European Journal of Clinical Nutrition (2006) 60, 1180–1188

ORIGINAL ARTICLE

Validity of an alternative anthropometric trait as cardiovascular diseases risk factor: example from individuals with traumatic lower extremity amputation

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Background: Published studies reveal that individuals with lower extremity amputation are vulnerable to cardiovascular diseases (CVD) because of poor physical activity level. Many cardiovascular risk assessment studies have utilized anthropometric traits (primarily body mass index and waist circumference) as cardiovascular risk factor. However, some studies emphasized the technical limitations of measuring waist circumference for studying cardiovascular risk, and so it is difficult to obtain correct measurement from the individuals with lower extremity amputation.
Objectives: The objectives of the present article are to study the prevalence of CVD risk factors among the individuals with traumatic lower extremity amputation and to test the validity of upper arm circumference (UAC) as an alternative anthropometric measurement for screening the CVD risk condition.
Subjects and setting: Anthropometric data and other cardiovascular traits data have been collected from unilateral traumatic lower extremity amputated adult males ($n = 85$) residing in Calcutta and adjoining areas.
Results: Results show higher prevalence of cardiovascular risk factor among individuals with above-knee amputation than below-knee amputation. The receiver operating characteristics curve analysis shows significant ability of upper arm circumference to diagnose cardiovascular risk condition. The cutoff value of UAC > 26.6 cm show maximum sensitivity and specificity for the diagnosis of cardiovascular risk condition. Although, binomial tests for equality of proportion does not show any significant difference, however, agreement statistics reveal better diagnostic ability of cutoff value of UAC than the existing cutoff value of waist circumference.
Conclusions: Therefore, UAC provides a better assessment of cardiovascular risk condition than does waist circumference especially for individuals with lower extremity amputation.
Sponsorship: Indian Statistical Institute, Kolkata.
European Journal of Clinical Nutrition (2006) **60**, 1180–1188. doi:10.1038/sj.ejcn.1602434; published online 17 May 2006

Keywords: cardiovascular risk factors; upper arm circumference; lower-extremity amputation

Introduction

Cardiovascular diseases (CVD) are the leading cause of mortality in humans (World Health Organization, 2002). Clinicians and researchers have identified several risk factors of CVD to screen out the persons at risk of attaining the CVD (Kannel *et al.*, 1961). The term 'risk factor' generally denotes a factor, which has a positive association of developing a particular disease (Beaglehole *et al.*, 1993). Framingham Heart Study (Wilson *et al.*, 1998) introduced the concept of cardiovascular risk factors, to make primary prevention of CVD more effective, which enables a categorization of patients for selection of appropriate interventions, through an assessment of cardiovascular risk.

Grundy *et al.* (1999) emphasized physical inactivity as one of the leading factors of CVD. This was supported by

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Contributors: Both the authors participated in the study design, data analysis and writing the article. AM collected field data.

Oldridge and Stump (2004) and Pollitt *et al.* (2005) and they proved that low physical activity level have a fatal effect, which often leads to enhance the risk of developing CVD in the general population. Physically disabled individuals are particularly vulnerable to the problem, especially the locomotor-disabled person, who generally have a very low physical activity level owing to their impairedness. Therefore, the risk of developing CVD is more among locomotor-disabled persons (Resnick *et al.*, 2004).

Various follow-up studies on prognosis of the lower extremity amputation (LEA) show that most of the individuals with LEA suffer from peripheral vascular or CVD (Weiss *et al.*, 1990; Condie *et al.*, 1996). Cross-sectional studies also reveal higher prevalence of CVD risk factors among individuals with LEA (Madan *et al.*, 1998; Resnick *et al.*, 2004). Again, Resnick *et al.* (2004) reported that the risk of developing CVD is more among individuals with amputation owing to peripheral vascular disease, but the individuals with traumatic amputation also show high mortality owing to CVD (Madan *et al.*, 1998). In a follow-up study among traumatic amputees, Hrubec and Ryder (1980) showed that the differential mortality rate owing to CVD varies depending on the site of amputation, and the mortality rate owing to CVD is higher in the individuals with proximal limb amputation than in the individuals with distal limb amputation.

