Meta-analysis of radioulnar contrasts in dermatoglyphic ridge counts between individual fingers

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META-ANALÝZA RADIOULNÁRNÍCH KONTRASTŮ DERMATOGLYFICKÝCH KVANTITATIVNÍCH HODNOT MEZI JEDNOTLIVÝMI PRSTY RUKY

ABSTRAKT   Radioulnární kontrasty (numericky: rozdíly) mezi kvantitativními hodnotami dermatoglyfických vzorů jednotlivých prstů lidské ruky (počet lišt – ridge count, RC) se ukázaly jako vhodné indikátory signalizace prenatálního vývoje. V této studii jsme porovnávali výsledky meta-analýzy mezipohlavních rozdílů v radioulnálních kontrastech mezi publikovanými *průměrnými hodnotami* RC (získány jako průměr z vyššího RC každého prstu) s mezipohlavními rozdíly, kdy radioulnární kontrasty byly vypočítány již na individuální úrovni.
Průzkumem databází NCBI-PMC, ScienceDirect a archivních zdrojů jsme našli celkem 273 dermatoglyfických studií (po odstranění duplikátů mezi databázemi). Avšak po aplikaci všech výběrových kritérií bylo pro meta-analýzu vhodných pouze 11 vzorků, a to i včetně našich vlastních čtyř vzorků. V porovnání s úsilím vynaloženým při hledání publikací se nám podařilo najít jen velmi málo studií, které by vůbec publikovaly statistické parametry RC na jednotlivých prstech, a které by tak byly vhodné pro studium kontrastů mezi prsty. Pokud již byly publikovány statistické parametry pro jednotlivé prsty, nepředstavovaly tyto údaje průměrné hodnoty RC z radiální i ulnární strany prstů (tj. 10 hodnot na každé ruce), ale pouze průměrné hodnoty RC z vyšší hodnoty za každý prst (tj. 5 hodnot na každé ruce) na individuální úrovni.
Pohlavní dimorfismus získaný meta-analytickými metodami (kontrasty mezi průměrnými hodnotami RC), koreluje téměř absolutně s hodnotou dimorfismu kontrastů vypočítaných na individuální úrovni (průměrné hodnoty individuálních kontrastů RC). Výběr jednoho (vyššího) RC z každého prstu však rozmazává dimorfismus a ztěžuje interpretaci mezipohlavních rozdílů. Výsledky pak nelze porovnávat s hodnotami získanými z kompletního souboru všech RC na prstech. V kombinaci s malým počtem studií s vhodnými daty publikovanými po jednotlivých prstech proto nemůžeme doporučit meta-analýzu publikovaných studií jako vhodný prostředek ke studiu meziprstních radioulnárních kontrastů. Za tímto účelem je třeba mít k dispozici primární data – RC na individuální úrovni.

KLÍČOVÁ SLOVA   dermatoglyfika; otisky prstů; počet lišt; meta-analýza; sexuální dimorfismus

ABSTRACT   Radioulnar contrasts (numerically: differences) between ridge counts of individual fingers of the human hand have been identified as promising features in respect to prenatal signalling. In this study, we compared the results of a meta-analysis of intersex differences in radioulnar contrasts between published mean values of dermatoglyphic ridge counts on the fingers of the hand (calculated from the higher RC of each finger) with intersex differences obtained from radioulnar contrasts already calculated at the individual level.
Searching the NCBI-PMC, ScienceDirect databases, and archival resources, we found a total of 273 dermatoglyphic studies (after merging duplicates in databases). However, only 11 of those studies were suitable for meta-analysis after application of all selection criteria, including our own four studies. Considering the effort spent in searching for articles, we were able to find very few studies that published statistical parameters of ridge counts by individual finger and that would thus be suitable for studying contrasts between fingers. When statistical parameters have been published for individual fingers, they did not represent the descriptions of all ridge counts from the radial and ulnar sides of the fingers (i.e., 10 values on each hand), but only the ridge count with the higher value is selected for each finger (i.e., 5 values on each hand) at the individual level.
The meta-analytically obtained sex dimorphism (contrasts between the mean values of the ridge counts) are virtually indistinguishable from the dimorphism from the contrasts calculated at the individual level (means of the contrasts). However, the step of selecting one (higher) ridge count from each finger blurs the dimorphism and makes interpretation of the sex differences difficult. The results cannot then be compared with those obtained from the complete set of all ridge counts on the fingers. Combined with the small number of studies with suitable data published on a finger-by-finger basis, we therefore cannot recommend meta-analysis of published studies as a suitable means of studying interfinger radioulnar contrasts. For this purpose, primary/raw ridge count data at the individual level must be available.

KEY WORDS   dermatoglyphic; fingerprints; ridge count; meta-analysis; sexual dimorphism

INTRODUCTION

Dermatoglyphics can draw from experience and the results of more than a hundred years of studies. Meta-analytic aggregations and comparisons of a large number of studies allow both to distinguish erroneous results from the biologically plausible major trends and to generate higher-level views of a multi-population nature, to study e.g., geographic gradients (e.g., Králík et al. 2019), dependence on climatic factors (e.g., Bhasin 2007; Rosa 1985), that are not possible in single population studies and limited samples. However, the use of published data in meta-analysis depends on the numerical nature of the secondary data that are published.

Because fingerprints and palm prints provide several different values per subject (e.g., patterns of 10 fingers), from the beginning of scientific interest in dermatoglyphics, features have been developed to allow the larger number of values for each subject to be somehow simplified, usually summed, averaged, or otherwise converted into a simple index that would be suitable as a representation of the subject for statistical comparisons. (Statistical methods for multilevel comparisons, e.g., mixed models, were not developed at that time). The secondary data (statistical parameters) of these derived features are then published, while the parameters of the original raw data (let alone the original raw data themselves) are not.

For example, the size of the dermatoglyphic pattern (called *quantitative value of pattern* or *ridge count*, abbreviated as RC) is a well quantifiable feature that can be objectively and reproducibly determined by counting the epidermal ridges crossed by the line connecting the triradius and the core of the pattern (Cummins a Midlo 1961). On ten fingers of the hand, 20 ridge counts can be evaluated in this way (**Figure 1**). In the following analyses, however, these were usually added together and only the sum was statistically evaluated. Two forms of this sum were applied: first, the so-called Absolute Finger Ridge Count (AFRC), where all 20 values were summed, and second, the Total Finger Ridge Count (TFRC), where only the larger of the two values from each finger was counted in the total (Holt 1952; 1968). TFRC was used more frequently. Since human populations (and also various pathological conditions) differ in the size of dermatoglyphic patterns, these summary features (TFRC, AFRC) were quite useful in comparing populations.

In particular, for RC, one of the most important quantitative dermatoglyphic features, it has been shown in recent years that not only the sum of RC values (TFRC) is important, but also the differences between individual fingers carry significant information (Kahn et al. 2008; 2001). Some radioulnar contrasts (differences) between RCs on different fingers show systematic sex dimorphism (Polcerová et al. 2022), so we can think of them as markers of prenatal sexual differentiation, similar to the 2D:4D ratio of finger length (cf. Jantz 2021). In these studies, however, the investigation of radioulnar gradients was only possible due to the availability of finger-resolved primary data, i.e., all 20 ridge counts. A meta-analysis based on the published data would be highly beneficial as it could greatly expand the number of included samples and help to confirm the broad universality of sexual dimorphism of radioulnar contrasts in RCs on the fingers of the human hand. However, such meta-analysis would only be possible if published data on individual RCs of all fingers were available. Given the predominant use of TFRCs instead of native RCs, it is unclear whether sufficient studies will be available.

The purpose of this study is to perform a meta-analysis of dermatoglyphic studies dealing with RCs and to determine whether radioulnar contrasts of published parameters of individual ridge counts are comparable to results (Polcerová et al. 2022) based on primary data of RCs of individual fingers. First, we had to find out what the published RC data are and whether it is possible to find data separately for each RC of each finger. If such data existed in the literature, the next step was to collect such studies and use their data to evaluate the radioulnar contrasts of the RCs and compare them with the results found by analysis of the primary individual data (Polcerová et al. 2022).

SUBJECTS AND METHODS

Resources

We searched within two selected databases: *NCBI-PMC* and *Science Direct* for key words: "dermatoglyphics", "finger ridge count", "population study" (14. 6. 2019). As mentioned in Králík et al. (2019) sources dating before year 1990 are complicated to reach as those resources are not yet fully digitalized or are in non-English literature which affected resulting number of studies: 127 in *NCBI-PMC* and 143 in *Science Direct*. After applying selection criteria (bellow), we decided to add our own data from an ongoing project TACR (approved in advance by the Ethic Committee for Research of our institution: EKV-2018-028) and archival resources from our institution. Ongoing project (TACR) represents *recent* Czech population and consists of adult volunteers. Fingerprints were obtained by standard dermatoglyphic methodology according to Cummins and Midlo (1943) and only those individuals where it was possible to analyse fingerprints from both palms and all fingers at the level of ridge count were included.

Archival resources were represented by three samples (collected in 1948, 1976, and 1989): sample of adult population of Lusatian Sorbs, sample of exchange Vietnamese students and *historical* sample of adult Czech population used in diploma thesis of Meinerová (2018); for further information about samples please ref. Polcerová et al. (2022).

