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ORIGINAL ARTICLE

# Chubby hands or little fingers: sex differences in hand representation

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**Abstract**
Disturbed body representation is a condition defined by the perception that one's body size is different from their anatomical size. While equal amounts of males and females suffer from disturbed body representation, there appear to be differences in the direction of this distortion. Females will typically overestimate, whereas males will typically underestimate body size. One part of the body that has been consistently misperceived is the hands. This misrepresentation consists of two distinct characteristics: an overestimation of hand width, and an underestimation of finger length. Many of these studies, however, have used predominately female participants, allowing for the possibility that women are driving this distortion. The aim of the present study was to examine possible sex differences in hand perception. To this end, participants estimated the location of ten landmarks on their hands when their hands were hidden from view. Our results indicate that females follow the characteristic distortion, whereas males only underestimate finger length (albeit more than females). These findings are surprising, because the hands are not an area of concern for weight gain/loss. We discuss these findings in relation to body dysmorphia literature.

## Introduction

Over 90% of anorexia and bulimia patients are female (Fairburn & Beglin, 1990; Hoek & Van Hoeken, 2003). One diagnostic criteria of these two disorders is a disturbed body representation (Grant & Phillips, 2004). Many studies that have investigated body perception in anorexic patients have found that they overestimate the size of their bodies (Cornelissen, Johns, & Tovée, 2013; Gutiérrez-Maldonado, Ferrer-García, Caqueo-Urízar, & Moreno, 2010; Hagman, J., Gardner, R. M., Brown, D. L., Gralla, J., Fier, J. M., & Frank, G. K., 2015; Mohr et al., 2010; Schneider, Frieler, Pfeiffer, Lehmkuhl, & Salbach-Andrae, 2009; Urdapilleta, Cheneau, Masse, & Blanchet, 2007). For example, one study asked female participants, both anorexic and controls, to judge if a photograph of their frontal profile was either too wide or too thin (Hagman et al., 2015). These photographs were distorted between 20 and 30% in either direction. The results showed that the anorexic participants overestimated body size significantly more than the controls suggesting that they believe they are larger than their own body size.

While most of the research on body perception in anorexic patients has focused on females, there is some evidence that anorexic males also overestimate the size of their bodies (Gila, Castro, Cesena, & Toro, 2005). However, males who have a disturbed representation of their body, are more likely to underestimate than overestimate their body size (McCreary & Sasse, 2000; Weltzin, T. E., Weisensel, N., Franczyk, D., Burnett, K., Klitz, C., & Bean, P., 2005). This tendency to underestimate body size is a subtype of body dysmorphia referred to as muscle dysmorphia. This disorder is characterized by a belief that your body is not muscular enough or that it is too small (Olivardia, 2001; Olivardia, Pope Jr, & Hudson, 2000). This has been described as "reverse anorexia" (Pope, Katz, & Hudson, 1993) and it is more prevalent in males than females (Grieve, 2007). So while the incidence of body dysmorphia is similar between the sexes, the direction of the dysmorphia is different with females tending to be more likely to desire a thinner body, and males wishing they had a larger body (McCreary & Sasse, 2000). These differences highlight that body dysmorphia presents itself in different directions in males and females.

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Interestingly, healthy controls have also demonstrated a distorted representation of their bodies. One study asked female participants to modify photos (using a computer) of their own bodies by adjusting its dimensions to the point where they believed it was accurate (Urdapilleta et al., 2007). They found that both anorexic and healthy controls significantly overestimated the size of their body. Thus, it is possible that even healthy females have inaccurate body representation. One area of the body that has been consistently misrepresented by healthy participants is the hands (Coelho & Gonzalez, 2017; Coelho, Zaninelli, & Gonzalez, 2016; Longo, 2014, 2015; Longo & Haggard, 2010, 2011, 2012a, 2012b; Longo, Mancini, & Haggard, 2015; Longo, Mattioni, & Ganea, 2015; Saulton, Dodds, Bülthoff, & de la Rosa, 2015; Saulton, Longo, Wong, Bülthoff, & de la Rosa, 2016). In these studies, participants were asked to place their hand underneath a tabletop (so it was hidden from view), and then localize ten different landmarks on their hands (the tips and metacarpal phalangeal joints (mp joints)). The results show a stereotypical pattern of distortion, which features participants overestimating hand width and underestimating finger length. Crucially, the majority of the previous studies of hand representation included more females than males. For example in the original experiment by Longo and Haggard (2010), there were 15 females and 3 males, and in a study (which replicated Longo and Haggard's results) from our lab there were 15 females and 2 males (Coelho et al., 2016). It is possible, therefore, that the characteristic distortion was primarily driven by the female participants. The direction of the distortion in terms of width would be consistent with previously discussed studies on body dysmorphia where females are more likely to overestimate body width. But if body dysmorphia affects females and males differently, it is possible that hand representation in males would have a very different pattern; one of underestimation.