Body composition assessment through anthropometric measurements is generally considered as one of the well-established method of assessment of cardiovascular health in human (Weiner and Lourie, 1981). Among the different anthropometric measurements and indexes, body mass index (BMI) and waist circumference (WC) are well-known measures and considered as cardiovascular risk factor traits (Grundy *et al.*, 1999). The utility of these two measurements has been discussed in many cardiovascular health studies as well (Janssen *et al.*, 2002; Bigaard *et al.*, 2003). Body mass index is a good predictor of overall nutritional status (Shetty and James, 1994) and obesity (Grundy *et al.*, 1999; Bigaard *et al.*, 2003), whereas, WC is the good predictor of central obesity only (Grundy *et al.*, 1999) and not a predictor of overall nutritional status. Janssen *et al.* (2004) mentioned that WC alone is good enough to assess obesity and cardiovascular health. However, Bigaard *et al.* (2004) show contrasting findings, for underweight persons, and in the normal weight range, WC does not show much sensitiveness to predict the CVD mortality rate. Besides, there are some technical ambiguity in taking the measurement of WC, for example, there are at least four sites for the measurement of WC (Wang *et al.*, 2003), which do not yield similar and comparable data. Moreover, it is difficult to measure WC on the individuals with LEA (as the non-perfect bipedal gait of the individuals with LEA may affect the soft tissue distribution around waist area of the body).

In view of the difficulties envisaged in working on the individuals with LEA, an alternative measurement is necessary, which has a strong correlation with other established cardiovascular risk factor measurements (such as BMI). It was thought that the measurement should be simple and may be obtained from any individual without any technical ambiguity. Upper arm circumference (UAC) measurement has proved to be very sensitive to the change of body composition and nutritional status (James *et al.*, 1994; Mozumdar and Roy, 2000).

In view of the above, the objectives of the present article are to study the following among the individuals with traumatic LEA from Calcutta and its adjoining areas: (1) to study the prevalence of cardiovascular risk factors among the individuals with traumatic LEA and comparing the prevalence of cardiovascular risk factors between groups of individuals with above-knee and of individuals with below-knee amputation; (2) to determine the diagnostic ability of UAC for the risk assessment of cardiovascular diseases; (3) to determine a cutoff point for UAC and its validity indicating the presence of cardiovascular risk; and (4) to test the validity of UAC in comparison with WC measurement.

Materials and methods

Subjects and setting

The data used in the present study have been collected as a part of a larger bio-medical program involving lower extremity-amputated individuals of Calcutta and its adjoining areas. Two national level rehabilitation centers, National Institute for the Orthopedically Handicapped and Mahavir Seva Sadan have been contacted for a list of addresses of amputated individuals. A statement of purpose of the present research and a consent form seeking their participation in the study have been mailed to about 1000 adult male individuals with unilateral LEA. Respondents (109 individuals), with written consent, have been included in the study. However, there were some dropouts in between the time of data collection owing to death or severe illness or migration, leaving 102 individuals with LEA, representing in all data sets. For the present study, 85 individuals, who has amputation owing to traumatic cause have been included. Individuals having amputation with a history of diseases (cancer, diabetes, and so on) have been excluded, as they carry on an evident cardiovascular risk. Out of 85 individuals, 27 individual are with above-knee amputation and 58 individuals with below-knee amputation. A number of 105 normal males, matched for age and socio-ecomonic status, were also measured as control group. The study was performed in accordance with the responsible committee on human experimentation (Scientific Ethical committee for Protection of Research Risks to Humans, Indian Statistical Institute).

The mean age of the subjects (individuals with traumatic LEA) is 42.58 ± 14.81 years. All subjects have prosthesis and all of them had been amputated at least 2 years prior to the study. All data have been collected by a single investigator (AM) through multiple home visits.

Data type and data collection

Anthropometric measurement of the individuals with traumatic LEA includes: (1) stature, (2) body weight, (3) WC and (4) UAC. Data on cardiovascular traits include blood pressure (both systolic and diastolic). Some metabolic traits have also been collected, which includes (1) blood glucose, (2) total cholesterol and (3) triglycerides in blood. Data on all the measurements have been collected following standard techniques as recommended by International Biological Program (IBP) (Weiner and Lourie, 1981). The subjects were requested to wear prosthesis before taking stature and body weight measurements (if required supported against a wall and with adequate precautions to guard against bending of the trunk and knees). The weight of the prosthesis was taken alone and subtracted from the previous weight with prosthesis, to get the actual weight (post-amputation) of the body. As there is no standard method for measuring stature of the amputated individuals, the stature measurement of an amputee was cross-checked for consistency by calculating body proportions (sitting height/stature) (Drillis and Contini, 1966) and compared with control individuals.

