Published in final edited form as:

Ann Hum Biol. 2017 December ; 44(8): 678–686. doi:10.1080/03014460.2017.1392603.

An anthropometric survey of US pre-term and full-term neonates

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Abstract

Background—Anthropometric data prove valuable for screening and monitoring various medical conditions. In young infants, however, only weight, length and head circumference are represented in publicly accessible databases.

Aim—To characterise length and circumferential measures in pre-term and full-term infants up to 90 days post-natal.

Subjects and methods—In eight US medical centres, trained raters recorded humeral, ulnar, femoral, tibial and fibular lengths along with mid-upper arm, mid-thigh, chest, abdominal and neck circumference. Data were pooled by post-menstrual age into 1-week intervals and population curves created using the lambda, mu and sigma (LMS) method. Goodness-of-fit was assessed by

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Supplemental data for this article can be accessed [here](#).

Disclosure statement

No potential conflict of interest was reported by the authors.

examining de-trended quantile-quantile plots, Q statistics and fitted centiles overlaid on empirical centiles.

Results—In total, 2097 infants were enrolled in this study with a mean $\pm$ SD gestational age and post-natal age of 37.1 ± 3.3 weeks and 27.3 ± 25.3 days, respectively. A re-scale option was used to describe all curves. The resultant models reliably characterised anthropometric measures from 33–52 weeks PMA, with less certainty at the extremes (27–55 weeks).

Conclusion—The population curves generated under this investigation expand existing reference data on a comprehensive set of anthropometric traits in infants through the first 90 days post-natal.

Keywords

Extra-uterine growth; infants; limb length; circumference; growth reference; anthropometry

Introduction

In addition to defining the boundaries of normal growth and development, anthropometric data demonstrate considerable utility in both clinical and public health sectors. Collectively, anthropometric data facilitate screening and monitoring for a number of medical conditions and congenital anomalies. They serve as robust and reliable surrogates of nutritional status, in some settings informing the thresholds for referral to supplemental feeding programmes (Myatt et al., 2006; United Nations High Commissioner for Refugees, 2011; World Health Organization, 2007). Alone, or in combination, anthropometric measures can be used to predict morbidity and mortality risks (Chasse et al., 2016; Gustafson et al., 2007; Heitmann & Frederiksen, 2009; Sinkey et al., 2016). They also provide a proxy for total body weight or length when the traditional measurements are problematic to obtain (Abdel-Rahman et al., 2013; Gauld et al., 2003; Haapala et al., 2015).

For decades, the National Health and Nutrition Examination Survey, co-ordinated by the Centres for Disease Control and Prevention (CDC) and National Centre for Health Statistics (NCHS), has been a vital source of anthropometric data on US children. These invaluable data have informed the development of paediatric growth charts, assisted in policy-making decisions and supported national health initiatives (Zipf et al., 2013). For infants under 2 months of age, however, only weight, length and head circumference (derived from state vital registries) are represented in these databases. Length and circumferential measures for other body segments remain incompletely characterised in early post-natal life. In this investigation, we characterise anthropometric measures in pre-term and full-term US infants up to 90 days post-natal age (PNA) and develop the reference tables against which clinical and research measures can be evaluated.

Subjects and methods

Design and participants

This was a multi-centre, cross-sectional, cohort study conducted between February 2015 and December 2015. Infants up to 90 days PNA were enrolled at eight paediatric medical centres across the US: Children's Mercy Hospitals and Clinics, Kansas City, MO; Penn State

College of Medicine, Hershey, PA; Wesley Medical Center, Wichita, KS; University of Arkansas for Medical Sciences and Arkansas Children's Hospital Research Institute, Little Rock, AR; Children's Memorial Hospital, Chicago, IL; Medical University of South Carolina, Charleston, SC; Cincinnati Children's Hospital Medical Center, Cincinnati, OH; and Oregon Health and Science University, Portland, OR. The participating sites were selected to balance enrolment across gestational age (GA), while making every effort to reflect the racial/ethnic distribution of the US population. Infants were excluded from participation if (1) there were known or apparent limb deformities, (2) there was external medical equipment that would impair the collection of measurements or (3) in the opinion of the investigator or treating physician, there were real or perceived contraindications for their inclusion. Multiples were not excluded from study participation; however, enrolment of infants in the study on more than one occasion was not permitted. All infants were enrolled with informed permission under a protocol that was reviewed and approved by the Institutional Review Boards at each participating institution.