Selection criteria for meta-analysis

We defined the following criteria for studies to be included in our final sample:

1. source has published mean ridge count for *each finger* on both hands with standard deviation;
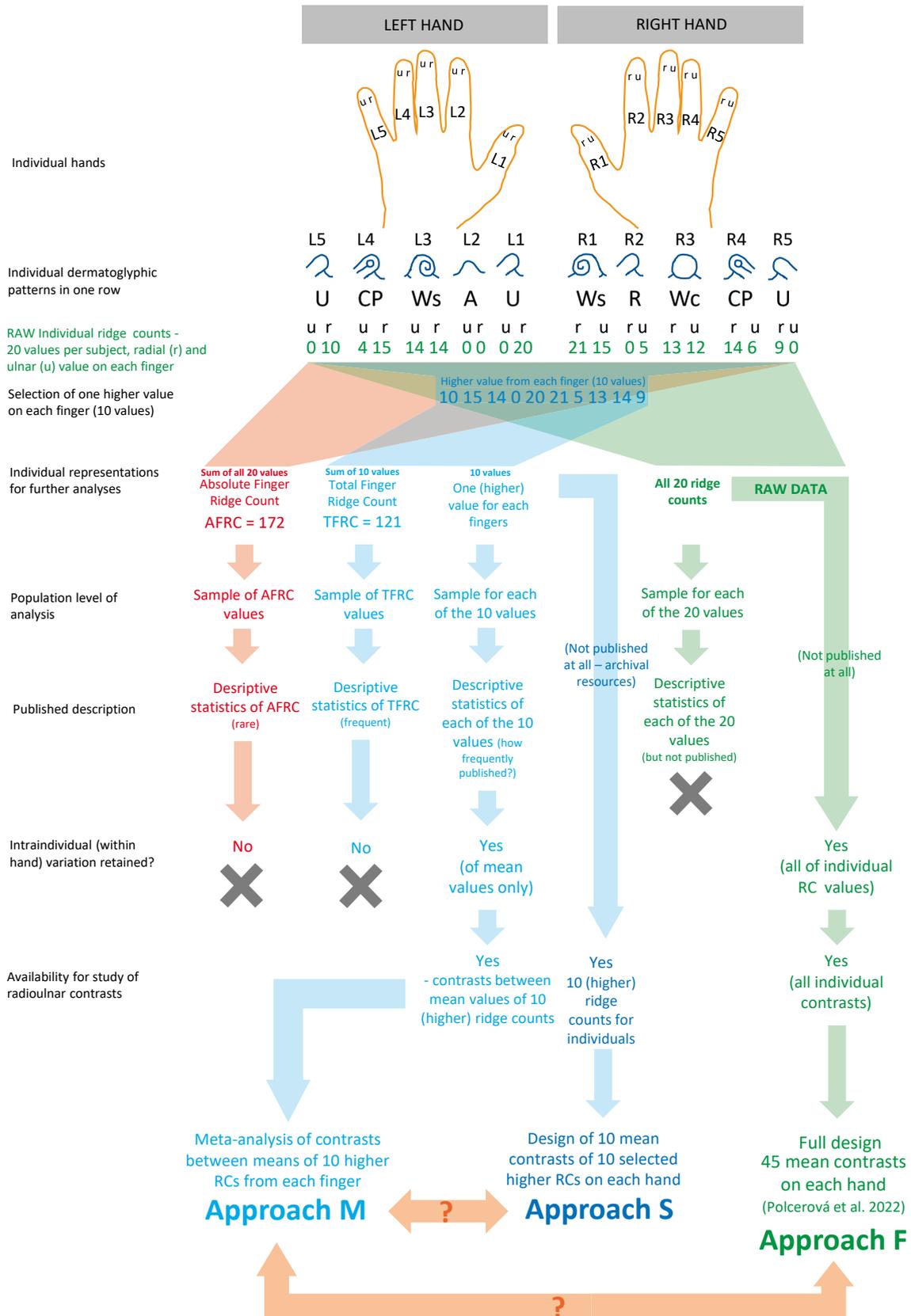2. data from source are categorized by sex (i.e., mean ridge

Figure 1: A research flowchart for the dermatoglyphic assessment of ridge counts on the fingers of the hand, its processing, analysis and publication, indicating the pathway and relationship of the three methodological approaches used in this study.
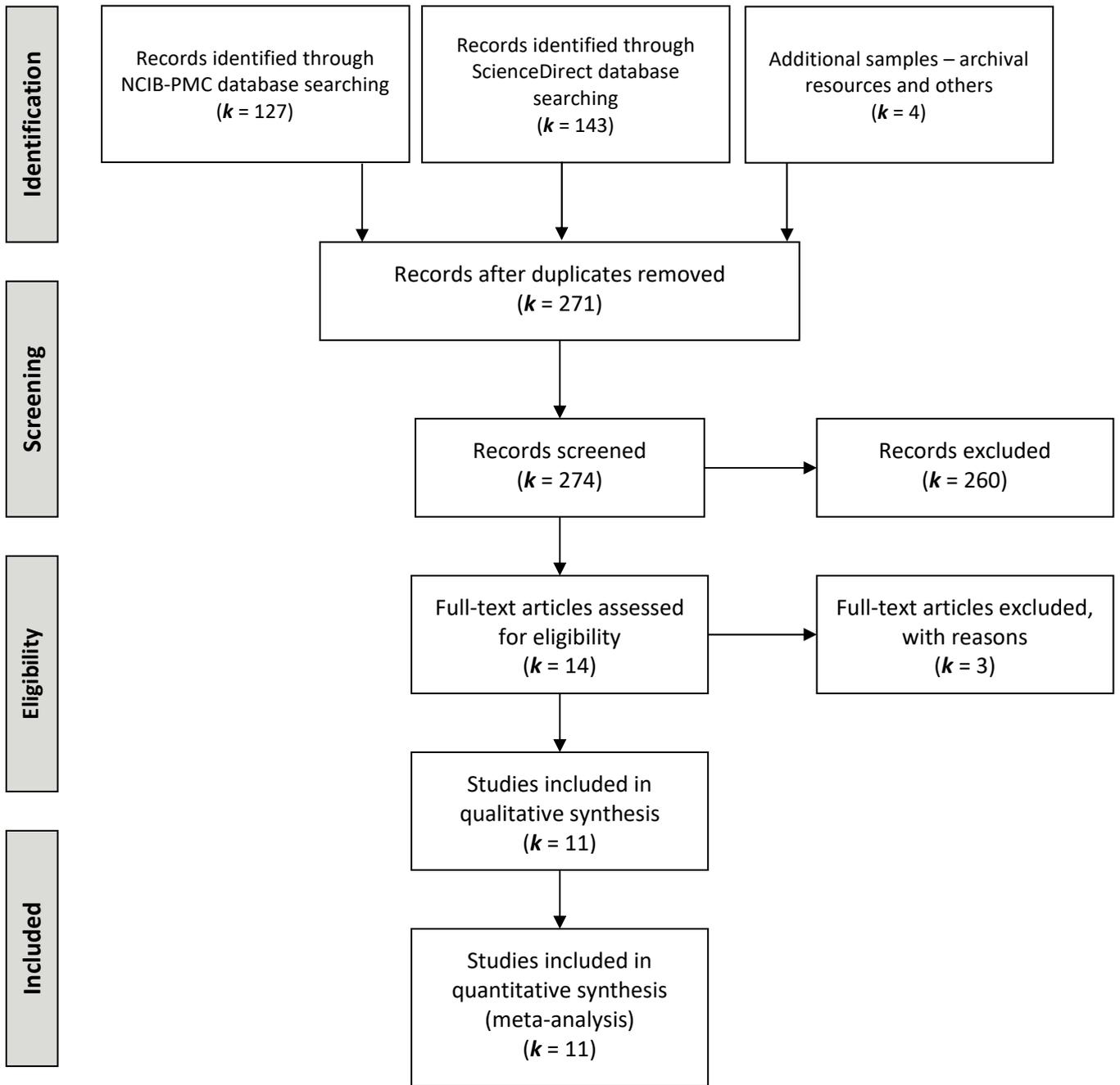
Figure 2: Selection of studies - PRISMA diagram (Moher et al. 2009). These 11 studies are represented by 12 samples as one of the studies provided two samples.

counts for individual fingers are not merged by sex but values for females and males are separately presented;

3. data represents healthy individuals (i.e., controls in medical studies);

4. methodology for fingerprinting is constant among studies. Based on search within resources we chose the nomenclature and methodology of ridge counting by Cummins and Midlo (1943) or in case of ridge counting also Holt (1968).

Studies that did not fulfil those criteria or had severe inconsistencies and computation errors within their data (standard deviation was higher that mean ridge count or number of individuals did not correspond with the published information) were excluded from our sample.

The whole selection process is described by flowchart (ref. Moher et al. 2009) in **Figure 2**. As can be seen from the flowchart, the largest reduction in the volume of studies occurred after screening of individual publications and their assessment for eligibility. At this step we discovered that the published studies did not contain primary individual data at all, i.e., individual subject RCs, which was to be expected to

Figure 3: Map of all 12 samples included in analysis with differentiated sexes.