The aim of the present study was to investigate sex differences in hand representation in healthy neurotypical participants. While previous research has investigated sex differences in body perception (Grieve, 2007; Sand, Lask, Høie, & Stormark, 2011; Sisson, Franco, Carlin, & Mitchell, 1997), these studies have focused on key areas such as the waist or thigh. By focusing on the hand, we intend to investigate if the perceptual patterns of body dysmorphia could affect perception of a body part that is not a primary concern for weight change. If this happens to be the case, an argument can be made regarding why females are more likely to suffer from anorexia and males to suffer from muscle dysmorphia. We split our participants into a male and female group and asked them to complete a similar task to Coelho et al., 2016. With their hands hidden from view, each participant was required to estimate where they believed ten different landmarks (the tips and mp joints of each of the five fingers) on their hands were located. Furthermore, we decided to include an analysis of both the left and the right hand as previous work from our lab (Coelho et al., 2016; Coelho & Gonzalez, 2017) as well as others (Linkenauger et al., 2009) have identified differences in perception between the hands. All these studies have found that the right hand is perceived as larger than the left hand. It has been proposed that these differences in hand perception are due to the fact that the right hand is perceived as being more capable than the left hand (Linkenauger et al., 2009). If this is the case, then we expect to see an overall difference of hand, with the right hand as being perceived larger than the left, for both males and females.

## Methods

### Participants

59 university students (25 males and 34 females) participated in the study in exchange for course credit. All participants were right-handed. Handedness was assessed using a modified version of the Edinburgh (Oldfield, 1971) and Waterloo (Brown, Roy, Rohr, & Bryden, 2006) handedness questionnaires. We conducted a power analysis using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) which revealed that to find sex differences with a 95% certainty a total of 46 participants (23 of each sex) were required.

### Materials

An Optotrak certrus camera (Northern Digital, Waterloo, ON, Canada) recorded the position of an iRED marker that was attached to the end of a wooden stylus. The position of the stylus was recorded for 1000 ms at 100 HZ for each trial.

### Procedure

The participants sat in front of a glass table (41 L × 86.5 W CM) with a wooden shelf located 12 cm below the glass top (see Fig. 1). They placed the palm of their hand (with their fingers spread apart) underneath the glass table, while their forearm rested on a thin pillow. The pillow was incorporated into our setup, to help ensure that the participants hand remained in a stable hand position for the duration of the study. Once they were comfortable a black tablecloth was placed over the table, occluding the participants hands from view (occluded hand condition). We then asked participants to estimate where they believed ten different locations on their hands (the tips and mp joints of their fingers) were located. The order of trials was pseudorandomized. The participants pointed by touching the top of the glass with the wooden stylus. After each trial, the participants returned the wooden stylus to a home spot that was located