Because the concept of age was central to the study and recruitment, several key concepts were established *a priori* and the sources of the information identified. Race and ethnicity were determined by parental self-report using National Institutes of Health categories. GA at birth, estimated from early ultrasound or last menstrual period as recorded in the medical record, was recorded in weeks and days. PNA was recorded in days, with the day of birth equal to day of life zero. Post-menstrual age (PMA) was calculated in completed weeks according to: GA (weeks) + PNA (days)/7.

Weight, when naked, was recorded to the nearest gram on calibrated infant scales that were verified against a certified weight (Troemner, Thorofare, NJ) prior to the start of the study. Length was obtained on infantometers with a fixed headpiece and a horizontal back piece and recorded to the nearest millimetre. The duration of time between the last feeding and stooling was also recorded. All remaining measurements were recorded to the nearest millimetre with a vinyl measuring tape that was verified accurate against a National Institute of Standards and Technology certified ruler (GEI International, Inc., Syracuse, NY). Enrolment was stratified based on gestational age and PNA, with an overall target sample size of 2000 infants, which provides adequate reliability to estimate centiles across the majority of the studied PMA ranges.

Length measures

Long bone length measurements were performed according to published protocols (Anton et al., 2009; Centers for Disease Control and Prevention (CDC), 2007). Upper arm length (hereafter referred to as humeral length) was measured from the upper edge of the posterior border of the acromion process to the tip of the olecranon process with the arm bent 90° at the elbow and the tape extending down the posterior surface of the arm. For the forearm, ulnar length was measured from the distal tip of the ulnar styloid process to the tip of the olecranon with the arm bent at the elbow 90–110°. Thigh length (hereafter referred to as femoral length) was measured from the inguinal crease to the proximal border of the patella with both the hip and knee bent at a 90° angle and the tape measure running down the anterior surface of the thigh. For the lower leg, tibial length was measured on the inner

aspect of the lower leg from the proximal aspect of the medial border to the distal point of the medial malleolus. Fibular length was obtained on the outer aspect of the lower leg from the proximal aspect of the fibular head to the distal point of the lateral malleolus.

Circumferential measures

Circumferential measurements were performed according to published protocols (CDC, 1998, 2007; National Institute of Standards and Technology, 1977). Mid-upper arm circumference was measured at the mid-point between with acromion and the olecranon process with the tape measure perpendicular to the long axis of the humerus. Mid-thigh circumference was measured at the mid-point between the inguinal crease and the proximal border of the patella with the measuring tape perpendicular to the long axis of the thigh. Chest circumference was obtained at the end of exhalation with the infant's arms extended outward and the tape positioned under the axilla wrapping around the chest at the level of the nipples. Abdominal circumference was measured with the tape positioned in a horizontal plane at the level of the ilium wrapping just over the umbilicus. Head circumference was measured across the frontal bones, slightly above the eyebrows and ears, over the occipital prominence at the back of the head with the tape measure perpendicular to the long axis of the face. Neck circumference was measured at the mid-point of the neck between mid-cervical spine and mid-anterior neck with the tape measure perpendicular to the long axis of the neck. For all circumferential measurements the measuring tape was pulled to fit snugly around the landmark without compressing the skin.

Rater training and reliability checks

All raters that performed anthropometric measurements were qualified prior to study initiation. Raters were required to perform each of the study related length and circumferential measurements in triplicate on at least three individuals and to demonstrate intra-rater variance of less than 5% for each measurement. Raters failing to meet the criteria on their initial qualification attempt for any measurement were offered one opportunity to remediate. Raters failing a second qualification attempt were not permitted to participate in the study. Inter-rater agreement was also evaluated during site qualification with an allowable variance threshold of no greater than 10% across all raters at a given site when examined against the values generated by an experienced measurer. During study execution, a minimum of 5% of study participants were selected at random for multi-rater assessment. In this sub-set of infants, two raters performed each measurement on the selected participant using the same measuring devices. Weekly, the measuring tapes were verified for accuracy against an acrylic ruler that had been verified for accuracy against the National Institute of Standards and Technology certified ruler.