No	Year	Author	Population	Sex	n (*males*)	n (*females*)
1	2017	Andreenko - Baltova	Bulgarians	f, m	414	480
2	1983	Cantor et al.	Americans	f, m	270	253
3	1973	Fuller	British	m	825	-
4	2015	Hong et al.	Han	m	129	-
5	2008	Karmakar et al.	Chuvashians	f, m	293	254
6	2018	Meinerova – CZ[A]	Czechoslovaks	f, m	36	44
7	2018	Meinerova – LSRB[A]	Lusatian Sorbs	f, m	51	45
8	2018	Meinerova – VNM[A]	Vietnamese	f, m	57	19
9	2005	Milicic - Vidovic	Slovenians - lowland	f, m	100	119
10	2005	Milicic - Vidovic	Slovenians - mountains	f, m	63	58
11	1975	Saldana - Garcia	British	f	-	825
12	2020	TACR[*]	Czechs and Slovaks	f, m	51	69

Table 1: Overview of samples used for meta-analysis. Samples marked [A] come from archive records and samples marked with an asterisk (*) come from ongoing research project (mentioned above in the chapter *Resources*). For these four samples (marked [A] and ˙), we have primary raw data and are subject to comparison across the three approaches (M, S and F, ref. **Figure 1**).

some degree, especially given our strict criteria. However, at the same time, it was also clear that secondary data (number of cases, mean and standard deviation) were available infrequently just for TFRC or AFRC, but almost never for all 20 RCs. If secondary data were available for individual fingers, it was always for the parameters of one RC of particular finger, i.e., not both RCs (radial and ulnar). Based on these findings, we realized that the original methodological design of the study had to be adapted.

The final sample included only 12 usable population samples within 11 publication sources, where one source published two samples that fulfilled our criteria. Out of those 12 samples 9 contains information about both sexes (**Table 1**). Geographical visualization of these samples is available in **Figure 3**. The predominance of samples is found in Europe, while the area of Asia and North America is less represented. All samples are from the Northern Hemisphere. This uneven distribution is due to sparsely published separate average ridge counts for individual fingers for each sex.

Meta-analytical procedures

Based on results of Polcerová et al. (2019; 2022) and Králík et al. (2019) we decided to explore the consistency of radioulnar gradients among multiple populations and possible sexual dimorphism in those radioulnar gradients via meta-analytical methods summarized in Borenstein et al. (2009).

It is important to note that the most promising results shown in Polcerová et al. (2022) are based on RCr and RCu (radial and ulnar ridge counts for each pattern on each finger), while in the collected sources and, therefore, also in the presented meta-analysis these values are combined according to the traditional methodology of Cummins and Midlo (1943) and Holt (1968). For each finger, descriptive statistics are not published separately for radial RC (RCr) and ulnar RC (RCu), but only the larger of the two RCs for each finger is counted, which on some fingers (or in some people) may be radial and on others (other people) ulnar RC. This had to be adjusted to our comparison with the results we produced and
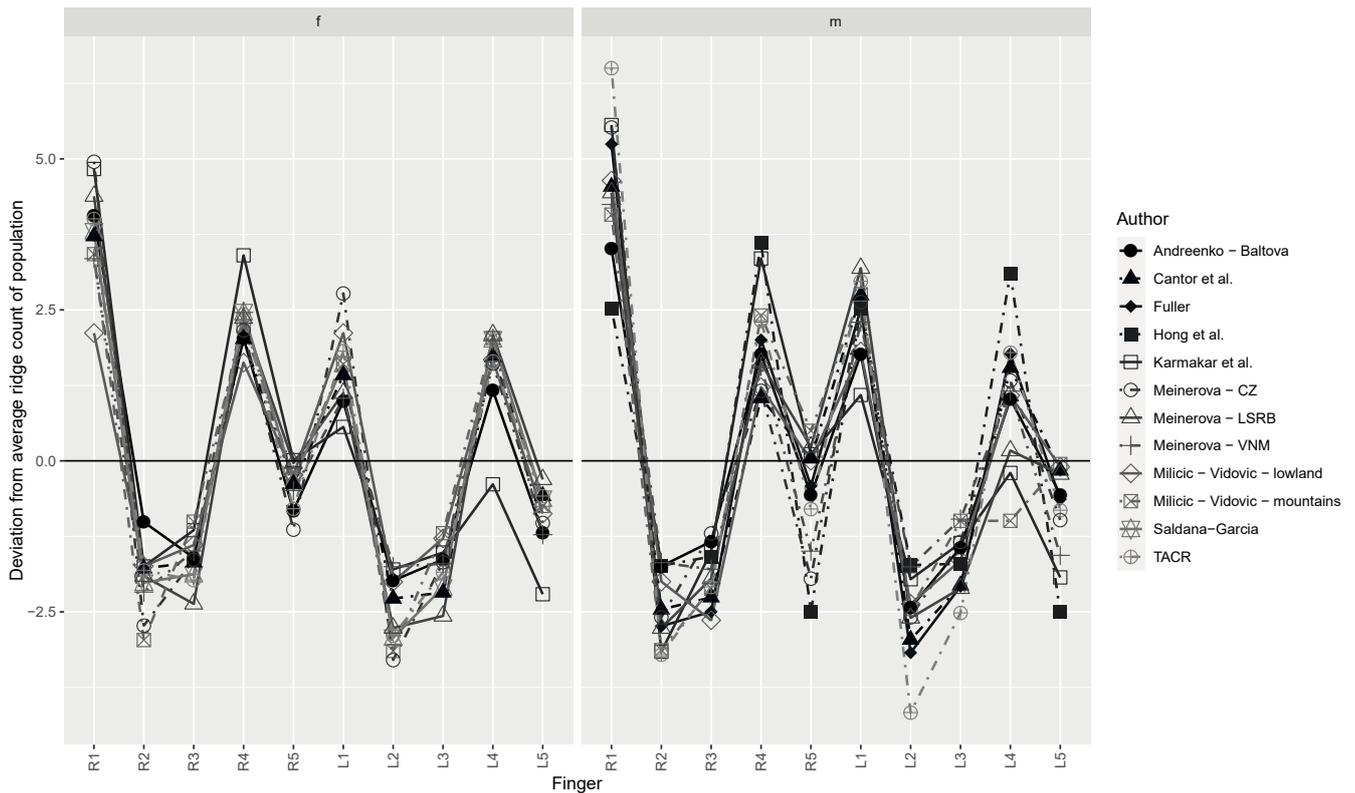
Figure 4: Mean ridge counts for individual fingers across all samples superimposed on overall average ridge counts of each sample with respect to sex (left field represents females – *f*, right field represents males – *m*). The *x*-axis shows the individual fingers, the *y*-axis shows the deviation from the average ridge count of the population.

published based on the primary data of all 20 RCs (Polcerová et al. 2022).

Thus, our results represent a comparison of three blocks (ref. **Figure 1**):

1. the first is the radioulnar contrasts obtained from the meta-analytic aggregation of the published mean values (larger RCs) from each finger (all 9 samples that contains information about both sexes);
2. the meta-analytic sample included a subset of 4 samples treated in the same way that were previously included in the publication by Polcerová et al. (2022); only the largest value from each of the two RCs was selected in each finger, statistical parameters were calculated for each of the ten fingers, and these entered the meta-analysis);
3. the latter 4 samples processed the mean radioulnar contrasts of all 20 RCs from the primary individual data (exactly those published in Polcerová et al. (2022)).

Objectives of the meta-analysis

In the meta-analysis we focused on two main questions:

- whether aggregated effects of radioulnar contrasts between mean values of finger RCs show sexual dimorphism and whether it is consistent among samples;
- how the manifested sexual dimorphism in radioulnar contrasts from meta-analysis differs from radioulnar

contrasts computed on individual level from raw RCu and RCr.

Because studies collected for the meta-analysis (published secondary data of RCs, **Table 2**) contained one mean RC value for each individual finger (**Figure 4**), the analysis represents a calculation with 10 fingers and 10 their radioulnar contrasts within each hand. Therefore, 10 separate meta-analyses were computed (contrasts of all finger pairs: F1-F2, F1-F3 … F4-F5) for each hand and sex i.e., 40 meta-analyses. First, we computed these aggregated effects of each radioulnar contrast and, subsequently, we used these aggregated values for males and females in each hand separately and computed their sex differences.