Body mass index has been calculated from the anthropometric measurements using the formula body weight/stature^2. Body mass index has been calculated after estimating the total body weight of the individuals with amputation using the method of Mozumdar and Roy (2004). The body weight for the amputees was estimated using the weight proportions of the different limb segments of the body (Osterkamp, 1995) with the help of following equations:

$$W_E = W_O/(1 - \Delta W/W_E)$$

$$\Delta W/W_E = 1.5 + 4.4(1 - L_{Stp}/L_{Kn})$$

(for individuals with below knee amputation)

$$\Delta W/W_E = 1.5 + 4.4 + 10.1(1 - L_{Stp}/L_{BtK})$$

(for individuals with above knee amputation)

Where W_O is the observed body weight, W_E is the body weight to be estimated, $\Delta W = (W_E - W_O)$, L_{Stp} is the length of the stump (remaining portion of the limb from its nearest distal bone joint), L_{Kn} is the knee height and L_{BtK} is the buttock knee length.

However, some additional anthropometric measurements have been taken for this purpose, that is, length of the stump and knee height (for individuals with below-knee amputation) or buttock knee length (for individuals with above-knee amputation). 'Stump' here denotes the remaining portion of the amputated limb from its nearest distal bone joint (knee joint in case of individuals with below-knee amputation and hip joint in case of individuals with above-knee amputation). The length of the stump has been measured from the distal most tip of the stump to tibiale (for individuals with below-knee amputation) or rearmost point of the buttock (for individuals with above-knee amputation). Followed standard techniques of measurement in case of other two measurements (i.e. knee height and buttock knee length), which have been included in the IBP list of standard measurements (Weiner and Lourie, 1981) and the measurements have been utilized in many studies on locomotor-disabled individuals including amputees (e.g. Goswami *et al.*, 1987; Jarosz, 1994; Das and Kozey, 1994). It is worthwhile to note that measurements like knee height and buttock knee length have been taken from the limb, which lies intact (not amputated) assuming bilateral symmetry. Waist circumference measurement has been taken at the iliac crest level.

Blood pressure measurements, that is, systolic blood pressure (SBP) and diastolic blood pressure (DBP), have been taken after 15 min' rest period, in a sitting position on the left hand by the auscultatory method using mercury blood pressure instrument (Sphygmomanometer) and stethoscope.

The blood samples have been collected by finger pricking following standard techniques and collecting the blood on different strips meant for different blood analysis. All the blood parameters have been analyzed immediately after taking the blood samples from the subjects on the spot, that is, in the field itself with a dry autoanalyzer (Accutrend-GCT manufactured by Borhinger-Mannheim, 1999). The blood samples were placed in different strips into the auto-analyser and the respective results were recorded.

Data analysis

A number of risk factors and their respective cutoff points have been considered for different cardiovascular risk traits

Table 1 Risk factors and their respective cutoff points for different cardiovascular risk traits

Risk factors	*Name of measurements*	*Cutoff points*	*Literatures*
Overweight	Body mass index	⩾25 kg/m^2	WHO (2002)
Central adiposity	Waist circumference	⩾90 cm	Tan *et al.* (2004)
Hypertension	Systolic blood pressure	⩾140 mm Hg	Wilson *et al.* (1998)
	Diastolic blood pressure	⩾90 mm Hg	Wilson *et al.* (1998)
Hyperglycemia	Random blood glucose	⩾126 mg/dl	ADA (2004)
Hyperlipidemia	Total cholesterol in blood	⩾200 mg/dl	NCEP (2001)
Hypertriglyceridemia	Total triglycerides in blood	⩾150 mg/dl	NCEP (2001)

