

Of the 11 anatomical dimensions in data set A, two or three appear to be defined by grid lines in the Egyp-

[90] The table published by Guralnick (1996b, 521, table 1) contains several errors. The height from top of knee to sternum is given as 240.7 in tables 1, 3a, 3b, 4, 5, and 6 but appears as 243.7 cm in table 2. The value of 243.7 produces the z-scores of 0.24 and –0.49 given in table 1. For height from top of knee to navel, the top-of-head to top-of-knee z-score is given as –1.13 in the table. This should be +1.13, and it is charted as a plus value in the z-score chart created from this data (Guralnick 1996b, 512, fig. 1). For depth of chest, the base to top-of-head z-score is given as –0.49; this should be –1.49. For base to navel, the base to top-of-head z-score is given as 0.00; this should be +1.33.

[91] Guralnick 1996b, 512–15, figs. 1–4.

[92] The Egyptian canon is treated as a single set of values in the cluster analyses and the z-score analyses. Eight examples of the Egyptian canon are charted in the principal components analyses (Guralnick 1978, 470–71, figs. 6, 7), and the article on Boeotian kouroi mentions two sets of values for the Egyptian canon included in cluster analyses, as if they were two additional statues (Guralnick 1996a, 39).

tian canon (see fig. 1): nipples to navel (3 units), navel to top of knees (6 units), and possibly sternal notch to nipples (perhaps 2 units, but Egyptian figures often wear a broad collar that covers the sternal notch). Other anatomical points—top of head, bottom of chin, and the widths of the head, shoulders, chest, waist, and hips—are not demarcated by grid lines.

Guralnick does not explain how she obtained the values for these ungridded dimensions of the Egyptian canon. Five two-dimensional Egyptian male figures with preserved grid lines are cited in her dissertation, and she apparently based the values for ungridded dimensions on these drawings.[93] In three drawings (one of which represents the same figure as fig. 1), the chin is about 19.5 units above the baseline; in the fourth drawing, it is about 19.7 units high; and in the fifth, about 19.3 units high. Guralnick assigned a value of 19.5 units for this dimension. In one drawing (see fig. 1), the total height of the figure is about 22.5 units; in three other drawings, the total height is a little less, and in one drawing, it is a little more. Guralnick assigned a value of 22.5 units for this dimension.[94] It seems clear that the values she used were rough averages rounded off to the nearest simple fraction, whereas the Egyptian examples do not indicate that the height of the chin or the total height had fixed, canonical values. Rather, the use of guidelines seems only intended to assure that ungridded anatomical features would be placed more or less uniformly.

The same conclusion applies to dimensions of width, most of which do not correspond to grid lines. This is true of the earlier Egyptian system, in which the vertical lines (which guide the horizontal dimensions) have a much looser relationship to the figure than do the horizontal lines that mark vertical distances from the baseline. The horizontal lines cross the figure at the hairline (18 units), at or near the junction of neck and shoulders (16 units), at or near the nipple (14 units), at or near the bottom of the rib cage (12 units), at or near the bottom of the buttocks (9 units), and at the top of the knees (6 units).[95] By contrast, the central vertical axis may pass through the front, middle, or back of the ear.[96] Vertical lines 3 squares to either side of this central axis usually define the outside of the upper arms, and often vertical lines 2 units on either side of the vertical axis pass through the armpits. However, the width of the waist and the depth of the hips do not correspond to vertical lines of the grid. Beyond a total width of approximately 6 units and upper arm width of 1 unit, then, there is no regular correspondence between vertical lines and anatomical points in the way that horizontal lines regularly mark fixed parts of the body. In the Late Period, with the second canon, the situation is even freer, and vertical lines usually do not align with any part of the figure. Robins illustrates two drawings from Theban tombs of the 26th Dynasty in which original grid lines have survived (see fig. 1).[97] In neither do the vertical lines correspond to the widest points of the shoulders, the chest, the waist, the hips, or the thighs.[98] Iversen and Robins agree that Egyptian representations follow a canonical pattern for vertical dimensions more closely than for horizontal dimensions, and Iversen observes that horizontal variations were greater with the second canon than with the earlier system.[99]