Effect sizes of radioulnar contrasts

For statistical computing we chose the R software (R Core Team 2020) and the RStudio interface (RStudio Team 2016) with the metafor package (Viechtbauer 2021). Within metafor package we used SMCR measure to calculate standardized mean difference as (*d*) since we consider fingers as matched groups. As mentioned in Borenstein et al. (2009) to compute *d* from the standard deviation of the differences it needs to impute the standard deviation *withing* groups, which would then serve as the denominator:

No	Year	Author	Sex	n	R1 m	R1 sd	R2 m	R2 sd	R3 m	R3 sd	R4 m	R4 sd	R5 m	R5 sd	L1 m	L1 sd	L2 m	L2 sd	L3 m	L3 sd	L4 m	L4 sd	L5 m	L5 sd
1	2017	Andreenko - Baltova	f	480	15.34	9.42	10.26	6.23	9.67	5.22	13.30	4.55	10.45	4.05	12.26	4.95	9.29	5.85	9.64	5.13	12.44	4.87	10.08	4.56
1	2017	Andreenko - Baltova	m	414	16.65	6.93	11.39	6.68	11.80	5.11	14.90	4.77	12.57	5.39	14.90	6.59	10.70	7.63	11.70	6.01	14.16	5.17	12.58	5.05
2	1983	Cantor et al.	f	253	16.30	6.00	10.80	6.50	10.90	5.30	14.60	6.00	12.20	5.40	14.00	6.30	10.30	6.00	10.40	5.80	14.30	5.80	12.00	5.10
2	1983	Cantor et al.	m	270	18.00	5.00	11.00	7.00	11.20	5.30	14.50	5.70	13.50	4.70	16.20	5.70	10.50	6.50	11.40	5.80	15.00	5.60	13.30	5.00
3	1973	Fuller	m	825	19.76	6.25	11.78	7.41	12.02	6.48	16.52	6.51	14.10	5.38	17.04	6.37	11.34	7.05	12.44	6.77	16.29	6.52	13.88	5.09
4	2015	Hong et al.	m	129	16.64	6.10	12.38	5.23	12.53	4.54	17.72	5.48	11.62	4.12	16.63	6.02	12.39	4.82	12.41	4.15	17.22	4.52	11.61	3.89
5	2008	Karmakar et al.	f	254	16.92	6.18	10.34	6.53	10.94	5.38	15.49	7.23	12.10	5.37	12.65	5.30	10.29	6.28	10.57	5.40	11.70	5.88	9.88	4.78
5	2008	Karmakar et al.	m	293	18.67	6.55	9.95	6.22	11.61	5.93	16.46	7.92	13.22	6.40	14.20	5.87	11.15	6.50	11.75	6.95	12.91	5.95	11.18	5.31
6	2018	Meinerova - CZ[A]	f	44	18.43	5.15	10.75	7.14	11.84	5.01	15.64	5.76	12.34	4.96	16.25	5.85	10.18	6.63	11.80	5.59	15.09	5.70	12.45	5.44
6	2018	Meinerova - CZ[A]	m	36	21.25	6.51	13.14	7.06	14.53	5.51	16.89	6.12	13.78	5.68	18.36	6.77	13.14	6.12	14.39	6.00	17.06	5.81	14.75	5.28
7	2018	Meinerova - LSRB[A]	f	45	16.53	5.02	10.24	6.76	9.78	5.27	14.51	6.88	12.11	5.69	13.27	5.61	9.38	5.98	9.58	5.54	11.24	6.76	11.84	4.82
7	2018	Meinerova - LSRB[A]	m	51	15.39	7.16	8.18	7.28	9.00	5.72	12.57	6.82	11.18	5.49	14.14	6.84	8.35	6.67	8.84	6.99	11.12	7.01	10.73	6.03
8	2018	Meinerova - VNM[A]	f	19	15.68	6.07	10.16	5.36	10.84	4.09	14.79	4.65	11.84	4.68	13.37	6.23	10.58	6.08	10.63	5.50	14.32	4.00	11.11	4.00
8	2018	Meinerova - VNM[A]	m	57	18.86	5.35	12.93	6.04	12.82	5.59	16.18	4.22	13.12	4.69	16.91	5.88	12.86	5.69	13.65	4.87	15.77	5.14	13.05	4.22
9	2005	Milicic - Vidovic - lowland	f	119	14.25	5.86	10.39	5.94	10.74	5.30	13.76	5.14	11.90	4.35	14.25	5.86	10.13	5.71	10.85	5.64	13.81	5.61	11.26	4.70
9	2005	Milicic - Vidovic - lowland	m	100	17.78	5.37	11.14	6.09	10.50	5.40	14.36	5.35	13.14	5.25	14.95	5.46	10.77	6.07	11.49	5.51	14.22	5.32	13.04	4.78
10	2005	Milicic - Vidovic - mountair	f	58	16.10	5.18	9.71	6.92	11.67	4.36	14.91	4.91	12.45	4.54	14.28	5.79	9.53	6.07	11.48	5.50	14.71	5.09	11.93	4.43
10	2005	Milicic - Vidovic - mountair	m	63	17.75	6.42	10.54	7.27	11.56	6.51	16.08	5.56	14.17	4.83	16.43	6.60	11.22	7.40	12.68	6.52	12.68	6.52	13.62	4.34
11	1975	Saldana-Garcia	f	825	16.50	6.49	10.68	7.23	10.82	6.23	15.16	6.78	12.36	5.95	14.30	6.37	9.77	7.03	10.60	6.76	14.71	7.13	12.07	5.77
12	2020	TACR*	f	69	17.68	7.08	11.86	7.24	11.70	5.99	16.10	6.04	12.88	5.88	15.49	6.64	10.78	7.02	11.83	5.97	15.32	6.00	13.09	5.40
12	2020	TACR*	m	51	19.20	7.06	9.49	7.17	10.61	6.24	15.02	6.94	11.90	6.12	15.67	7.40	8.53	6.95	10.18	6.43	14.49	7.08	11.88	5.57

Table 2: Input data for meta-analysis (approach M). Published studies, archive samples ([A]) and ongoing research (*). In addition *m* represents mean values and *sd* represents standard deviation for each finger.

$$d = \frac{\bar{X}_{Fx} - \bar{X}_{Fy}}{\frac{s_{diff}}{\sqrt{2(1-r)}}},$$

where the mean ridge count of one finger ($\bar{X}_{Fy}$) (positioned relatively more in ulnar side to the finger *Fx*) is subtracted from the mean ridge count of another finger ($\bar{X}_{Fx}$) (relatively more on radial side) and divided by standard deviation within groups. This within groups standard deviation can be calculated from the standard deviation of the difference (as shown in equation) where *r* is the correlation between pairs – in our case between fingers. And then calculate fixed effect for each contrast. However, because we work mainly with published secondary data, where there is usually no available published correlation between individual fingers, it is difficult to obtain precise *r*. In the accompanying documentation for the `metafor` package, maintained by W. Viechtbauer, it is recommended to substitute $r = 0$ for this issue. With reference to the work of Gibbons et al. (1993), who consider the change score and its variance as a single sample problem hence the homogeneity of variance assumption and known value of *r* are not required.

To aggregate the resulting effects (results shown in **Figure 5**) we used *random effect model* represented by `rma` function as part of `metafor` package. For evaluating the heterogeneity between the effects of different studies value I^2 is used which indicates the proportion of dispersion between studies to the total dispersion of the effect.

Effect of sexual dimorphism in radioulnar contrasts

Standardized mean difference (*yi*) and corresponding sampling variance (*vi*) of radioulnar contrasts for males and females calculated in the previous step were further used to calculate the effect size of sexual dimorphism (d_{dim}) of each radioulnar contrast by using standardized mean differences of males (yi_M) minus standardized mean differences of females

(yi_F) radioulnar contrasts, with SMD measure as in this case we consider sexes as independent groups:

$$d_{dim} = \frac{yi_M - yi_F}{s_{pvi}}$$

And divided by their pooled sampling variance (s_{pvi}). Sampling variance for each sex was obtained as $s_f = \sqrt{vi} \cdot \sqrt{n_f}$ for females and $s_m = \sqrt{vi} \cdot \sqrt{n_m}$ for males where n_f and n_m are number of individuals.

Similarly to the previous step, we used *random effect model* represented by `rma` function as part of `metafor` package to aggregate the resulting effects.

For better understanding of the results, we called the above-mentioned **meta-analytical** procedure the **approach M** (see **Figure 1**). To sum it up, it is based on a meta-analytical procedure where published mean values of RCs (higher values selected on each finger) are used to compute contrasts between fingers (i.e., differences between mean RCs for contrasted fingers) and these are used to express sex differences as standardized mean difference (SMD). The **approach M** was applied to all available meta-analytical data – secondary data extracted from published literature (**Table 2**), including samples available to us (**Table 1**).