Data analysis

Handling of outliers—Outliers that might be the result of measurement error or reflect recording error were identified by application of the modified Thompson tau test. Data were segregated by PMA and the mean ($\bar{x}$) and standard deviation (σ) for each anthropometric measure calculated at each week of PMA. We chose to use PMA rather than PNA to correct for GA at birth. The absolute deviation for each data point (δ_i) was determined according to

$\delta_i = |x_i - \bar{x}|$. The modified Thompson tau value was calculated according to $\tau = [t_{\alpha/2}^*(n - 1)] / [n^* (n - 2 + t_{\alpha/2}^2)]$, where n is the number of data points and $t_{\alpha/2}$ is the student's t -value with $n - 2$ degrees of freedom. A conservative α value of 0.005 was selected for the uncommon anthropometric measurements. A more conservative α value of 0.001 was selected for anthropometric measurements routinely generated as part of clinical care (e.g. height and weight). The individual sample with the largest δ_i value at each PMA was rejected when $\delta_i > \tau^* \sigma$. Subsequently, x were re-calculated and a process of recursive elimination employed to remove each successive maximum δ_i value until no additional outliers were identified (i.e. $\delta_i \leq \tau^* \sigma$). In total, the number of outlying values identified for each measure were as follows: humerus (13), ulna (33), femur (13), tibia (30), fibula (18), mid-upper arm (38), mid-thigh (36), chest (18), abdomen (26) and neck (39), distributed across 196 infants.

Validation—Given the availability of normative values for newborn length, weight and head circumference, the distribution of z -scores for each measure was examined to investigate whether the study population deviated from the general population (i.e. whether the mean $\pm$ standard deviation diverged from 0.0 ± 1.0). For full-term infants, gender- and PNA-specific z -scores were calculated according to $z_i = ((x_i/M)^L - 1)/(LS)$. Where z_i represents the individual z -score, x_i the individual length, weight, or head circumference value, and LMS the lambda, mu and sigma values as published by the CDC (<https://www.cdc.gov/growthcharts/zscore.htm>). For cases where $L = 0$, z -score was calculated according to $z_i = \ln(x_i/M)/S$.

For pre-term infants, gender- and PMA-specific z -scores were calculated using the Fenton growth chart calculator published on-line (www.ucalgary.ca/fenton/2013chart). It should be noted that the pre-term z -score data were generated from curves that reflect intra-uterine growth. For the purposes of comparison with our study population, extra-uterine growth is expected to lag behind intra-uterine growth. Thus, average length and weight z -scores for pre-term infants in this study were expected to fall below zero (Bhatia, 2013; Sauer, 2007).

Curve construction—Population sizes for PMA curves were generated for humeral length, ulnar length, femoral length, tibial length, fibular length, mid-upper arm circumference, mid-thigh circumference, chest circumference, abdominal circumference and neck circumference. Principal components analysis was performed to identify the most relevant demographic variable by which to stratify infants (JMP version 12.0, SAS, Cary, NC). Sizes for PMA curves were created using the lambda, mu and sigma (LMS) method described by Cole and Green (1992) and executed with LMSchartmaker Pro v2.54 (Harlow Printing Limited, Tyne & Wear, UK). The distribution of anthropometric values was summarised for each PMA group using a Box-Cox power transformation of skewness (L), median (M) and coefficient of variation (S). This method transforms the anthropometric data so that they are approximately normally distributed and generates PMA-specific estimates of LMS as cubic smoothing splines by non-linear regression. Maximum penalised likelihood estimation was used to optimise the effective degrees of freedom for M followed by L and then S. Goodness-of-fit was assessed by examining (1) the de-trended quantile (Q) – Q plots

of the z -scores, (2) the Q statistics for L, M, S and kurtosis and (3) the plots of the fitted centiles overlaid on the empirical centiles.

Statistical analyses—Continuous demographic and anthropometric measures are reported using standard descriptive statistics (e.g. mean, standard deviation). Discrete variables are summarised by counts and percentages. Inter-rater reliability was examined by calculating the intra-class correlation coefficient (ICC) along with the 95% confidence intervals for ICC. Differences in z -score distributions between racial and ethnic sub-groups were examined using analysis of variance with a Tukey post-hoc test. SPSS version 23 (IBM Analytics, Armonk, NY) and SAS version 9.3 (SAS, Cary, NC) were used for all analyses unless otherwise noted above.