This is problematic for the cluster, principal components, and z-score analyses, all of which include about the same number of horizontal dimensions as vertical dimensions. Since the Egyptians allowed flexibility in the horizontal dimensions while adhering more strictly to some vertical dimensions, we would expect that Greek sculptors using the Egyptian system would likewise be more concerned with observing a standard set of vertical proportions. Thus, if Greek sculptors had used the Egyptian canon, it would be the vertical, not the horizontal, proportions of the kouroi that would most convincingly reflect their dependence on the Egyptian method. In Guralnick's cluster analysis, however, the horizontal dimensions appear to have played a more important part in defining clusters than the vertical dimensions did. As Guralnick noted, the cluster analyses "singled out . . . as frequently being

[93] Guralnick (1970, 41, 127, table 10) recognizes variable horizontal values and gives the dimensions for the widths of waist and shoulders as 2.5–3.0 squares and 6–7 squares, respectively. The five drawings on which Guralnick relied are Guralnick 1970, figs. 12, 14, 40 (three standing male figures from the 26th Dynasty [including the figure on which fig. 1 herein is based], all reproduced from Iversen 1955, figs. 5, 9, 4, respectively); fig. 39 (a standing, nude, male child from Memphis, 26th Dynasty, reproduced from Edgar 1906, 55); fig. 42 (a standing male figure from the Persian or Ptolemaic period reproduced from Murray 1930, 27).

[94] Guralnick 1970, 127, table 10.

[95] Robins 1994, 70–4, fig. 4.8.

[96] Robins 1994, 61.

[97] Robins 1994, 161, figs. 7.1, 7.2.

[98] Robins (1994, 160–63) states that, in the late Egyptian grid, "armpits are roughly 5 squares apart," "the distance across the shoulders is approximately 7 squares," and "the width across the body at the level of the small of the back is roughly 2¾ to 3 squares."

[99] Iversen 1975, 79. Robins (1994, 61) remarks, in reference to applying a grid to any Egyptian figure: "it is more difficult to place the verticals [i.e., the vertical lines of the grid], because there are no points to which they are exactly fixed."

significant determinants in the clustering decisions . . . the distance from eye to the chin, and the widths of the head, the shoulders, the chest, and the thighs" (i.e., one vertical and four horizontal dimensions).[100]

The vertical dimensions may have had less influence on the clustering than the horizontal dimensions because the amount of variation in the vertical proportions is considerably less than the variation in the horizontal dimensions. This can be seen clearly in the z-scores of the Egyptian canon and five kouroi (see fig. 5). Here, the heights of the kouroi from knee to navel, knee to nipples, and knee to sternum are almost always within +0.1 to –0.5 standard deviations of the average male. For the Egyptian canon, these standard deviations are –0.58 (knee to navel), –0.55 (knee to nipple), and –0.34 (knee to sternum).[101] The vertical proportions of the kouroi and the Egyptian canon are both quite similar to each other and quite close to those of an average man. These apparently naturalistic dimensions in both the canon and the kouroi are probably the result of their resemblance to real humans; there is no reason to conclude that they reflect Greek use of the Egyptian system.

There is one vertical dimension of the second canon that is not within the range of most real men, and that is the height from baseline to knee-top (+2.68 SD). A kouros that was proportioned according to the second canon (and not according to nature) should be similar to the canon in this dimension. Three of the five kouroi found by Guralnick to resemble closely the Egyptian canon are complete; the other two, Ptoon 12 and Thera, are broken below the knees. For the complete kouroi, Guralnick charts the knee heights in standard deviations from an average man as follows: +1.55 for New York; +0.85 for Melos; +2.38 for Tenea.[102] In the case of the vertical proportion of the Egyptian canon that is least imitative of nature, then, there are sizeable differences among the canon and the kouroi.