as shown in Table 1. In classic studies, the standard cutoff value ⩾94 cm of WC had been considered as a CVD risk. However, Lear *et al.* (2002, 2003) studied the relationship of anthropometric measurements and risk factors (mostly metabolic) across different ethnic groups (Europeans and South Asians). One of the major findings of them is that the men and women of South Asian descent show more adverse risk profile than those of European descent at the same BMI and/or WC (Lear *et al.*, 2003). Therefore, the inappropriateness of the recommended cutoff value of WC for diagnosis of CVD risk in Asian population, owing to their smaller build, was noted. In a study to determine the appropriate cutoff value of WC for metabolic syndrome among Asian population, Tan *et al.* (2004) had found that cutoff value of WC higher than 90 cm among male is more appropriate for the said purpose than the conventional 94 cm cutoff value for WC. In present article, therefore, the cut-off value of >90 cm WC has been considered as one of the CVD risk condition (Table 1).

Subjects with LEA and controls have been classified into two groups depending on the presence or absence of cardiovascular risk. The comparisons between subjects with above and below-knee amputation in respect of prevalence of cardiovascular risk have been tabulated and relative risks have been calculated. Comparisons have also been made between controls and individuals with above- and below-knee amputation with respect to cardiovascular risk.

In course of the analysis, it was found that WC is not sufficient enough in diagnosing the cardiovascular risk independently in the present case (LEA). It is worth mentioning that the technical problems of undertaking the WC measurement cannot be ruled out especially in case of individuals with LEA. Review of literature revealed that UAC is a comparable measurement with BMI. Therefore, the diagnostic performance of UAC for cardiovascular risk assessment has been evaluated by 'receiver operating characteristics' (ROC) curve analysis using the presence of two or more CVD risk factors (BMI, SBP, DBP, random blood glucose, total cholesterol and total triglycerides) as a true positive case of CVD risk. Waist circumference has been kept aside from this analysis, although in further analysis the diagnostic ability of WC has been checked and compared with UAC. An appropriate cutoff value of UAC has been calculated for the diagnosis of CVD risk in the individuals with LEA.

Receiver operating characteristics curve is a graph that plots the true positive rate in function of the false positive rate (100−specificity) at different cutoff points. The value for the area under ROC curve generally varies from 0.5 to 1, which means the probability of being a randomly selected individual from the positive group has a test value larger than that for a randomly chosen individual from the negative group. When the variable under study cannot distinguish between the two groups, that is, where there is no difference between the two distributions, the area will be equal to 0.5 (the ROC curve will coincide with the diagonal line). Whereas, in case of a perfect separation, that is, no overlapping of the distribution, the area under the ROC curve equals 1. The 95% confidence interval for the area can be used to test the hypothesis that the theoretical area is 0.5. If the confidence interval does not include 0.5 value, the test is supposed to have an ability to distinguish between the two groups (Zweig and Campbell, 1993). Every possible selection criterion or cutoff value has its positive and negative predictive value. The selection criteria with the minimal false negative and false positive value, that is, maximum sensitivity and specificity, supposed to have highest accuracy and thereby accepted as cutoff value for the test method (Griner *et al.*, 1981).

The individuals with lower extremity amputation have been classified according to the calculated (obtained from ROC analysis) cutoff value of UAC for CVD risk. Agreement statistics (Cohen's Kappa − *k*) have been calculated for cutoff values of UAC (obtained in ROC analysis) and WC (>90 cm) with presence of CVD risk in the individuals with LEA. The *k* value indicates the degree of association, which varies from −1 to +1. Kappa value (*k*) closer to +1 indicates stronger diagnostic ability of the cutoff value of a particular trait to detect CVD risk condition (Cohen, 1960).

To determine the possible difference between UAC and WC to diagnose the CVD risk condition with respect to sensitivity, specificity and efficiency of the cutoff values, binomial test for equality of proportions have been calculated. All statistical analyses have been performed using Medcalc software package (version 7.2.0.2, Frank Schoonjans, Mariakerke, Belgium).

Results

Subjects

Descriptive statistics of cardiovascular risk factor traits of the individuals with traumatic LEA and controls has been presented in Table 2. The result shows higher mean values of all cardiovascular risk factor traits of individuals with above-knee amputation than that of individuals with below-knee amputation. The comparison between individuals with above-knee and below-knee amputation, in terms of *t*-test values, show significant difference in stature, body weight, BMI, UAC, WC and triglycerides in blood. Controls shows higher mean value of most of the traits than that of individuals with below-knee amputation, except for blood pressures and blood glucose. However, controls show lower mean values of all traits than that of individuals with above-knee amputation.