Results

Demographics

A total of 2097 infants were enrolled in this study. Participant sites went live with enrolment in the following order coincident with completion of training: Hershey, PA ($n = 414$), Wichita, KS ($n = 338$), Charleston, SC ($n = 203$), Little Rock, AR ($n = 285$), Chicago, IL ($n = 280$), Cincinnati, OH ($n = 137$), Kansas City, MO ($n = 396$) and Portland, OR ($n = 44$). A demographic breakdown across the entire population and within the pre-term and full-term cohorts is provided in Table 1. Within the pre-term cohort ($n = 787$), 4.5% of infants were <28 weeks gestation, 16% were 28–31 weeks gestation and 79.5% were 32–36 weeks gestation. Compared with the most recent US census data (2014), the infants enrolled in this study were represented by a higher proportion of African-Americans (28.6% vs 13.2%) and Hispanics (19.1% vs 17.4%) (www.census.gov). The mean $\pm$ standard deviation z -scores for weight (0.08 ± 1.17), length (0.25 ± 1.06) and head circumference (-0.09 ± 0.88) suggested that the full-term infants in this study were taller and marginally heavier, with a slightly smaller head circumference than the reference US population (Figure 1(A)). Negative deviations from population reference values were observed in mean z -scores for these same measures in our pre-term population (weight = -0.63 ± 0.99 ; height = -0.50 ± 1.02 ; head circumference = -0.11 ± 0.94 , Figure 1(B)).

Size for PMA curves

An exploratory principal components analysis revealed that the majority (71.1%) of variability in the length and circumferential measures was accounted for by the first principal component, which was most highly correlated with PMA ($r^2 = 0.749$, F -ratio = 5436.7, $p < 0.0001$) as opposed to GA or PNA. Gender, although significant, was only weakly correlated with the first principal component. As such, data were pooled by PMA into 1-week intervals and not further segregated by other demographic variables, an approach consistent with a recent publication of longitudinal growth standards in pre-term infants (Villar et al., 2015). An examination of the relationships between abdominal circumference and time since last stooling or feeding revealed that these time frames accounted for 1.8% and 2.7% of the variability in abdominal circumference, respectively. Accordingly, abdominal circumference data were combined across the entire cohort in a single size for PMA curve.

A re-scale option was used to describe the curves for all anthropometric variables with effective degrees of freedom values for L/M/S detailed as follows: humeral length = 3/5/3, ulnar length = 2/4/2, femoral length = 2/4/3, tibial length = 3/5/4, fibular length = 2/5/3, mid-upper arm circumference = 2/5/3, mid-thigh circumference = 2/4/2, chest circumference = 2/5/2, abdominal circumference = 2/5/2, neck circumference = 2/5/3. For nearly all anthropometric measures, the detrended Q-Q plots satisfied the desired criteria (Supplemental Figure); the worms pass through the origin, the slope approximates 0 and the curve is not parabolic in shape. However, some curves reflected a bit of residual kurtosis, which could not be minimised during fitting.

Figure 2 depicts the fitted 5th, 25th, 50th, 75th and 95th percentiles overlaid on the raw centiles. Although the intent of pooling children by PMA prior to constructing size for PMA curves was to minimise the imprecision that can be introduced with small sample sizes, we still observed sub-groups at the extremes of PMA with exceedingly few children. As such, areas of reduced certainty wherein only a small number of infants were available for fitting are depicted with a dashed line. For all measures, the data appeared to fit reasonably well with no sacrifice in fit at the extremes of PMA. The LMS values for each model are defined in Supplemental Tables S1–S10.

As expected, the average $\pm$ SD z -scores across the entire population for every measure were 0.00 ± 1.00 ; however, an examination of the z -scores generated by these curves reveals that a number of measures differ statistically by ethnicity (Table 2). Hispanic infants demonstrated longer upper leg lengths, shorter lower leg lengths and larger circumferential values than their non-Hispanic counterparts. Differences in the mean spanned 0.25 standard deviations, on average, ranging in absolute values from 0.16–0.40. For mid-upper arm circumference, where the mean difference was 0.16 z -score, essentially no misclassification bias would occur, with 4.8% of Hispanic children classified above the 95th percentile ($z = 1.645$) vs 4.9% of non-Hispanic children. The bias is greater for chest circumference (mean difference = 0.40), where 11% of Hispanic children would be classified above the 95th percentile vs 4.7% of non-Hispanics. Far fewer racial differences were observed, these being restricted primarily to circumferential measures between subjects of European descent and African-Americans. Exploring abdominal circumference as an example (mean difference = 0.17), these differences would translate into 7% and 5% of African-American children classified below the 5th percentile and above the 95th percentile, respectively. In European-derived children, these respective numbers would be 6% and 5.7%.