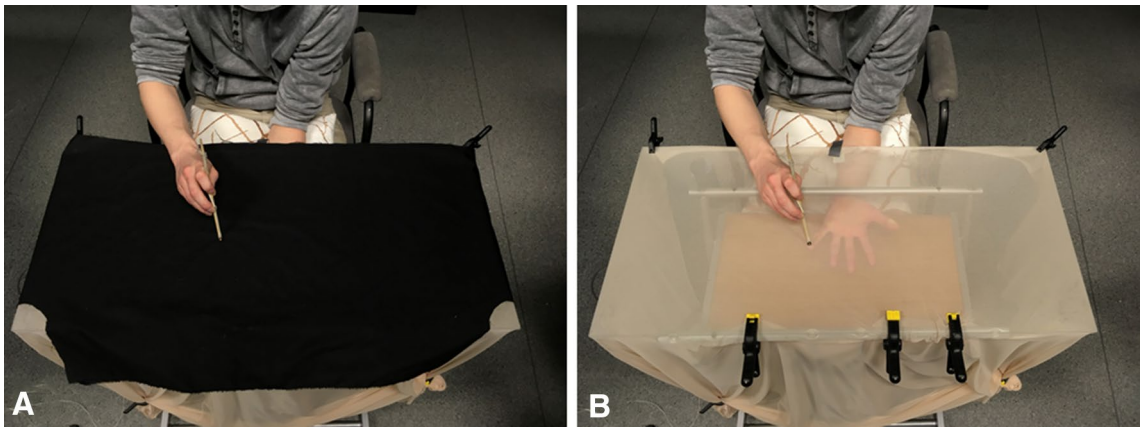


**Fig. 1** View of the experimental setup. **a** The occluded hand condition is shown. Participants placed their hands underneath the glass table top and rested their forearm on a thin pillow. A black tablecloth was placed over top of the table and participants had to estimate where they believed the different landmarks were on the

directly above the participants forearm (as in Coelho et al., 2016). Each location was pointed to five times for a total of 50 trials per condition. After the occluded hand condition was completed, the tablecloth was removed and then the participant repeated the same task, but with full vision of their hands (non-occluded hand trials). The non-occluded condition was completed so the estimation trials (occluded hand condition) could be compared to the actual size of the participant's hand. This task was repeated for both the participant's right and left hands (for a total of 200 trials, 50 per condition), with the starting hand being counterbalanced across participants. To investigate how sex effects the representation of our hands, we split our participants into two groups (male and female) depending on their sex.

### Analyses

We conducted two main analyses on the data. The first analysis (Occluded vs non-occluded hand) was a series of a-priori t-tests conducted on the raw values (expressed in mm). This was conducted to determine if the estimated values (occluded hand condition) were different from the physical metrics of the hand (non-occluded hand condition). We modeled this analysis after the analysis used in the original report (Longo & Haggard, 2010), and it was identical to the analysis used by Coelho et al., 2016.

The second analysis (effects of hand and sex) was a $2 \times 2$ repeated measures ANOVA, where hand (left, right) was the within-factor, and sex (male, female) was the between-factor. For this analysis, data were expressed as the percent of the real value ((occluded − non-occluded)/(non-occluded)) × 100. This analysis was included as it allowed us to compare directly between individuals, as it takes into account individual hand size differences.

The two analyses were repeated for two different variables: hand width (the great span), and finger length. The great span was calculated as being the summed distance between the tip of digit 1 to the tip of digit 5. We calculated finger length as the average between the tip and base of each of the five digits. These variables were identical to those used by Coelho et al., 2016.

### Data processing

Trials were excluded if participants moved the stylus before the 1000-ms recording was finished, or if the participant pointed to the incorrect landmark (< 5% of all trials).

All data were analyzed using Matlab R2015a (Mathworks, Natick, MA, USA), and statistics were completed using SPSS 23.

## Results

### Analysis one: occluded vs non-occluded hand

Only significant results are reported. All values are Bonferroni corrected.

#### Females

Great span: female participants significantly overestimated the width of their right ($t$ (33) = 3, $p$ = 0.02, $d$ = 1; occluded hand 200.93 ± 6.4 mm, non-occluded hand 181 ± 3.5 mm) and left ($t$ (33) = 2.9, $p$ = 0.02, $d$ = 1; occluded hand 201.1 ± 5.7 mm, non-occluded hand 186.9 ± 3.7 mm) hands.

Finger length: Finger length was underestimated by female participants for both the right ($t$ (33) = − 6.2, $p$ < 0.01, $d$ = 2.1; occluded hand 44.4 ± 1.6 mm,

non-occluded hand 54 ± 0.6 mm) and left ($t$ (33) = − 7.8, $p < .01$, $d = 2.7$; occluded hand 45 ± 1.3 mm, non-occluded hand 54 ± 0.7 mm) hands.

#### Males

Great span: male participants accurately estimated the width of both their right and left hands ($p$'s > 0.4).

Finger length: male participants underestimated finger length for both the right ($t(24) = -11$, $p < 0.01$, $d = 4.5$; occluded hand 43.3 ± 0.9 mm, non-occluded hand 56.8 ± 0.9 mm) and left ($t(24) = -6.5$, $p < 0.01$, $d = 2.6$; occluded hand 43.7 ± 1.2 mm, non-occluded hand 60 ± 2 mm) hands.