Table 3 shows correlation coefficient (Pearson's correlation) matrix of anthropometric measurements and CVD risk traits of individuals with traumatic LEA. Most of the traits show univariate association between each other. Most of the traits under study show strong positive correlation with other traits. Body mass index shows significant correlation with most of the traits.

Table 2 Descriptive statistics of anthropometric and cardiovascular risk factor measurements in the individuals with lower extremity amputation and control group

Anthropometric and cardiovascular risk factor measurements	*Above-knee amputees (N = 32)*		*Below-knee amputees (N = 70)*			*Controls (N = 105)*	
	Mean	*s.d.*	*Mean*	*s.d.*	*P (df = 83)*	*Mean*	*s.d.*
Stature (cm)	164.47	6.16	161.22	7.41	0.05	163.79	6.52
Body weight (kg)	66.79	13.58	57.54	12.30	>0.01	59.71	11.28
Body mass index (kg/m^2) (estimated)	24.51	3.89	22.02	3.74	0.01	22.20	3.60
Upper arm circumference (cm)	29.34	3.14	26.63	3.15	>0.01	27.13	3.29
Waist circumference (cm)	90.04	10.72	83.07	12.76	0.02	85.82	10.91
Systolic blood pressure (mm Hg)	138.00	28.77	132.29	16.91	0.25	131.14	15.98
Diastolic blood pressure (mm Hg)	89.78	15.68	86.55	11.20	0.28	86.21	10.43
Random blood glucose (mg/dl)	141.11	79.89	128.33	63.11	0.43	122.90	59.44
Total cholesterol (mg/dl)	180.29	28.09	171.82	26.18	0.34	178.71	37.64
Total triglycerides (mg/dl)	197.88	84.62	152.83	86.06	0.03	162.99	82.96

Table 3 Univariate associations (correlation coefficients) between anthropometric measurements and CVD risk traits among individuals with traumatic LEA

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	Upper arm circumference	—	0.87**	0.88**	0.79**	0.21	0.35**	0.45**	0.07	0.31**
2	Body weight		—	0.92**	0.83**	0.20	0.28**	0.50**	0.00	0.26*
3	Body mass index			—	0.84**	0.21*	0.30**	0.45**	−0.02	0.27*
4	Waist circumference				—	0.34**	0.37**	0.44**	0.11	0.26*
5	Systolic blood pressure					—	0.74**	0.12	0.01	−0.05
6	Diastolic blood pressure						—	0.23*	−0.03	0.11
7	Random blood glucose							—	0.56*	0.33**
8	Total cholesterol								—	0.35**
9	Total triglycerides									

**$P<0.01$, *$P<0.05$.
Abbreviations: CVD, cardiovascular disease; LEA, lower-extremity amputation.

Prevalence of cardiovascular risk factors

Prevalence of cardiovascular risk factors among individuals with above- and below-knee amputation and control group has been presented in Table 4. Considering risk factors like BMI, WC and triglycerides, the relative risk calculation show significantly higher CVD risks among the individuals with above knee amputation than individuals with below-knee amputation; however, the relative risk is less only in case of total cholesterol. The individuals with above-knee amputation are relatively at higher risk in case of systolic and diastolic blood pressure than individuals with below-knee amputation, although the risk is not statistically significant. The odds ratios for individuals with above-knee amputation are significantly high in case of BMI, WC and triglycerides compared to control group. Odds ratios are also high among the individuals with above-knee amputation compared to controls for the presence of high blood pressure and high glucose level, although not statistically significant. Individuals with below-knee amputation do not show any significant difference with the control group in the CVD risk factors and do not show significant odds ratios. The odds ratios among individuals with below-knee amputation are higher than 1 in BMI, blood pressure traits and blood glucose compared to control group.

Receiver operating characteristics curve analysis

Receiver operating characteristics curve analysis of UAC has been carried out to diagnose the CVD risk condition among individuals with LEA (Figure 1). The analysis shows that the area under the ROC curve is 0.75. This signifies that in 75% of the time, the individuals having CVD risk supposed to have a higher UAC than the individuals without CVD risk. The 95% confidence interval of the value under the area ranges between 0.65–0.84, which strengthen the validity of testing ability of UAC to diagnose CVD risk, because the confidence interval never goes below 0.5 value.