Our observations about the values used by Guralnick for the Egyptian canon are connected to a basic methodological problem. Should the Egyptian canon be considered a complete system of fixed values, as Guralnick assumed, or did it operate more loosely as a limited set of guidelines? This and related questions have been central to the discussion of the Egyptian system for the last century.[103] Several scholars in the first half of the 20th century believed that, in practice, Egyptian artists used the proportional system somewhat flexibly. Edgar, for example, thought that the Egyptian artist "worked with a good deal of freedom" and "was content to come within reasonable closeness to the conventional standard."[104] A major challenge to this view came in 1955 with the publication of Iversen's *Canon and Proportions in Egyptian Art*. Iversen believed that in real humans, "the separate parts of the body are related to each other proportionately and . . . these natural proportions are regular and relatively fixed irrespective of the differing dimensions of individual persons."[105] He thought that the dimensions of one body part will equal the same multiple or fraction of another body part for all parts of all human beings. Thus, in Iversen's view, the Egyptian system could use one body part as a proportioning system for the whole figure and thereby produce proportionally identical figures regardless of the scale. For example, in the first canon, the side of 1 grid square equals 1 fist, and the 18 squares from the baseline to the hairline equals 18 fists.[106] For Iversen, the Egyptian canons were conceptual and comprehensive frameworks applicable not just to the anatomical points that coincided with grid lines but to the entire anatomy.

Iversen's account[107] of the Egyptian systems remained standard until the publication of Robins' *Proportion and Style in Ancient Egyptian Art* in 1994. Robins offered a detailed critique of Iversen, documenting instances in which he had adjusted actual examples of the Egyptian grid lines to conform to his theoretical system.[108] Since there is no extant Egyptian text that explains how the Egyptians proportioned their figures, the surviving guidelines are the only evidence for their system. Robins therefore relied on a fresh examination of Egyptian monuments. She concluded that "plainly Egyptian artists were not working within a rigid, unchangeable system from which only bad practitioners deviated,"[109] and she demonstrated that the gridlines do not always correspond to a static set of

[100] Guralnick 1976, 160; cf. Guralnick 1978, 467.

[101] Measured from Guralnick 1985, 403, fig. 4.

[102] Measured from Guralnick 1985, 403, fig. 4; 404, fig. 5.

[103] For an overview of the scholarship, see Robins 1994, 31–56.

[104] Edgar 1905, 146. Other scholars who favored this view include Mackay 1917; Baud 1935; see also Robins 1994, 39–40. Edgar (1906) wrote the volume of the *Catalogue Général* of the Egyptian Museum in Cairo that dealt with sculptors' studies of the Late Period; he made a careful study of the guidelines preserved on many of these pieces.

[105] Iversen 1955, 27.

[106] Iversen 1955, 32–3. This does not mean that the fist was the unit used; Iversen stresses that since every body part had a fixed proportional relationship to every other body part, any part could be used as a unit.

[107] Iversen 1955, 1975.

[108] Robins 1994, 47–56.

[109] Robins 1994, 56.

proportions.[110] In place of Iversen's abstract concept, Robins understands the Egyptian system as pragmatic and flexible.

When Guralnick conducted her statistical studies from 1976 to 1985, she relied on Iversen's work and so conceived of the Egyptian canon as an invariable set of proportions that applied to every part of the body.[111] Guralnick assumed, for example, that the total height of a figure had an abstract canonical value, however much the total height varied in actual examples. Guralnick could therefore use a single, fixed set of values for the Egyptian canon in the cluster and z-score analyses. Robins' empirically based study radically undermines such assumptions. While there is good reason to believe that in a given period, some specific anatomical points regularly aligned with certain grid lines, Robins provides equally good reason to believe that grid lines functioned as approximate guidelines for other parts of the figures. Robins found that the average value for an ungridded dimension could change from monument to monument and vary according to sex and pose.[112] Guralnick's use of an invariable value for such dimensions does not reflect how Egyptian artists actually used the grid lines.