On the four samples with available raw data of individual RCs for both sexes available to us, we expressed sex dimorphism also as standardized mean difference computed from individual-level radioulnar contrast using the procedure described by Polcerová et al. (2022). To be directly comparable with the **approach M**, one version was computed on **selected** higher RCs from each individual finger which resulted into sex differences of 10 contrasts in each hand – we called it the **approach S** (see **Figure 1**). In the second version contrasts with **full** number of raw RC data, both RCu and RCr (45 contrasts on each hand) were calculated at the individual level, and the means and sexual dimorphism of these means were then cal-
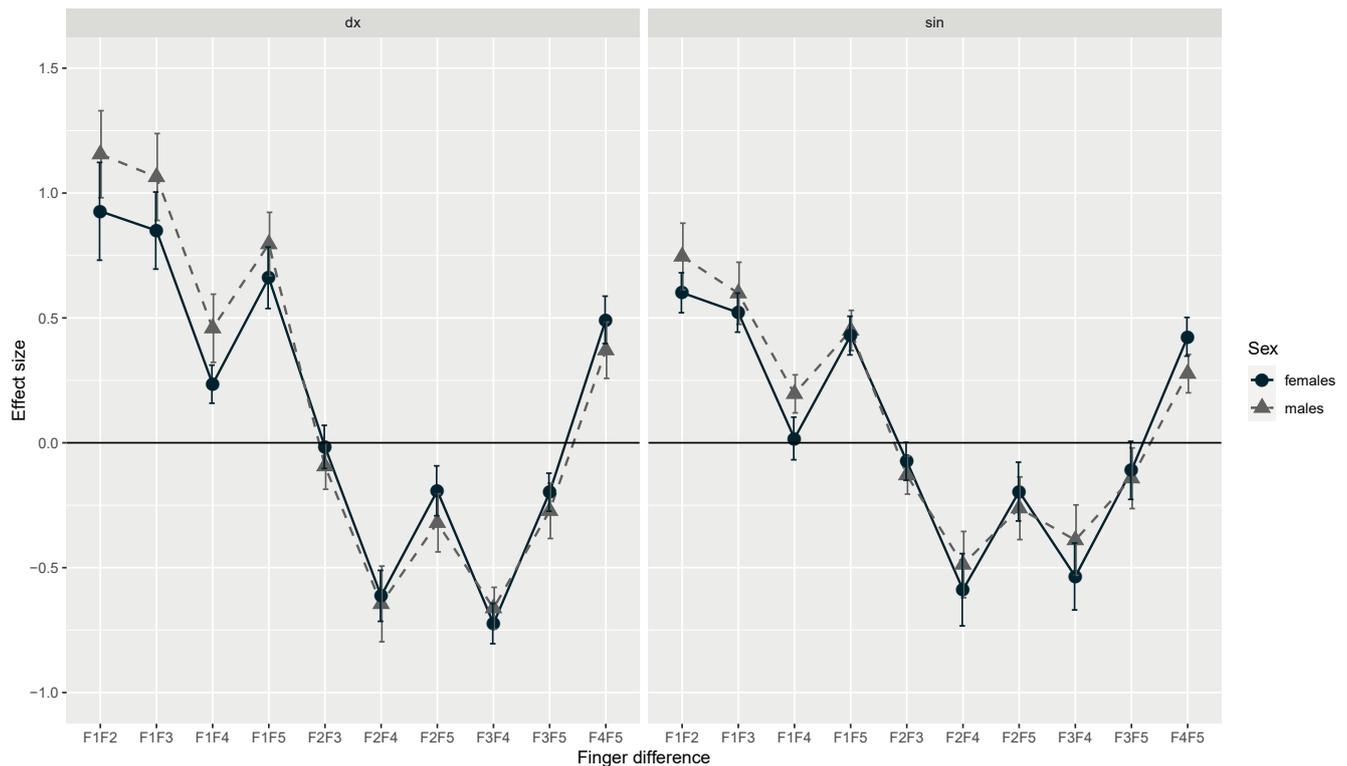
Figure 5: Aggregated effects of standardized radioulnar contrasts (i.e., differences between mean RCs for contrasted fingers of all 9 samples that contains information about both sexes) of approach M, with their confidence intervals (males and females separately). Left field represents results for right hand (*dx*) and right field represents results for left hand (*sin*). On *x*-axis is effect size, *y*-axis represents radioulnar contrasts.

culated – we called it the **approach F**. The available raw data of the four samples allowed us to compute all 45 mean contrast on each hand and were published in the previous paper in full (ref. Polcerová et al. 2022). For the four samples for which we also had individual data (marked [A] and [*] in **Table 1**), we were able to make this comparison for each sample separately and by individual fingers and contrasts, respectively.

RESULTS

Meta-analysis of published secondary data

The distribution of the mean ridge counts for individual fingers between the meta-analytical samples with respect to sex is available in **Figure 4**. The graph shows that between fingers the changes of these mean ridge counts maintain approximately the same direction in all samples, where the 2nd, 3rd and 5th fingers are below the average ridge count values of the given sample, while the 1st and 4th fingers have higher values than the average ridge count of the given sample. It is also evident that males have mostly higher numbers of ridge counts above and below average ridge count values of the given samples. At the same time, a tendency to lower values in the left hand comparing to the right is evident in most fingers.

Aggregated effect for radioulnar contrasts for each hand and each sex are shown in **Figure 5**. Radioulnar contrasts presented positive mean values with 1st finger (F1) on both hands and in both sexes. The contrast F1F4 on the left hand for females is an exception, as the value is close to zero. Other radioulnar contrasts show mostly negative mean values with the exception of F2F3 contrast (for both hands in both sexes) where the contrast was close to zero, and F4F5 contrast that also presented positive mean values again for both hands in both sexes. Contrasts on the left hand tend to have generally lower absolute values (close to zero) than corresponding contrasts on the right hand.

Population standardized sex differences in radioulnar contrasts (**Figure 6**) range from about -0.5 to 0.5 SD, with aggregated averages ranging from ca. -0.1 to 0.15 SD. Average sex differences are relatively low and close to zero for contrasts F1F5, F2F3, F2F4, F3F4, and F4F5, whereas contrasts F1F2, F1F3, F1F4, F2F5 and F4F5 were relatively far from zero and the resulting confidence intervals of their aggregated effects did not contained zero, so the sex differences can be deemed statistically significant. At the same time, it is evident from both the distributions of population effects and the ranges of the confidence intervals that contrasts differ also in diversity of their effects between populations.
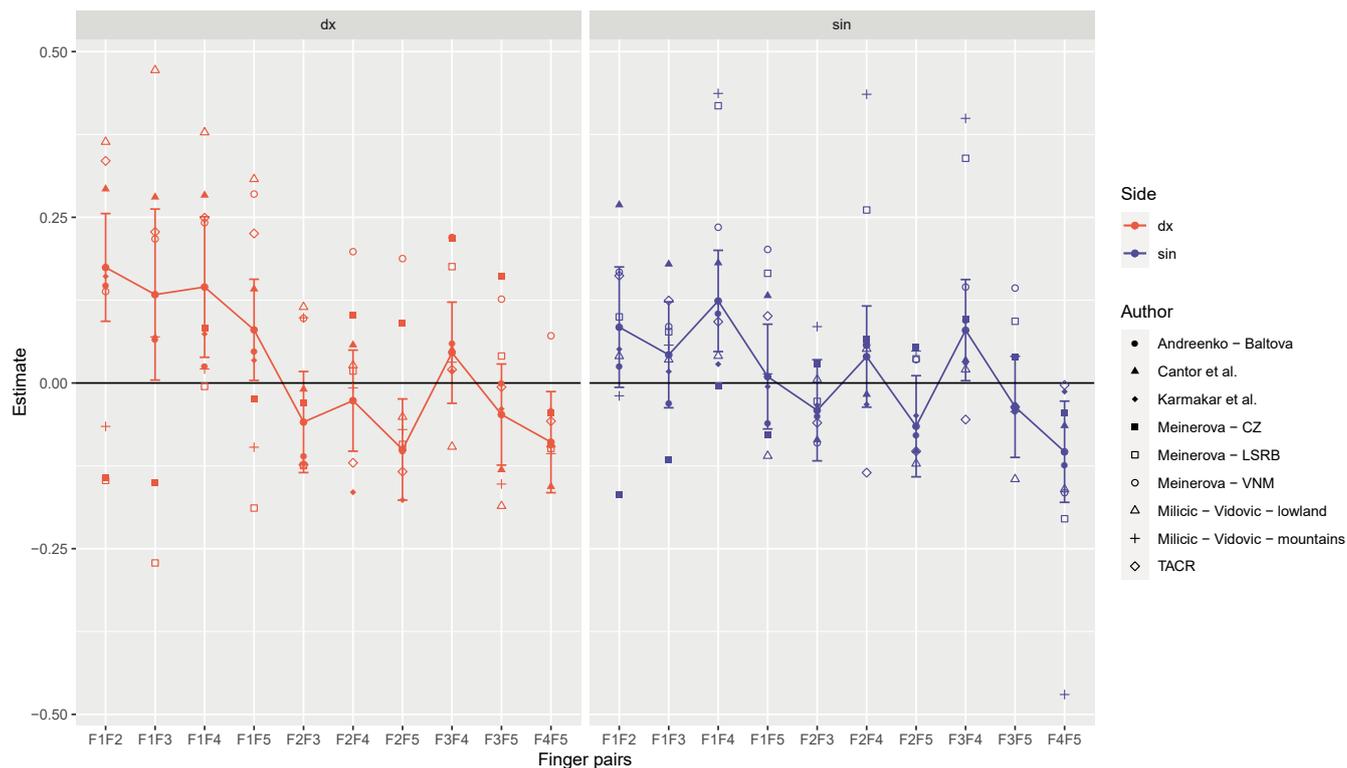
Figure 6: Aggregated effect with their respective confidence intervals of sexual dimorphism in standardized radioulnar contrasts (i.e., differences between mean RCs for contrasted fingers of all 9 samples that contains information about both sexes) of approach M.

Comparison of all three approaches on documented datasets

Meta-analytic effect sizes of sexual dimorphism of radioulnar contrasts (standardized mean difference i.e., contrasts between mean values) were almost absolutely correlated with the values of sexual dimorphism of individual contrast calculated from primary data (the larger value from each finger selected at the individual level) using the method of Polcerová et al. (2022). This was true for all 10 contrasts (**Table 3** and **4**). Therefore, we proved that with selected 10 values (higher value for each finger), contrasts between population means (**Approach M**) are virtually identical to population means of individual contrasts (**Approach S**). However, the results of the paired tests show (**Table 4**) that the mean dimorphisms of all 10 standardized contrasts are systematically numerically higher (Mean Diff systematically positive) for the means of the individual contrasts (**Approach S**) than for the meta-analytic contrasts of the means in the four test populations. In other words, the meta-analytic approach using contrasts of average values provides an overall lower estimate of the effect of dimorphism than when calculated from contrasts determined at the level of contrasts between fingers within each individual hand. In three of the ten contrasts, the result of the permutation test (n = 8) was even statistically significant – F1F2, F1F4 and F4F5.

