THE RELATIONSHIP BETWEEN ARM SPAN AND STATURE IN NIGERIAN ADULTS

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Abstract:

Studies have shown that the relationship between stature and arm span varies with age and population. Whether this is true for the Nigerian population is not known. This cross-sectional study examines the relationship between stature and arm span in Nigerian adults. Standing stature and arm span of 306 (180 men and 126 women) healthy students between 20 and 49 years of age were measured in February 2009. The arm span exceeded stature in all the age groups of both genders. The mean difference between the stature and arm span values for women was 4.4±4.5 cm (t=14.24, p<.001) and for men it was 5.8±6.2 cm (t=12.85, p<.001). Gender difference between stature and arm span measurements was statistically significant (t=9.71, p<.001 and t=10.03, p<.001, respectively). Arm span was a good predictor of stature for men (stature=67.63+.577 (Arm span); r=.77) and women (stature=55.16+.642 (Arm span); r=.72), accounting for 59.3% and 51.8% of variance in the subjects' stature, respectively. The correlation between arm span and stature (r=.82; p<.01) was high and significant in all the age groups. The findings could be of practical significance in sports, ergonomics, growth and development monitoring, and in physical anthropology.

Key words: *cross-sectional study, t-test, age difference, gender difference, linear regression analysis stature prediction*

Introduction

The measurement of stature is important in many settings. Stature measurement is required for the evaluation of children's growth, calculation of nutritional indices of children and adults, prediction and standardization of physiological variables such as lung volumes (Golshan, Crapo, Amra, Jensen, & Golshan, 2007), muscle strength, glomerular filtration, metabolic rate, and for the tailoring of drug dosage in patients (Zverev, 2003). However, in some cases the accurate stature cannot be determined directly because of deformities of the limbs or in patients who have undergone amputations. Measuring stature can also be difficult in physically and mentally frail nursing home patients, e.g. patients that are wheelchair-bound or bedridden and those with osteoporosis, sequelae after hip fractures, or stroke. In such situations, an estimate of stature has to be derived from other reliable anthropometric indicators. These estimations help in predicting age--related loss in stature, identifying individuals with disproportionate growth abnormalities and skeletal dysplasia or stature loss during surgical procedures on the spine. These measurements have also found application in normalizing pulmonary function in scoliosis (Golshan, et al., 2007). It could also be utilized in sport settings in estimating the stature of wheelchair athletes or other sports individuals with disabilities involving amputation of a leg, or other deformities. Additionally, in many older people it is difficult, if not impossible, to measure standing stature accurately because of mobility problems and kyphosis (Hickson & Frost, 2003). Therefore, measurements of other body segments like arm span (Hickson & Frost, 2003; Jalzem & Gledhill, 1993; Yun, et al., 1995; Mohanty, Babu, & Nair, 2001), demi-span (Hickson & Frost, 2003; Weinbrenner, Vioque, Barber & Asensio, 2006), knee height (Hickson & Frost, 2003; Neruda, 2004), skull (Bidmos & Asala, 2005; Bidmos, 2006), scapula (Campobasso, Di-Vella, & Introna, 1998) and vertebral column length (Nagesh & Pradeep,

2006) can be used as an alternative to estimate standing stature.

Several studies have reported the effectiveness of using various body variables in estimating stature (Jalzem & Gledhill, 1993; Yun, et al., 1995; Mohanty, Babu, & Nair, 2001; Hickson & Frost, 2003) and arm span was found to be the most reliable. However, correlations between arm span and stature have been shown to vary in different ethnic groups (Steele & Chenier, 1990; Reeves, Varakamin, & Henry, 1996; Brown, Feng, & Knapp, 2002). Even though several studies of this nature are available on western populations, hardly has such a study been reported for the Nigerian population. Therefore the purpose of this study was to examine the relationship between arm span and stature in a group of Nigerian adults.

Methods

Participants

The participants for this study were 306 (180 men and 126 women) students (aged 20-49 years) of the Benue State University (BSU), Makurdi, Nigeria. They were purposively selected from the BSU's Department of Human Kinetics and Health Education. All the students from the department were eligible to participate in the study. The exclusion criterion was being non-Nigerian. Participants with physical deformities that could affect stature or arm span, and without informed consent were excluded from the study. The age group included in the study was chosen because by this age the growth of an individual ceases. Students were admitted into BSU regardless of ethnicity, geographical residence and socio-economic status. Therefore, we believe that our study sample might fairly represent the population of the Benue state, Nigeria. The nature and scope of the study were explained to the participants who gave their informed written consent.