Rater reliability

Forty-three clinical raters were recruited across the eight study sites. Of these, 23 qualified on their first attempt, 14 passed with remediation, and six failed, or elected not to remediate. During the study period, inter-rater reliability assessments were performed on 138 (6.6%) of the enrolled infants. Intra-class correlation coefficients for each anthropometric measure are reported in Table 3. The highest concordance rates were observed for head circumference, chest circumference and abdominal circumference (ICC = 0.99). The measurements that suffered the greatest discordance were mid-thigh circumference, tibial length and fibular length (ICC = 0.89).

Discussion

At the lower limit of age, the routine use of segmental or limb lengths or circumferential measures is largely restricted to the pre-natal period, where ultrasonography is used to estimate foetal weight and *in-utero* growth as well as to diagnose or predict morbidities associated with pre-term birth (Kehl et al., 2014; Mailath-Pokorny et al., 2015; Spaggiari et al., 2015; Williams et al., 2015). In the newborn period, anthropometrics are typically limited to observations of weight, length and head circumference. Yet, a limited body of work suggests other measurements may hold value for estimating GA or low birth weight, identifying nutritional management issues and predicting neurodevelopmental outcomes (Arisoy & Sarman, 1995; Das et al., 2012; Kaur et al., 2015; Marchant et al., 2014; Pfister & Ramel, 2014; Sauerborn et al., 1990; Thawani et al., 2013). Normative data for anthropometric and other measures of body composition will be increasingly important for paediatricians and neonatologists as we expand our knowledge of the association with early weight gain and later development of metabolic syndrome (Ekelund et al., 2007; Koyama et al., 2014). However the paucity of reference data on a comprehensive set of anthropometric traits, along with the lack of studies having performed the necessary analyses to transform measurements into centiles or *z*-scores, limits the scope of anthropometric applications for infants during their first few months of life (Bertino et al., 2007).

This study attempts to address these shortcomings by providing descriptive data on 10 distinct measures from a large cohort of pre-term and full-term children through 90 days PNA. The models described in this paper reliably characterise segmental limb lengths and circumferential measures from 33–52 weeks PMA. Although the available data permitted extrapolation of our models down to 27-weeks and up to 55-weeks PMA, the limited sample size in these PMA groups supports the need for measurements from additional children to improve confidence in these models at the extremes of PMA. PMA offered the strongest association with the various measures, independent of gender; however, this may limit the utility of these size-for-PMA curves in settings where GA cannot be reliably estimated.

Among the 10 measurements, chest circumference and abdominal circumference represented the most reproducibly performed circumferential measurements while humeral length and femoral length were the most reproducible limb length measures. Consequently, these measurements may warrant consideration when exploring anthropometric predictors of selected co-morbidities or surrogates for weight or total body length. Notably, others have reported that surrogate anthropometric measures including ulnar length have shown good precision for predicting infant length (Forman et al., 2014; Weidauer et al., 2014). These applications are critical in settings where length measurement may not be reliable to aid in estimation of body mass index and body surface area (Haycock et al., 1978).

Demographically, the infants represented in this study reasonably approximate the US population, thus the data contained herein can serve as a reference on which to examine growth, habitus or stature in US infants. However, we are careful to point out that this was a cross-sectional study with no exclusion for conditions which could lead to intra-uterine growth restriction. The minor deviations we observed between our population and the reference population may reflect a combination of the initial extra-uterine weight loss that

infants experience shortly after birth or sub-optimal growth of premature infants in the extra-uterine environment (Fenton & Kim, 2013). In addition, our study included premature infants whose post-natal growth may have been affected by illness and complications of prematurity. For example, a 25-week infant now 10 weeks old and corrected to 35 weeks PMA would not be expected to have similar weight and measurements as an infant born at 35 weeks gestation. As such, these reference data are descriptive and in no way intended to reflect prescriptive standards to which post-natal development should conform. This is in contrast to recent WHO and Intergrowth-21st initiatives which are designed to define optimal growth patterns in infants and children (Villar et al., 2013; World Health Organization Multicentre Growth Reference Study, 2006a). The absence of exclusion criteria limiting infants with non-optimal intra-uterine growth in this study broadens the distribution of infants to which these reference data apply, including premature children with varying degrees of intra-uterine growth restriction; however, the reliability of our models at the extremes of PMA needs to be emphasised. Nevertheless, further investigations aimed at integrating anthropometric measures into health and nutrition or monitoring and screening strategies for infants up to 90 days PNA are needed.