In **Table 5** we have a comparison of the standardized values of sex dimorphism based on the meta-analytic approach (**approach M**) and these based on the full approach using contrasts of all four original radial and ulnar ridge counts of individual fingers (**approach F**). The effects obtained from the meta-analysis correlates highly variably with the effects from the individual contrasts. Correlations with contrasts composed of RCs of the radial side of the radially placed finger and RCs of the ulnar side of the ulnar finger (ru, e.g., F3rF5u) were generally very weak and all statistically insignificant (even negative for contrast F2rF5u). For comparison, for some contrasts between two RCs from the radial sides of two fingers, the correlations with the meta-analytic results were higher than $r = 0.9$ and statistically significant (F1F3, F1F4, F1F5, and F3F5). Also in these contrasts the meta-analytical effects of dimorphism are systematically weaker than these computed from individual contrasts.

DISCUSSION

By searching the literature, we found that despite the large number of dermatoglyphic studies, there are very few studies of RCs on fingers with publication of secondary data divided by RCs of individual fingers and virtually none that publish

R1R2		y	smd	ru	rr	uu	ur
right	Czechs	0.11	0.13	0.08	0.26	0.03	0.17
	Lusatian Sorbs	0.10	0.14	-0.17	0.22	0.25	0.55
	Slovaks	0.04	0.05	-0.08	0.25	-0.02	0.25
	Vietnamese	0.05	0.07	-0.24	0.53	-0.16	0.42
L1L2							
left	Czechs	-0.01	-0.02	0.05	-0.02	-0.03	-0.09
	Lusatian Sorbs	0.21	0.31	0.24	0.15	0.14	0.05
	Slovaks	0.05	0.06	0.21	0.01	0.10	-0.10
	Vietnamese	0.15	0.21	0.08	0.20	0.08	0.16
mean		0.09	0.12	0.02	0.20	0.05	0.18

R1R3		y	smd	ru	rr	uu	ur
right	Czechs	0.13	0.18	0.12	0.14	0.06	0.06
	Lusatian Sorbs	-0.044	-0.062	-0.58	-0.11	-0.04	0.32
	Slovaks	0.164	0.228	0.07	0.25	0.13	0.24
	Vietnamese	0.157	0.209	0.19	0.30	0.21	0.26
L1L3							
left	Czechs	-0.077	-0.117	0.124	-0.096	0.033	-0.145
	Lusatian Sorbs	0.180	0.267	0.05	0.27	-0.05	0.12
	Slovaks	0.102	0.149	0.24	0.18	0.13	0.02
	Vietnamese	0.068	0.089	0.25	0.11	0.21	0.09
mean		0.08	0.12	0.06	0.13	0.09	0.12

R1R4		y	smd	ru	rr	uu	ur
right	Czechs	0.07	0.10	-0.17	0.10	-0.19	0.03
	Lusatian Sorbs	0.087	0.127	-0.51	0.07	0.01	0.40
	Slovaks	0.157	0.222	-0.02	0.26	0.04	0.26
	Vietnamese	0.256	0.369	0.32	0.28	0.34	0.25
L1L4							
left	Czechs	-0.061	-0.089	0.046	-0.051	-0.035	-0.124
	Lusatian Sorbs	0.429	0.645	0.28	0.65	0.20	0.40
	Slovaks	0.069	0.096	0.09	0.13	-0.02	-0.01
	Vietnamese	0.271	0.398	0.28	0.17	0.26	0.14
mean		0.16	0.23	0.04	0.20	0.08	0.17

R1R5		y	smd	ru	rr	uu	ur
right	Czechs	0.13	0.20	0.23	0.20	0.14	0.09
	Lusatian Sorbs	-0.025	-0.033	-0.24	-0.08	0.24	0.36
	Slovaks	-0.036	-0.051	0.14	-0.04	0.19	0.03
	Vietnamese	0.262	0.377	-0.01	0.36	0.03	0.29
L1L5							
left	Czechs	-0.101	-0.155	0.150	-0.103	0.043	-0.164
	Lusatian Sorbs	0.239	0.295	0.24	0.32	0.13	0.20
	Slovaks	-0.011	-0.015	0.17	0.00	0.03	-0.12
	Vietnamese	0.220	0.316	0.38	0.24	0.29	0.17
mean		0.08	0.12	0.13	0.11	0.14	0.11

R2R3		y	smd	ru	rr	uu	ur
right	Czechs	0.01	0.01	-0.13	-0.16	0.04	0.03
	Lusatian Sorbs	-0.145	-0.199	-0.75	-0.36	-0.32	0.07
	Slovaks	0.112	0.181	-0.17	-0.05	0.15	0.28
	Vietnamese	0.100	0.189	-0.23	-0.29	0.54	0.58
L2L3							
left	Czechs	-0.061	-0.095	0.149	-0.068	0.069	-0.127
	Lusatian Sorbs	-0.032	-0.060	-0.10	0.09	-0.23	-0.02
	Slovaks	0.048	0.084	0.24	0.17	0.02	-0.09
	Vietnamese	-0.096	-0.158	0.10	-0.11	0.18	-0.01
mean		-0.01	-0.01	-0.11	-0.10	0.06	0.09

R2R4		y	smd	ru	rr	uu	ur
right	Czechs	-0.04	-0.05	-0.43	-0.18	-0.24	-0.01
	Lusatian Sorbs	-0.013	-0.017	-0.75	-0.14	-0.28	0.20
	Slovaks	0.105	0.165	-0.25	-0.03	0.06	0.30
	Vietnamese	0.190	0.324	-0.18	-0.28	0.58	0.50
L2L4							
left	Czechs	-0.046	-0.069	0.065	-0.026	-0.009	-0.103
	Lusatian Sorbs	0.225	0.338	0.16	0.41	0.05	0.31
	Slovaks	0.019	0.030	0.09	0.11	-0.12	-0.12
	Vietnamese	0.109	0.155	0.12	-0.04	0.17	0.04
mean		0.069	0.109	-0.147	-0.023	0.026	0.142

R2R5		y	smd	ru	rr	uu	ur
right	Czechs	0.01	0.01	-0.06	-0.13	0.11	0.06
	Lusatian Sorbs	-0.126	-0.182	-0.50	-0.29	-0.03	0.11
	Slovaks	-0.073	-0.112	-0.14	-0.31	0.19	0.06
	Vietnamese	0.199	0.276	-0.56	-0.22	0.23	0.50
L2L5							
left	Czechs	-0.083	-0.126	0.166	-0.067	0.074	-0.141
	Lusatian Sorbs	0.011	0.016	0.08	0.17	-0.03	0.07
	Slovaks	-0.058	-0.091	0.16	-0.01	-0.07	-0.24
	Vietnamese	0.047	0.071	0.22	0.01	0.20	0.09
mean		-0.009	-0.017	-0.080	-0.105	0.086	0.062

R3R4		y	smd	ru	rr	uu	ur
right	Czechs	-0.05	-0.08	-0.32	-0.05	-0.31	-0.04
	Lusatian Sorbs	0.133	0.211	-0.51	0.19	0.08	0.59
	Slovaks	-0.006	-0.010	-0.26	0.01	-0.12	0.15
	Vietnamese	0.088	0.139	0.05	-0.02	0.08	0.02
L3L4							
left	Czechs	0.016	0.031	0.13	0.06	-0.08	-0.19
	Lusatian Sorbs	0.256	0.516	0.07	0.50	0.32	0.50
	Slovaks	-0.031	-0.055	-0.05	-0.04	-0.18	-0.15
	Vietnamese	0.223	0.388	0.23	0.08	0.01	-0.14
mean		0.078	0.142	-0.081	0.091	-0.025	0.091

R3R5		y	smd	ru	rr	uu	ur
right	Czechs	0.00	0.00	0.11	0.04	0.10	0.02
	Lusatian Sorbs	0.020	0.026	-0.14	0.03	0.50	0.53
	Slovaks	-0.213	-0.317	-0.11	-0.33	0.06	-0.12
	Vietnamese	0.100	0.144	-0.35	0.02	-0.25	0.05
L3L5							
left	Czechs	-0.020	-0.032	0.26	0.00	0.01	-0.23
	Lusatian Sorbs	0.046	0.071	-0.02	0.10	0.29	0.29
	Slovaks	-0.123	-0.189	0.02	-0.20	-0.11	-0.28
	Vietnamese	0.164	0.241	0.27	0.15	0.07	-0.09
mean		-0.003	-0.007	0.005	-0.021	0.084	0.024

R4R5		y	smd	ru	rr	uu	ur
right	Czechs	0.05	0.09	0.14	0.09	0.46	0.38
	Lusatian Sorbs	-0.114	-0.185	-0.27	-0.16	0.31	0.46
	Slovaks	-0.205	-0.359	-0.11	-0.39	0.17	-0.01
	Vietnamese	0.017	0.026	-0.28	0.05	-0.32	-0.03
L4L5							
left	Czechs	-0.036	-0.077	0.21	-0.06	0.11	-0.14
	Lusatian Sorbs	-0.228	-0.402	-0.36	-0.37	-0.12	0.02
	Slovaks	-0.085	-0.148	0.05	-0.17	0.07	-0.10
	Vietnamese	-0.077	-0.150	0.22	0.09	0.06	-0.10
mean		-0.084	-0.151	-0.049	-0.115	0.093	0.059

Table 3: Standardized sex differences. *y* represents **Approach M**, *smd* **Approach S** and contrasts at the individual level (*ru, rr, uu, ur*) represent **Approach F.** The mean for 4 populations is under respective contrasts for respective finger pairs.