The sensitivity and specificity value for different diagnostic criteria of UAC has been plotted in Figure 2. The intersection of line diagram of sensitivity and specificity shows the highest accuracy point, which corresponds with the UAC criteria of >26.6 cm. Therefore, an UAC measurement of >26.6 cm has been determined as cutoff value of UAC for prediction of CVD risk condition among the individuals with LEA.

Validity of the upper arm circumference

The frequency distribution of the individuals with LEA according to cutoff points of both UAC and WC has been

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Anthropometric and cardiovascular risk factor measurements	*Above-knee amputees (N = 32)*		*Below-knee amputees (N = 70)*			*Controls (N = 105)*	
	Mean	*s.d.*	*Mean*	*s.d.*	*P (df = 83)*	*Mean*	*s.d.*
Stature (cm)	164.47	6.16	161.22	7.41	0.05	163.79	6.52
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Body mass index (kg/m^2) (estimated)	24.51	3.89	22.02	3.74	0.01	22.20	3.60
Upper arm circumference (cm)	29.34	3.14	26.63	3.15	>0.01	27.13	3.29
Waist circumference (cm)	90.04	10.72	83.07	12.76	0.02	85.82	10.91
Systolic blood pressure (mm Hg)	138.00	28.77	132.29	16.91	0.25	131.14	15.98
Diastolic blood pressure (mm Hg)	89.78	15.68	86.55	11.20	0.28	86.21	10.43
Random blood glucose (mg/dl)	141.11	79.89	128.33	63.11	0.43	122.90	59.44
Total cholesterol (mg/dl)	180.29	28.09	171.82	26.18	0.34	178.71	37.64
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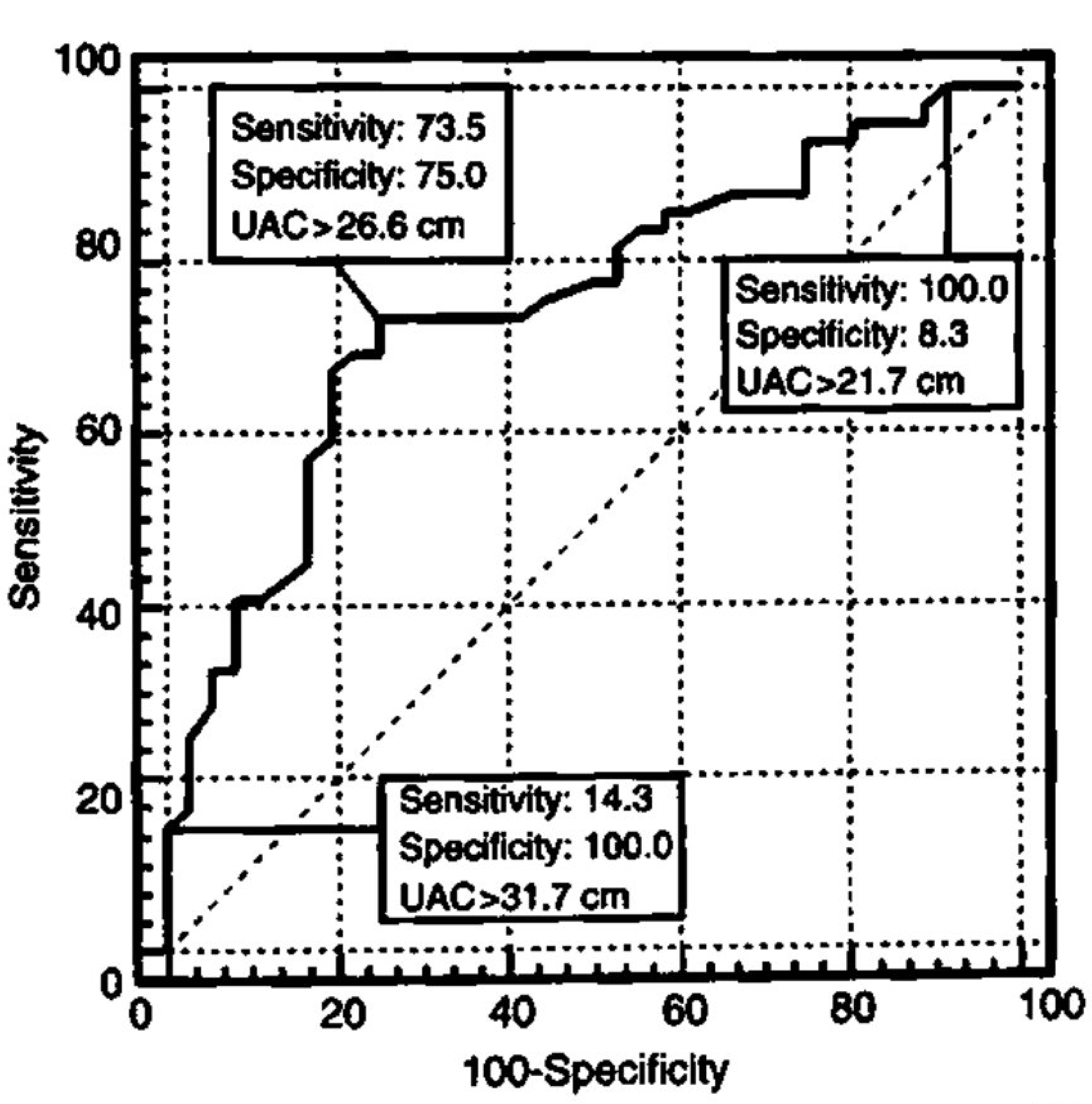
Validity of the upper arm circumference