Measurements

Stature and arm span were measured for all the participants according to the standard anthropometric methods of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones, Olds, Stew, & Carter, 2006). Stature was measured to the nearest .1 centimetres (cm) in bare feet with the participants standing upright against a stadiometer. Arm span was measured with a calibrated steel tape. Participants stood bare-foot with feet together on a level concrete floor, with their upper backs, buttocks and heels touching the wall. The participant's head was held erect and the eyes looking forward. The lower margin of the eye socket (orbitale) and the tragion (the notch superior of the tragus of the ear) were in the Frankfort plane. Arm span was measured with a flexible steel tape from the tip of the middle fingers of the left and right hands, with the individual standing with the back to the wall and both arms abducted to 90 degrees; the elbows and wrists extended and the palms facing directly forward. Readings were taken to the nearest .1 cm. Each participant was measured twice. When the two measurements agreed within .4 cm, their average was taken as the best estimate for the true value (Steele & Chenier, 1990). When the two initial measures did not satisfy the .4 cm criterion, two additional determinations were made and the mean of the closest records was used as the best score. The anthropometric measurements were taken in the morning by two certified technicians (Level II ISAK anthropometrist). One took all height measurements and the other measured the participants' arm span.

Statistical analysis

Means and standard deviations (SD) of the participants' data were computed. The *t*-test was utilized to examine significant differences in stature and arm span by gender and age groups, respectively. Linear regression analyses with adjustment for age were performed to examine the extent to which arm span can reliably predict stature. An internal cross-validation approach in which the total sample was split randomly into two groups (n=244 and n=62) was used and an equation was developed for each, with the other group being used to cross-validate each equation. A single equation was then developed for the entire sample. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS) version 17.0. The significance level was 5%.

Results

Table 1 presents the means and standard deviations of stature and arm span measurements, and the differences between the two variables according to age group and gender in the Nigerian sample. The arm span exceeded stature in 89.7% of the participants. Measurements in 10.3% of the participants indicated a contrary result. The mean difference between the stature and arm span for women was 4.0±4.5 cm ($t=14.24$, $p<.001$) and for men 5.8±6.2 cm ($t=12.85$, $p<.001$). The gender difference between stature and arm span measurements was statistically significant ($t=9.71$; $p<.001$ and $t=10.03$; $p<.001$, respectively).

Arm span and stature were positively correlated ($r=.83$) in the sample regardless of gender and age. The correlation coefficient between stature and arm span was high and significant in both groups of participants (men: $r=.76$; $p<.01$) and women: $r=.72$; $p<.01$). Results of the regression analysis aimed at predicting stature from arm span is shown in Table 2.

Table 1. Means and standard deviations of anthropometric variables of adult Nigerians

Age groups (years)	Men				Women			
	n	Stature (cm)	Arm span (cm)	Difference (cm)	n	Stature (cm)	Arm span (cm)	Difference (cm)
20-29	139	167.2 (6.5)	172.7 (9.1)	5.5 (5.6)*	76	160.3 (5.7)	164.2 (6.9)	3.9 (4.6)*
30-39	28	167.8 (8.1)	174.5 (8.2)	6.7 (6.3)*	31	160.9 (4.0)	164.7 (4.2)*	3.8 (4.0)*
40-49	13	167.7 (5.0)	175.8 (10.7)	8.1 (7.28)*	19	159.3 (5.1)	163.7 (4.9)*	4.4 (3.8)*
Total	180	167.4 (6.6)	173.2 (9.1)	5.8 (6.2)*	126	160.2 (5.2)	164.2 (5.9)*	4.0 (4.5)*

*p≤.05.

Table 2. Equation for estimating stature from arm span in adult Nigerians

	Coefficient	SE	t	*p* value
Males:				
Intercept	67.626	5.655	11.96	.000
Arm span	.577	.032	17.67	.000
SEE=4.029, R^2=.634				
Females:				
Intercept	55.156	8.972	6.15	.000
Arm span	.642	.054	11.72	.000
SEE=3.637, R^2=.521				

SEE, standard error of the estimate

For every unit increase in arm span, the stature increases significantly in both males and females. The estimated regression equations were obtained as: Men: Stature (cm)=67.63+.577 [Arm span (cm)]; Women: Stature (cm)=55.16+.642 [Arm span (cm)].

The total sample was split randomly into two groups (n=244 and n=62) to develop prediction equations for stature based on the arm span measurements. The estimated regression equation for the validation group (n=244) was as follows: Stature (cm)=49.51+.681 Arm span (cm) (r=.85, p<.001). For the cross-validation group (n=66) the predicted regression equation was obtained as: Stature (cm)=83.31+.483 Arm span (cm) (r=.71, p<.001). The overall equation for the sample was as follows: Stature (cm)=56.36+.644 Arm span (cm) (r=.83, p<.001). There was a significant linear relationship between stature and arm span observed among the subjects (Figure 1).

Age had a significant effect on stature and arm span in men (F=232.3, p<.000; F=292.1, p<.000, respectively) and women (F=143.2, p<.000; F=297.4, p<.000, respectively). Nevertheless, the introduction of age in the prediction equations significantly decreased R^2 values. The standardized residual plots showed that the linear model of the relationship between stature and arm span values was suitable and adequate.