	Pearson r		Mean Diff	
F1F2	0.997	****	0.035	*
F1F3	0.998	****	0.033	.
F1F4	1.000	****	0.074	*
F1F5	0.996	****	0.032	
F2F3	0.995	****	0.003	
F2F4	0.997	****	0.041	
F2F5	0.999	****	0.008	
F3F4	0.993	****	0.064	
F3F5	1.000	****	0.004	
F4F5	0.999	****	0.067	*

	Contrast rr	Contrast ru	Contrast ur	Contrast uu
F1F2	0.121	0.392	0.118	0.521
F1F3	**0.973 ******	0.461	0.321	0.316
F1F4	**0.913 ****	0.571	0.692 .	**0.742 ***
F1F5	**0.986 ******	0.331	0.576	0.110
F2F3	0.261	0.274	0.600	0.637 .
F2F4	0.364	0.404	**0.763 ***	**0.722 ***
F2F5	0.127	-0.261	**0.758 ***	0.596
F3F4	**0.780 ***	0.381	0.496	**0.881 ****
F3F5	**0.941 *****	0.122	0.348	0.065
F4F5	0.312	0.163	0.292	0.383

Table 4: Relationship between the meta-analytical effect size (standardized mean difference, SMD, Table 3) of sex differences in contrasts between means (**Approach M**), and the effect size computed by means of method by Polcerová et al. (2022) using contrasts computed at individual level (Table 3) from higher RCs on each finger (**Approach S**) expressed as Pearson product moment correlation coefficient (Pearson *r*, with p-value) in the sample of values for right and left hand of the four testing populations (hands separately, n=8). Differences between these two methods are expressed as differences between mean values (Mean Diff) and tested by permutation Monte Carlo exact test. Significance codes: '****' 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Table 5: Relationship between the meta-analytical effect size (standardized mean difference, SMD, Table 3) of sex differences in contrasts between means (**Approach M**), and the effect size computed by means of method by Polcerová et al. (2022) using contrast computed at individual level (Table 3) from all four original ridge counts (**Approach F**) expressed as Pearson product moment correlation coefficient (Pearson *r*, with p-value) in the sample of values for right and left hand of the four testing populations (hands separately, n=8). Significance codes: '****' 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

statistical parameters of all 20 RCs (from both radial and ulnar sides of fingers). When data are published separately by fingers, they are the mean of the higher of the RCs for that finger which is an intermediate step for computation of TFRC. Then, nowhere is it stated what the combination of radial and ulnar RCs is (moreover, this may be different for each finger, person, and sample). Even these studies with selected higher RCs for each finger were found in very seldom, and therefore, in terms of future development of meta-analysis in dermatoglyphics, the opportunities for studying intraindividual variability by meta-analytical approaches are small.

In general, if we compare the magnitude of the sex dimorphism obtained by the meta-analytic procedure (**approach M**) with the values calculated from individual contrasts (**approaches S and F**), the meta-analytic results provide a dimorphism of visibly lower values. In pairwise comparisons, we saw that the meta-analytic dimorphism effects are smaller than the effects calculated for the same samples from individual contrasts of selected higher values for each finger (**approach S**). This is true systematically for all contrasts. Although this shift/bias is different for each contrast, e.g., for F2F3 it is almost zero on average, for some contrasts it can be up to three-quarters of a tenth of a standard deviation (on average out of 8 samples) but up to one-fifth of the SD for individual samples. Given that sexual dimorphism in RC contrasts reaches a maximum of about 1SD overall in individual samples (ref. Polcerová et al. 2022), and moreover, this is just a methodological bias due to purely different inference from exactly the same raw data, it should be concluded that the **approach M** substantially reduces the observed dimorphism compared to calculations based on the **approach S**. However, when we add a comparison with **approach F**, the difference is even more pronounced. The sexual dimorphism calculated from the original radial and ulnar RCs (**approach F**) is often significantly higher than the sexual dimorphism found by meta-analysis (**approach M**), and some combinations of r and u RCs have a dimorphism significantly greater than the dimorphism calculated in the same way but from individually selected higher values for each finger (**approach S**). Both the selection of a higher value for each finger and the meta-analysis of contrasts of mean values of RCs contribute in some way to reducing the effect of the observed sexual dimorphism and thus to the ability of the method to discriminate and compare dimorphism. On the other hand, even in the **approach M** the side difference found in the original paper with the **approach F** is retained (Polcerová et al. 2022) where for most contrasts the sex differences were higher on the right hand than on the left.

Overall, it is evident that one cannot mix and directly compare the dimorphism obtained by any of these three approaches in a single study and infer anything from the differences in dimorphism. One should always maintain the unity of the method used and, if possible, use the original method of contrasts according to Polcerová et al. (2022), or another statistically more advanced procedure.

In any case, however, further advances in meta-analytic studies of radioulnar intraindividual finger contrast cannot be expected, as the data are not suitably descriptive in published studies and all raw RCs at the individual level (i.e., primary data) need to be available.

CONCLUSION

Despite the large number of dermatoglyphic studies, the character of the published data does not usually allow to study trends between RCs of different fingers on the hand and thus to use the studies for meta-analytical purposes to study radioulnar effects. Raw RC data are usually not published at all; if statistical parameters of RCs for individual fingers are available, it is a matter of selecting the larger RC for each finger that is otherwise used to calculate TFRC. Even so, we were only able to find 11 suitable studies.

Comparison of the meta-analytic effects of sex differences in contrasts between RC means with the effects of dimorphism of contrasts computed on individual level showed that meta-analysis of means yields weaker effects. Selecting only one RC per finger then (regardless of how the dimorphism effect is calculated) does not match the original effects from the original finger-side-specific RCs (radial and ulnar), except for a few finger combinations that have larger radial ridge counts in the vast majority of individuals and populations.

Overall, we are compelled to conclude that the dermatoglyphic literature does not provide a sufficient number of appropriately presented results on RCs of individual fingers, and to study dermatoglyphic intraindividual hand radioulnar trends, the original raw data – RCs at the individual level – must be available.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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APPENDIX

males

ID	Karmakar et al.	Miličić - Vidovic - lowland	Miličić - Vidovic - highlands	Cantor et al.	Andreenko - Baltova	TACR*	Meinerova - CZ[A]	Meinerova - LSRB[A]	Meinerova - VNM[A]	Karmakar et al.	Miličić - Vidovic - lowland	Miličić - Vidovic - highlands	Cantor et al.	Andreenko - Baltova	TACR*	Meinerova - CZ[A]	Meinerova - LSRB[A]	Meinerova - VNM[A]
					yi										vi			
n	293	100	63	270	414	51	36	51	57	293	100	63	270	414	51	36	51	57
R1R2	1.328	1.227	1.109	1.396	0.758	1.355	1.219	0.992	1.093	0.010	0.028	0.042	0.011	0.006	0.057	0.076	0.049	0.046
R1R3	1.075	1.345	0.952	1.356	0.699	1.198	1.010	0.879	1.114	0.009	0.029	0.039	0.011	0.005	0.053	0.070	0.047	0.046
R1R4	0.337	0.632	0.257	0.698	0.252	0.583	0.655	0.388	0.494	0.007	0.022	0.032	0.008	0.005	0.043	0.062	0.041	0.037
R1R5	0.830	0.857	0.551	0.897	0.588	1.018	1.123	0.579	1.058	0.008	0.024	0.034	0.009	0.005	0.049	0.073	0.043	0.045
R2R3	-0.266	0.104	-0.139	-0.028	-0.061	-0.154	-0.193	-0.111	0.018	0.007	0.020	0.032	0.007	0.005	0.039	0.056	0.039	0.035
R2R4	-1.044	-0.525	-0.753	-0.499	-0.524	-0.760	-0.520	-0.594	-0.531	0.009	0.021	0.036	0.008	0.005	0.045	0.059	0.043	0.038
R2R5	-0.524	-0.326	-0.493	-0.356	-0.176	-0.331	-0.089	-0.406	-0.031	0.007	0.021	0.034	0.008	0.005	0.040	0.056	0.041	0.035
R3R4	-0.816	-0.709	-0.686	-0.621	-0.606	-0.696	-0.419	-0.615	-0.593	0.008	0.023	0.035	0.008	0.005	0.044	0.058	0.043	0.038
R3R5	-0.271	-0.485	-0.396	-0.433	-0.150	-0.204	0.133	-0.375	-0.053	0.007	0.021	0.033	0.008	0.005	0.040	0.056	0.041	0.035
R4R5	0.408	0.226	0.339	0.175	0.488	0.443	0.497	0.201	0.715	0.007	0.020	0.033	0.007	0.005	0.041	0.059	0.040	0.040
L1L2	0.518	0.760	0.780	0.997	0.636	0.950	0.754	0.834	0.680	0.007	0.023	0.037	0.009	0.005	0.048	0.063	0.046	0.039
L1L3	0.416	0.629	0.561	0.840	0.485	0.731	0.574	0.763	0.547	0.007	0.022	0.034	0.009	0.005	0.044	0.060	0.045	0.038
L1L4	0.219	0.133	0.561	0.210	0.112	0.157	0.188	0.435	0.191	0.007	0.020	0.034	0.007	0.005	0.039	0.056	0.041	0.035
L1L5	0.513	0.347	0.421	0.507	0.351	0.504	0.522	0.491	0.648	0.007	0.021	0.033	0.008	0.005	0.042	0.059	0.042	0.039
L2L3	-0.092	-0.118	-0.195	-0.138	-0.131	-0.234	-0.200	-0.072	-0.137	0.007	0.020	0.032	0.007	0.005	0.040	0.056	0.039	0.035
L2L4	-0.270	-0.564	-0.195	-0.690	-0.453	-0.845	-0.627	-0.409	-0.505	0.007	0.022	0.032	0.008	0.005	0.046	0.061	0.041	0.037
L2L5	-0.005	-0.371	-0.320	-0.430	-0.246	-0.475	-0.257	-0.351	-0.033	0.007	0.021	0.033	0.008	0.005	0.041	0.056	0.040	0.035
L3L4	-0.166	-0.492	0.000	-0.619	-0.409	-0.660	-0.435	-0.321	-0.429	0.007	0.021	0.032	0.008	0.005	0.043	0.058	0.040	0.037
L3L5	0.082	-0.279	-0.142	-0.327	-0.146	-0.260	-0.059	-0.266	0.122	0.007	0.020	0.032	0.008	0.005	0.040	0.056	0.040	0.035
L4L5	0.290	0.220	-0.142	0.303	0.305	0.363	0.389	0.055	0.522	0.007	0.020	0.032	0.008	0.005	0.041	0.058	0.039	0.037