In reality, of course, every example of an Egyptian figure based on the canon departs to some extent from every other example. Senk's 1934 study demonstrates this variability.[113] Like Iversen, Senk believed that all dimensions of Egyptian figures represented multiples of some body part. He measured eight standing figures from the Old Kingdom; these sculptures should reflect the first canon, which prescribed 18 grid units between the baseline and the hairline. He found that among the eight statues, the total height may be as little as 15 grid units or as much as 23 units. The width of the shoulders varies from 4.5 units to 7.3 units, and the width of the waist, from 1.9 units to 3 units.[114] Without a similar study of second-canon statues, we cannot know whether Late Period Egyptian sculpture in the round varied similarly; however, Guralnick's principal components graphs do indicate variations among the eight examples of the second canon included. Four examples of the second canon are charted as a single point, and three other Egyptian examples, along with two or three kouroi, are closely associated, but one Egyptian example is clearly an outlier.[115]

If we follow Robins' understanding of the Egyptian system as a flexible system of guidelines, we would have to take the variability of Egyptian examples into account. An analysis designed to identify similarities between the kouroi and the second canon as it was actually used (which is all we know about) would begin with measurements of a group of second-canon statues that are representative in their dimensions to the population of all second-canon statues, and the analysis would include only statues in the round and not two-dimensional representations.[116] We could then compute the mean and standard deviations for pro-

[110] Cf. Boardman 2006, 20. As Robins (1994, 254–56) demonstrates, for example, the proportions of figures changed during the course of the New Kingdom, although the grid of 18 units to the hairline remained in use.

[111] Guralnick 1978, 464 n. 28. Curiously, Guralnick continued to use the first (Iversen 1955) edition of Iversen rather than the new (Iversen 1975) edition, which offers a revised account of the second canon.

[112] See, e.g., Robins' (1994, 115–16) conclusions about the varying lengths of the forearm in the New Kingdom. Iversen held that the forearm from elbow to middle fingertip was 5¼ squares. Robins measured forearms in different monuments (e.g., the Temple of Amenhotep III at Luxor, the Temple of Sety I at Abydos) and found that the average length of the forearms in different monuments ranged from 5.0 squares to 5.4 squares.

[113] Senk 1934.

[114] Senk 1934, 320, table C. Senk (1934, 309–10) argued that the anatomical unit used as the basis for proportioning the figure was the distance from the junction of the neck and shoulders to the hairline. This distance equals 2 units of the first canon grid. Thus, his values for dimensions in terms of the proportioning unit must be doubled to show their relation to the grid of 18 units from base to hairline.

[115] Guralnick 1978, 470–71, figs. 6, 7. One might expect that the second canon allowed as much variation as occurred in the Old Kingdom, since most scholars agree that the proportional changes in Egyptian works starting in the 25th Dynasty represent a deliberate return to classic Old Kingdom proportions and involved direct examination of Old Kingdom monuments (Bothmer 1960, xxxiii, xxxvii; Robins 1994, 256–57; 1997, 210–13; Taylor 2000, 356–58).

[116] The validity of comparing two-dimensional Egyptian works with three-dimensional Greek statues is problematic. Attention has focused on two-dimensional Egyptian works because the evidence for grids in three-dimensional works is very slight. Unfinished sculptures in the round, almost all dating from the 26th Dynasty through the Roman period, were studied and catalogued by Edgar (1906). Among these pieces, there are only three standing human figures sculpted in the round that retain traces of guidelines (nos. 33301 with ht. of 0.98 m, 33307 with ht. of 0.56 m, and 33308 with ht. of 0.28 m). The surviving guidelines on these pieces are few and suggest that no complete grids were used. All have a central vertical line, and two (nos. 33307, 33308) have two partial vertical lines on each side of the central vertical. On number 33307, there are horizontal lines at four levels; on number 33308, there are horizontal lines or dashes at five levels. While there is little doubt that similar methods were used to proportion both statues in the round and two-dimensional figures, the surviving guidelines on statues in the round are not sufficient to reconstruct canonical dimensions (e.g., depths) not shown on two-dimensional works. Unfinished heads, busts, and reliefs are more numerous.

portioned dimensions of the Egyptian statues. This would allow us to compare the proportioned dimensions of an individual kouros to those of the population of second-canon statues.[117] The results might admit a statistically significant similarity between that kouros and second-canon statues. One possible explanation of such a result would be that the Greek sculptor of that kouros used the Egyptian canon. Another explanation, as proposed above, would be that both the canon and the kouros reflect a similarly stylized ideal with largely naturalistic proportions. We argue that the second explanation accords better with what we know generally about Greek kouroi.