### Analysis two: effects of hand and sex

Great span: there was a significant main effect of hand [$f(1,57) = 5.8$, $p = 0.02$, partial $\eta^2 = 0.09$], where the right hand (7 ± 2.5%) was significantly more overestimated than the left hand(2.4 ± 1.8%). There was also a main effect of sex [$f(1,57) = 6.8$, $p = 0.01$, partial $\eta^2 = 0.11$], where females (9.9 ± 2.5%) overestimated the width of their hands, while males (− 0.2 ± 2.5%) made accurate estimations. See Fig. 2.

Finger length: There was a main effect of sex [$f(1,57) = 5.6$, $p = 0.02$, partial $\eta^2 = 0.09$], where male participants (− 24.6 ± 2.4%) underestimated finger length more than the female participants (− 17.2 ± 2%). See Fig. 3.

## Discussion

The purpose of the present study was to investigate possible sex differences in body perception in healthy individuals. The hand was chosen as a model because studies have consistently documented misrepresentation of this body part. Female and male participants completed a hand perception task. For this, participants placed their hands underneath a tabletop (the hands were occluded from view), and were asked to localize ten landmarks on their hands (the tips and mp joints of their fingers). Using 3D motion capture technology, the width of the hands and length of the fingers were derived from *XY* coordinates. The results showed significant differences between the sexes for both hand width and finger length. Our hypothesis was partially supported in that females overestimated hand width. Males however, did not underestimate width but instead had accurate representations. With respect to finger length the prediction was less straight forward as studies of body dysmorphia have focused mostly on width. We found that both groups underestimated finger length but more so in the male group. The results suggest that representation of the hands is different for females and males.

One of the diagnostic criteria for anorexia is an overestimation of body size (Cornelissen et al., 2013). This disorder predominately affects females with over 90% of all clinical anorexic patients being female (Fairburn & Beglin, 1990; Hoek & Van Hoeken, 2003). In the present study, we found that healthy females overestimated the width of their hands. This is in line with previous research that has found that healthy females also overestimate body size (Schneider et al., 2009; Urdapilleta et al., 2007). For example, Schneider

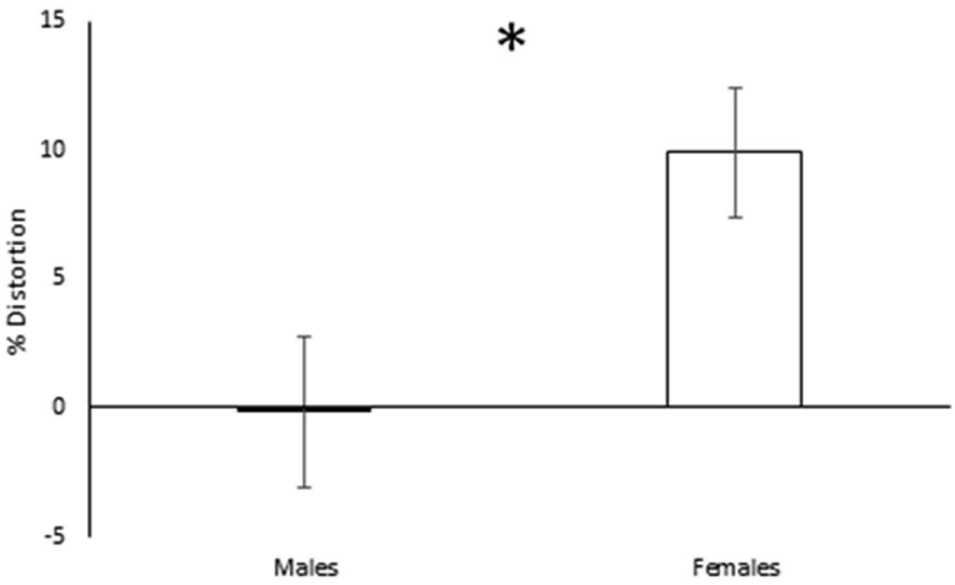


**Fig. 2** Main effect of sex for the great span. Females overestimated the width of their hands, while males made accurate estimations