Table A1: Results of meta-analysis (measure = SMRC) for individual male samples ([A] – archival, * ongoing research): *yi* - standardized mean difference; *vi* - corresponding sampling variance.

females

ID	Karmakar et al.	Miličić - Vidovic - lowland	Miličić - Vidovic - highlands	Cantor et al.	Andreenko - Baltova	TACR*	Meinerova - CZ[A]	Meinerova - LSRB[A]	Meinerova - VNM[A]	Karmakar et al.	Miličić - Vidovic - lowland	Miličić - Vidovic - highlands	Cantor et al.	Andreenko - Baltova	TACR*	Meinerova - CZ[A]	Meinerova - LSRB[A]	Meinerova - VNM[A]
					yi										vi			
n	254	119	58	253	480	69	44	45	19	254	119	58	253	480	69	44	45	19
R1R2	1.062	0.655	1.217	0.914	0.538	0.813	1.465	1.231	0.871	0.010	0.019	0.047	0.010	0.004	0.034	0.070	0.061	0.125
R1R3	0.965	0.595	0.844	0.897	0.601	0.835	1.257	1.322	0.764	0.010	0.018	0.041	0.009	0.005	0.034	0.063	0.064	0.121
R1R4	0.231	0.083	0.227	0.282	0.216	0.221	0.532	0.395	0.140	0.008	0.017	0.035	0.008	0.004	0.029	0.049	0.046	0.106
R1R5	0.778	0.398	0.695	0.681	0.518	0.670	1.162	0.865	0.606	0.009	0.017	0.039	0.009	0.004	0.032	0.061	0.053	0.115
R2R3	-0.092	-0.059	-0.279	-0.015	0.095	0.022	-0.150	0.067	-0.121	0.008	0.017	0.035	0.008	0.004	0.029	0.046	0.044	0.106
R2R4	-0.786	-0.564	-0.742	-0.583	-0.487	-0.579	-0.673	-0.621	-0.827	0.009	0.018	0.039	0.009	0.004	0.031	0.051	0.049	0.123
R2R5	-0.269	-0.253	-0.391	-0.215	-0.030	-0.139	-0.219	-0.272	-0.300	0.008	0.017	0.036	0.008	0.004	0.029	0.046	0.045	0.108
R3R4	-0.843	-0.566	-0.733	-0.696	-0.694	-0.726	-0.745	-0.882	-0.925	0.009	0.018	0.039	0.009	0.005	0.033	0.052	0.053	0.128
R3R5	-0.215	-0.217	-0.177	-0.245	-0.149	-0.195	-0.098	-0.435	-0.234	0.008	0.017	0.035	0.008	0.004	0.029	0.046	0.047	0.107
R4R5	0.467	0.360	0.494	0.399	0.625	0.527	0.563	0.343	0.608	0.008	0.017	0.037	0.008	0.005	0.031	0.049	0.046	0.115
L1L2	0.444	0.699	0.810	0.586	0.599	0.701	1.019	0.682	0.429	0.008	0.019	0.040	0.009	0.005	0.033	0.057	0.050	0.110
L1L3	0.391	0.577	0.477	0.570	0.528	0.545	0.747	0.646	0.421	0.008	0.018	0.036	0.009	0.004	0.031	0.052	0.049	0.110
L1L4	0.179	0.075	-0.073	-0.047	-0.036	0.025	0.195	-0.170	-0.146	0.008	0.017	0.035	0.008	0.004	0.029	0.046	0.045	0.106
L1L5	0.521	0.507	0.401	0.317	0.440	0.357	0.638	0.251	0.347	0.008	0.018	0.036	0.008	0.004	0.030	0.050	0.045	0.108
L2L3	-0.044	-0.125	-0.317	-0.017	-0.060	-0.148	-0.240	-0.033	-0.008	0.008	0.017	0.035	0.008	0.004	0.029	0.046	0.044	0.105
L2L4	-0.224	-0.640	-0.842	-0.665	-0.538	-0.640	-0.728	-0.799	-0.589	0.008	0.019	0.041	0.009	0.004	0.032	0.051	0.052	0.114
L2L5	0.065	-0.197	-0.390	-0.282	-0.135	-0.325	-0.336	-0.404	-0.083	0.008	0.017	0.036	0.008	0.004	0.030	0.047	0.046	0.105
L3L4	-0.209	-0.521	-0.580	-0.670	-0.545	-0.578	-0.578	-0.827	-0.642	0.008	0.018	0.037	0.009	0.004	0.031	0.049	0.052	0.116
L3L5	0.127	-0.072	-0.081	-0.275	-0.086	-0.209	-0.114	-0.401	-0.084	0.008	0.017	0.035	0.008	0.004	0.029	0.046	0.046	0.105
L4L5	0.309	0.452	0.539	0.395	0.484	0.368	0.455	0.349	0.769	0.008	0.018	0.037	0.008	0.004	0.030	0.048	0.046	0.121

Table A2: Results of meta-analysis (measure = SMRC) for individual female samples ([A] – archival, * ongoing research): *yi* - standardized mean difference; *vi* - corresponding sampling variance.

	Karmakar et al.	Milicic - Vidovic - lowland	Milicic - Vidovic - mountains	Cantor et al.	Andreenko - Baltova	TACR	Meinerova - CZ	Meinerova - LSRB	Meinerova - VNM
R1R2	0.161	0.364	-0.066	0.293	0.147	0.335	-0.143	-0.147	0.138
R1R3	0.069	0.472	0.070	0.280	0.066	0.228	-0.150	-0.272	0.217
R1R4	0.074	0.378	0.021	0.283	0.025	0.249	0.083	-0.005	0.242
R1R5	0.034	0.308	-0.097	0.142	0.047	0.226	-0.024	-0.189	0.285
R2R3	-0.123	0.115	0.098	-0.009	-0.110	-0.123	-0.030	-0.125	0.098
R2R4	-0.165	0.027	-0.007	0.057	-0.026	-0.120	0.103	0.018	0.198
R2R5	-0.177	-0.051	-0.070	-0.099	-0.103	-0.134	0.091	-0.093	0.188
R3R4	0.018	-0.096	0.031	0.050	0.060	0.020	0.218	0.176	0.220
R3R5	-0.039	-0.186	-0.152	-0.131	-0.001	-0.006	0.162	0.041	0.127
R4R5	-0.041	-0.093	-0.107	-0.156	-0.094	-0.058	-0.044	-0.099	0.071
L1L2	0.051	0.041	-0.019	0.269	0.025	0.162	-0.169	0.100	0.167
L1L3	0.017	0.035	0.057	0.179	-0.030	0.124	-0.115	0.077	0.085
L1L4	0.028	0.041	0.437	0.181	0.105	0.092	-0.005	0.418	0.235
L1L5	-0.005	-0.110	0.014	0.132	-0.061	0.101	-0.078	0.165	0.202
L2L3	-0.034	0.005	0.085	-0.086	-0.050	-0.060	0.028	-0.028	-0.090
L2L4	-0.032	0.051	0.436	-0.017	0.058	-0.135	0.067	0.261	0.057
L2L5	-0.049	-0.122	0.048	-0.102	-0.078	-0.103	0.055	0.036	0.035
L3L4	0.030	0.020	0.399	0.035	0.094	-0.055	0.097	0.339	0.145
L3L5	-0.032	-0.145	-0.043	-0.036	-0.043	-0.036	0.039	0.093	0.143
L4L5	-0.013	-0.161	-0.470	-0.064	-0.124	-0.003	-0.045	-0.205	-0.165

Table A3: Aggregated effect of sexual dimorphism in standardized radioulnar contrasts (i.e., differences between mean RCs for contrasted fingers of all 9 samples that contains information about both sexes) of **approach M**.