CONCLUSIONS

The statistical methodology of Guralnick's studies presents fundamental difficulties. Cluster analyses cannot demonstrate statistically significant similarities. Moreover, different similarity measures and different algorithms produce different results in cluster analyses, and they can be strongly influenced by small changes in data values and by outliers. We found important discrepancies between the results of Guralnick's cluster analyses and the principal components analyses. Finally, Guralnick's z-score profiles combine standard deviations computed from dimensions of the average man with proportioned dimensions of the statues although these two types of data are not statistically comparable.

In examining Guralnick's data for the Egyptian canon and for archaic Greek statues, we found reason to question both the accuracy of the values and the choice of dimensions used in the analyses. Robins' work on the Egyptian grid lines has decisively changed the conception of the Egyptian system on which Guralnick relied and has shown that the values used by Guralnick for many dimensions of the Egyptian canon may not ever have been canonically fixed in Egyptian practice.

The kouros that consistently appears to resemble most closely the proportions of the Egyptian canon in all three statistical methodologies used by Guralnick is the Ptoon 12 kouros of ca. 530–520 B.C.E.[118] We argue that this resemblance, if true, could indicate that both figures are slender, similarly idealized, and by and large naturalistic. We do not see a causal relationship here. A number of kouroi fit this general description, and similarities among these kouroi can be explained by a Naxian style that affected other Cycladic centers and the mainland. We believe that the evolution of regional styles can better explain whatever degree of similarity may exist than sporadic use of the Egyptian canon by Greeks in different places and at wide chronological intervals.

While the problems we identify in Guralnick's methods must cast doubt on her claims for Greek use of the Egyptian second canon, her observations about similarities among kouroi appear to add support to conclusions formed by scholars on stylistic grounds. In very general and simplified terms, the development of Greek kouroi in the sixth century could be described as follows. The earliest marble kouroi were made of Naxian marble possibly by Naxian sculptors. These kouroi tend to have slender proportions and linearly articulated anatomy. Attic sculptors adopted the kouros type from Naxian models, and Attic kouroi of the first half of the sixth century likewise tend to be slender, while their anatomical articulation becomes less superficial and more plastic. In the second quarter of the sixth century, sculptors on Paros began using Parian marble to make kouroi. Their statues and the early kouroi from East Greece tend to have relatively heavier proportions, more fluid anatomical modeling, and softer, less muscular forms. Around the middle of the sixth century, some mainland kouroi appear to adopt Parian/East Greek traits. In the decade between 540 and 530 B.C.E., these two primary stylistic strains merge into Ridgway's International Style. Attic kouroi, in particular, become more thickset, while the Attic preference for robust and well-articulated musculature continues.

Guralnick's analyses appear to offer independent evidence of a relatively slender group of kouroi ultimately related to the Naxian type (see figs. 2, 3, 6) and a heavier group of kouroi that show the influence of the Parian/East Greek type (see fig. 7) in the formation of the International Style. Moreover, while stylistic studies have concentrated on how the anatomical modeling of kouroi becomes more naturalistic over time, Guralnick's studies demonstrate specifically how the proportions of kouroi become more naturalistic. In the course of the sixth century, the proportional difference between the widths of shoulders and waist diminishes and becomes more like that of real men (see table 3). Nevertheless, the preferred idealization

[117] Guralnick's z-score analyses, by contrast, illustrate how similar individual kouroi and one set of values for the Egyptian canon are to an average man. Such charts could show the statistical probability that (in terms of the variables used) individual kouroi and one version of the second canon are not unlike real 20th-century men. But these charts do not show how similar the proportions of individual kouroi and one version of the second canon are to each other in statistically measureable terms.

[118] Guralnick 1978, 465–67, figs. 3–5 (cluster analyses); 470–71, figs. 6, 7 (principal components); Guralnick 1985, 403, fig. 4 (z-score).

continues; even the latest kouroi appear to have a proportional difference between shoulder and waist width that is outside the range of most real men. These are important contributions for understanding the development of the Greek kouros.

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