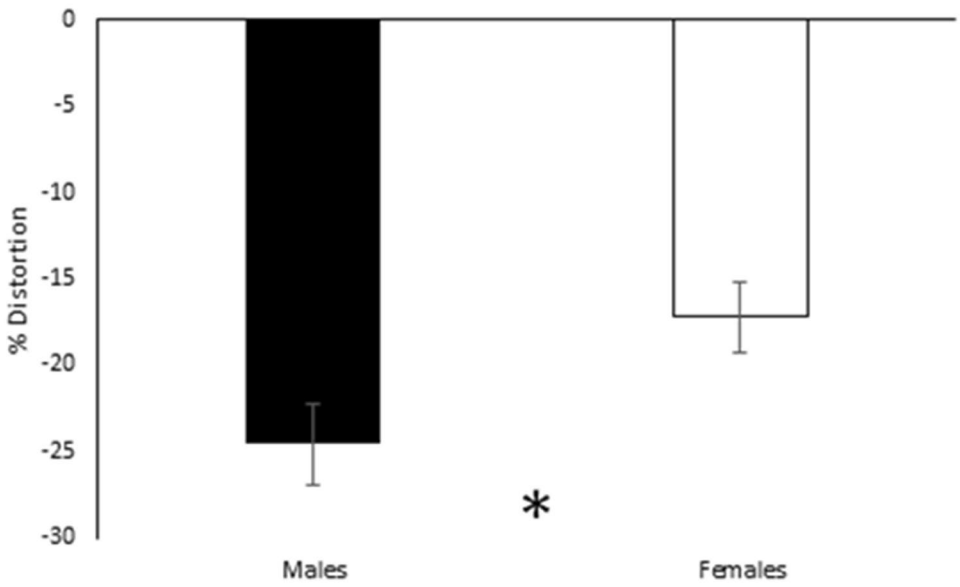


**Fig. 3** Main effect of sex for finger length. Males underestimated finger length significantly more than females did

et al. asked participants to estimate the size of their waist, thighs, and arms. Participants estimated the circumference of each of these body parts by adjusting a string. They found that while the eating disorder participants overestimated circumferences significantly more than the healthy controls, the healthy controls still overestimated these body parts by 8–16%. In the current study overestimation of hand width by the female group fell exactly within this range (13.6%). It is puzzling that the hand would follow the results observed on the waist and thigh, because one could argue that hand width is not usually a body part that women (including those with eating disorders) are concerned about (Berscheid, Walster, & Bohrnstedt, 1973; Petrie, Tripp, & Harvey, 2002). This is probably due to the fact that diet and exercise would not result in big changes regarding hand shape/size (as it would to say the stomach or the thighs). In particular, the distance between the thumb and the pinky would seldom be affected by gain/loss of body fat. The finding that females overestimate hand width suggests that females have a tendency to overestimate width of all their body parts. Disturbed body representations are one of the diagnostic criteria for anorexia and bulimia, and these are female-dominated disorders. It is possible that females are more likely to develop these disorders because they overestimate the width of all body parts.

With respect to males, they underestimated finger length more than females. This finding is also in line with the common type of body dysmorphia experienced by males. While body dysmorphia rates are similar between males and females, males are more likely to underestimate body size (Sand et al., 2011; Sisson et al., 1997). Males have self-reported that they feel their bodies to be small, and that they wished their bodies were bigger (McCreary & Sasse, 2000; Olivardia, 2001; Olivardia et al., 2000). One study investigated how youth (aged 12–15) perceive their own body size. Participants were asked to adjust a distorted photograph of themselves on a computer screen until it reflected what they believed to be their body metrics (Sand et al., 2011). They found that males at risk of developing an eating disorder underestimated body size. Although in the present study we did not collect information about eating habits, it is possible that males in general underestimate the size of all body parts including, as we found, finger length. Future research is needed to elucidate if body perception changes as a function of body mass index (BMI), eating habits, and/or exercise regimens.

While previous research has identified that there are sex differences in body perception disorders (Grieve, 2007; Sand et al., 2011; Sisson et al., 1997), a puzzle remains as to why these sex differences exist. One possibility is that sex differences are driven by the different biopsychosocial influences that females and males experience (McCabe, Ricciardelli, Sitaram, & Mikhail, 2006). McCabe et al., investigated the predictors of body size accuracy, and found that female's predictors included depression levels, and media/peer influences. Although studies have shown strong links between body dysmorphia and depression (Olivardia, Pope Jr, Borowiecki III, & Cohane, 2004; Otto, Wilhelm, Cohen, & Harlow, 2001) for both males and females. For females the two seem to comorbid more often in males (Stice, Hayward, Cameron, Killen, & Taylor, 2000; Vaughan & Halpern, 2010). Future research on body perception, including that of the hand could include a measure of depression as a covariate.