It is also important to recognise that we present single-size charts irrespective of race and ethnicity. Our results suggest that impact of race on these measures was limited, although we are unlikely powered to detect differences that may be present for the low frequency races enrolled in our study. Thus, establishing the universality of these data will require additional investigations that explore whether published differences in total body length between children of varying ethnicity extend to differences in segmental or circumferential measures (World Health Organization Multicentre Growth Reference Study, 2006b).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding

This work was supported by Eunice Kennedy Shriver National Institute of Child Health and Human Development (HHSN275201000003I).

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Figure 1.
Histograms of z-scores for weight, length and head circumference for the (A) full-term and (B) pre-term infants enrolled in this survey.

Figure 2.

Fitted centiles overlaid on raw centiles for the anthropometric measures in infants 27–55 weeks post-menstrual age: (A) humeral length; (B) ulnar length; (C) femoral length; (D) fibular length; (E) tibial length; (F) mid-upper arm circumference; (G) mid-thigh circumference; (H) abdominal circumference; (I) chest circumference; (J) neck circumference. Dashed lines depict areas of reduced certainty wherein only a small number of infants were available for fitting.

Table 1

Demographics.

	Pre-term (<37 weeks) (n = 787)	Full-term (≥ 37 weeks) (n = 1310)	Total (n = 2097)
Male (%)	52.1	51.1	51.5
Gestational age (weeks), mean ± SD (min, max)	33.8 ± 2.7 (23.6, 36.9)	39.2 ± 1.2 (37.0, 42.0)	37.1 ± 3.3
Post-natal age (days), mean ± SD (min, max)	26.0 ± 23.4 (0, 90)	28.2 ± 26.3 (0, 90)	27.3 ± 25.3
Hispanic ethnicity (%)	11.8	23.5	19.1
Race			
European-derived (%)	67.5%	59.5%	62.5%
African-American (%)	24.8%	30.9%	28.6%
Asian (%)	1.1%	2.4%	2.0%
Native Hawaiian or Pacific Islander (%)	0.5%	0.4%	0.4%
American Indian or Alaska Native (%)	0.6%	0.2%	0.4%
Multiracial (%)	3.0%	3.3%	3.2%

Table 2

Mean differences in *z*-score by race and ethnicity.

Measure	Mean <i>z</i> -score difference					
	Hispanic vs Non-Hispanic	European-derived vs African-American	European-derived vs Multi-racial	European-derived vs Pacific Islander	European-derived vs Asian	European-derived vs Native American/Alaskan
Humeral length	-0.02	0.01	0.11	0.10	-0.03	-0.44
Ulnar length	0.01	0.00	0.15	0.62	-0.48*	-0.12
Femoral length	0.30*	0.04	0.25	-0.03	-0.11	0.03
Tibial length	-0.21*	-0.07	0.04	0.02	-0.29	-0.21
Fibular length	-0.29*	-0.14	-0.05	-0.21	-0.25	-0.22
Mid-upper arm circumference	0.16*	-0.11	-0.05	-0.22	-0.03	-0.13
Mid-thigh circumference	0.18*	0.09	0.13	-0.36	0.03	-0.28
Chest circumference	0.40*	0.16*	0.02	-0.03	-0.01	0.00
Abdominal circumference	0.24*	0.17*	-0.01	-0.47	0.09	-0.12
Neck circumference	0.07	-0.24*	-0.12	-0.83	0.08	-0.30

* $p < 0.05$.

Table 3Inter-rater reliability assessments ($n = 138$ participants).

Measure	Intra-class correlation (95% CI)
Humeral length	0.94 (0.92–0.96)
Ulnar length	0.91 (0.87–0.93)
Femoral length	0.95 (0.93–0.97)
Tibial length	0.87 (0.83–0.91)
Fibular length	0.89 (0.85–0.92)
Mid-upper arm circumference	0.94 (0.92–0.96)
Mid-thigh circumference	0.78 (0.70–0.84)
Chest circumference	0.99 (0.98–0.99)
Abdominal circumference	0.99 (0.98–0.99)
Neck circumference	0.97 (0.96–0.98)