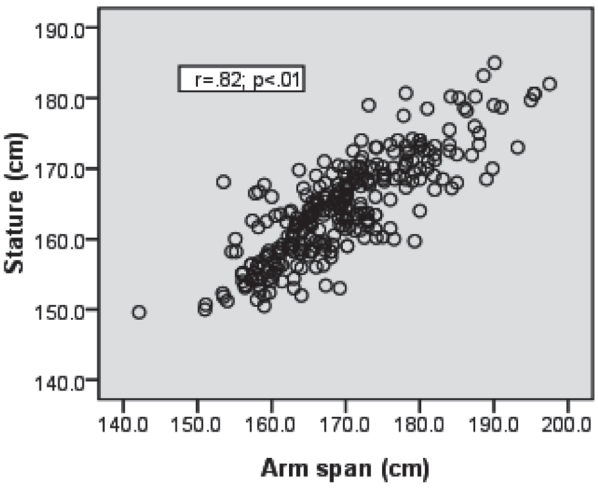

Figure 1. The relationship between stature and arm span.

Discussion and conclusion

The prediction of stature utilizing arm span measurement has been attempted by many authors using smaller samples (Steel & Chenier, 1990; Kwok & Whitelaw, 1991; Yun, et al., 1995; Aggrawal, Gupta, Ezekiel, & Jindal, 2000; Hickson & Frost, 2003; Zverev, 2003). Additionally, this cross-sectional study provided us with the data which

aided our understanding of the relationship between arm span and stature in adults living in Makurdi, Nigeria; information which is currently lacking. The results of this study showed that the mean arm span measure exceeded stature measure in Nigerian adults, consistent with other studies (Steele & Chenier, 1990; Yun, et al., 1995; Reeves, et al., 1996; Aggrawal, et al., 2000; Hickson & Frost, 2003; Zverev, 2003). Consistent with Zverev (2003) study of Malawians adults, this study found statistically significant gender difference between stature and arm span measures in adult Nigerians. Standard procedures were applied in the measurement of arm span and stature in these samples as such the larger differences between the arm span and stature values are unlikely ascribable either to systematic error in measurement or nor the likelihood that the arm span of a comparatively large sample of Nigerian participants was affected by a pathological condition such as Marfan's syndrome, which is portrayed by disproportional elongation of extremities. The large difference between the measures of arm span and stature found in this study, which was observed by Zverev (2003) among the Malawians too, might be explained in the light of a relatively short stature of the participants. There is scanty data on arm span in African populations, therefore it was not possible to make further comparisons of Nigerians with other Africans.

A strong correlation between arm span and stature (r=.83) was observed in our sample consistent with other studies which found strong associations between arm span and stature. For example, Kwok and Whitelaw (1991) (r=.93), Nygaard (2008) (r=.75), Mohanty et al. (2001) (r=.82), Hickson and Frost (2003) (r=.86), and Zverev (2003) reported a correlation of r=.87 for men and .81 for women. The correlation between stature and arm span was high and significant in both groups of participants, which was similar to other reports (Steele & Chenier, 1990; Yun, et al., 1995; Aggrawal, et al., 2000; Zverev, 2003). The arm span measure therefore seems to be a reliable indirect physical measurement for estimating stature. However, such prediction estimates might vary across races thus warranting the need for similar studies in different ethnicities and regions.

Consistent with other studies, the surrogate measurement described in this study could be used for estimating the stature of an individual. It could be useful among wheelchair athletes or other sports individuals with disabilities involving amputation of the leg, or other deformities affecting standing stature.

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POVEZANOST RASPONA RUKU I VISINE TIJELA U ODRASLIH NIGERIJACA

Istraživanja su pokazala da povezanost raspona ruku i visine varira s godinama i među populacijama. Trenutačno nije poznato vrijedi li navedena znanstvena činjenica i za nigerijsku populaciju. Ovo transverzalno istraživanje utvrđuje povezanost raspona ruku i visine tijela u odraslih Nigerijaca. Tijekom veljače 2009 godine izmjerene su varijable *visina tijela u stajanju* i *raspon ruku* u 306 zdravih studenata (180 muškaraca i 126 žena) u dobi od 20 do 49 godina. Raspon ruku bio je veći od visine tijela u svim dobnim grupama ispitanika i ispitanica. Razlika u aritmetičkim sredinama raspona ruku i visine tijela za žene bila je 4,4±4,5 cm (t=14,24; p<,001), a za muškarce 5,8±6,2 cm (t=12,85; p<,001). Razlike između spolova u visini tijela i raspona ruku bile su statistički značajne (t=9,71; p<0,001, odnosno t=10,03; p<0,001). Raspon ruku se pokazao kao dobar prediktor visine tijela za muškarce (visina tijela=67,63+0,577 (raspon ruku); r=0,77) i žene (visina tijela=55,16+0,642 (raspon ruku); r=0,72), budući da je objasnio 59,3% varijance visine tijela u muškaraca i 51,8% varijance visine tijela u žena. Korelacija između raspona ruku i visine tijela (r=0,82; p<0,01) bila je velika i statistički značajna u svim dobnim skupinama ispitanika. Rezultati ovoga istraživanja mogu imati veliki praktični značaj za sport, ergonomiju, proučavanje rasta i razvoja čovjeka te, osobito, za kineziološku antropologiju.

Ključne riječi: *transverzalno istraživanje, t-test, dobna razlika, spolna razlika, linearna regresijska analiza, procjena tjelesne visine*