Interestingly, depression was not a predictor of body dysmorphia in males, but instead peer influence and BMI were predictors. Males with greater BMI had more distorted

body representation. Puzzling, BMI was not a predictor in females, indicating that body perception is similar regardless of body composition. This is important as it suggests that females who suffer from body dysmorphia may place more importance on the social factors (such as media and peer pressure) than on their real weight (i.e. BMI). Furthermore, an additional study found that only females linked body dissatisfaction with their self-esteem (Furnham, Badmin, & Sneade, 2002) supporting the view that social factors influence body representation particularly in females. Because our females were inaccurate in both width and length, this would suggest that social cues may have greater influence on body perception.

Another possible explanation for the sex differences found in the current study pertains to the visuospatial nature of the task. It is known that males outperform females in some visuospatial tasks (Bull, Cleland, & Mitchell, 2013; Delgado & Prieto, 1996; Kramer, Ellenberg, Leonard, & Share, 1996; Postma, Jager, Kessels, Koppeschaar, & van Honk, 2004; Voyer & Jansen, 2016; Weiss, Kemmler, Deisenhammer, Fleischhacker, & Delazer, 2003). For example, Delgado and Prieto (1996) asked participants to complete two visuospatial tasks (a rotation of solid figures task and a 3D mental rotation task). They tested a large number of participants (621 males and 821 females), and found that males were more accurate than females in both measures of visuospatial ability. It is possible that males made accurate estimates of hand width, because our task requires mental visualization and perhaps some degree of mental rotation (although we did not measure this). A visuospatial advantage cannot, however, explain why males underestimated finger length significantly more than females. Furthermore, a recent study has found similar results to the ones described here (Walk & Heller, 2014). The experiment required participants to estimate the size of their hands when the hand was magnified, reduced, or with no added distortion (control condition). These authors found that males underestimated hand size significantly more than females when judging their hands with normal vision. Perhaps there is a clear asymmetry in the way males and females perceive their hands, with males underestimating length and females tending overestimating width.

Last, the left and the right hand were not perceived to be the same size. The right hand was perceived larger than the left in both females and males. This result has been found on several other occasions (Buchner, Kauert, & Radermacher, 1995; Coelho et al., 2016; Linkenauger, Witt, Bakdash, Stefanucci, & Proffitt, 2009). One reason that could explain a larger representation for the right hand is that there is more cortical area devoted to this hand when compared to the left (Buchner et al., 1995). It is also possible that this asymmetry exists because we perceive the right hand as being more capable than the left hand. Evidence for this comes from a study that asked participants to estimate their hand size, as well as the largest object (from an array) that they thought they could grasp with each hand (Linkenauger et al., 2009). These authors showed that participants not only estimated their right hands as larger than their left hands, but they also estimated that they could grasp larger objects with their right hand. Thus, the larger representation of the right hand could be due to the fact that this hand is perceived as more capable than the left hand. Our results indicate that the difference in perceived hand size is well-conserved across sexes. It is puzzling, however, that hand differences only appears in measures of hand width; there were no differences between the hands in terms of finger length ($p = 0.78$) for either males or females. It is possible that we did not find finger length differences between the hands because participants pointed to the landmarks of their hands in a random fashion (tip of the thumb followed by base of the middle finger, followed by tip of the pinky, etc). In a previous study (Coelho et al., 2016), we found that when participants pointed in a systematic fashion (moving from one location to the nearest adjacent digit pairing), perception of finger length for the left hand was that of being shorter than for the fingers of the right hand. We argued in that paper that when the hand is perceived in a holistic manner (in the systematic fashion) differences between the hands occur for both hand width and finger length. A different possibility is that because we collapsed across the fingers, any difference between the hands (in relation to a specific digit) was washed out. To ensure this was not the case, we conducted an additional analysis where we looked at individual digit length, and found no main effect of hand ($p = 0.66$), and importantly no hand by digit interaction ($p = 0.33$).

To conclude, we investigated sex differences in a hand perception task. The results showed significant effects of sex for both hand width and finger length. Females overestimated width while males made accurate judgements. Males underestimated finger length significantly more than females. We propose that the characteristic distortion of hand perception described previously may only be present in females. The sex differences found in this study align with the body dysmorphia literature which finds that females are more likely to overestimate the width of their bodies, whereas males are more likely to underestimate its size. Further research is needed to investigate a possible link between hand perception and overall body perception.

## Data availability

The data set used and analyzed in this study are available from the corresponding author upon request.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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