The frequency distribution of the individuals with LEA according to cutoff points of both UAC and WC has been

Table 4 Prevalence of cardiovascular risk factors among the individuals with above-knee (AK) and below-knee (BK) amputation and controls; comparison between the two groups of amputees (relative risk) and comparison between amputee groups and controls (odds-ratios)

Risk factor	*Above-knee amputees*		*Below-knee amputees*		*Relative risk (95% CI)*	*Controls*		*Odds ratios (95% CI)*	
	N	%	N	%		N	%	*Control vs AK*	*Control vs BK*
Body mass index $\geqslant$*25 kg/m²*									
Present	15	55.56	14	24.14	2.3 (1.3–4.0)	22	20.95	4.7 (1.9–11.5)	1.2 (0.6–2.6)
Absent	12	44.44	44	75.86		83	79.05		
Waist circumference >*90 cm*									
Present	16	59.26	18	31.03	1.9 (1.2–3.1)	38	36.19	2.6 (1.1–6.1)	0.8 (0.4–1.6)
Absent	11	40.74	40	68.97		67	63.81		
Systolic blood pressure $\geqslant$*140 mm Hg*									
Present	9	33.33	17	29.31	1.1 (0.6–2.2)	29	27.62	1.3 (0.5–2.8)	1.1 (0.5–2.2)
Absent	18	66.67	41	70.69		76	72.38		
Diastolic blood pressure $\geqslant$*90 mm Hg*									
Present	14	51.85	25	43.10	1.2 (0.8–1.9)	44	41.90	1.5 (0.6–3.5)	1.1 (0.6–2.0)
Absent	13	48.15	33	56.90		61	58.10		
Random blood glucose $\geqslant$*126 mg/dl*									
Present	10	37.04	21	36.21	1.0 (0.6–1.9)	35	33.33	1.2 (0.5–2.8)	1.1 (0.6–2.2)
Absent	17	62.96	37	63.79		70	66.67		
Total cholesterol in blood $\geqslant$*200 mg/dl*									
Present	2	7.41	5	8.62	0.9 (0.2–4.2)	10	9.52	0.8 (0.2–3.7)	0.9 (0.3–2.8)
Absent	25	92.59	53	91.38		95	90.48		
Total triglycerides in blood $\geqslant$*150 mg/dl*									
Present	19	70.37	20	34.48	2.8 (1.3–6.3)	45	42.86	3.2 (1.3–7.9)	0.7 (0.4–1.4)
Absent	8	29.63	38	65.52		60	57.14		



N = 85, CVD risk prevalance = 57.6, area under ROC curve = 0.75, SE = 0.05, 95% CI = 0.65 to 0.84

Figure 1 Receiving operating characteristics curve of upper arm circumference (UAC) diagnosing cardiovascular disease (CVD) risk condition among the individuals with traumatic lower-extremity amputation (LEA).

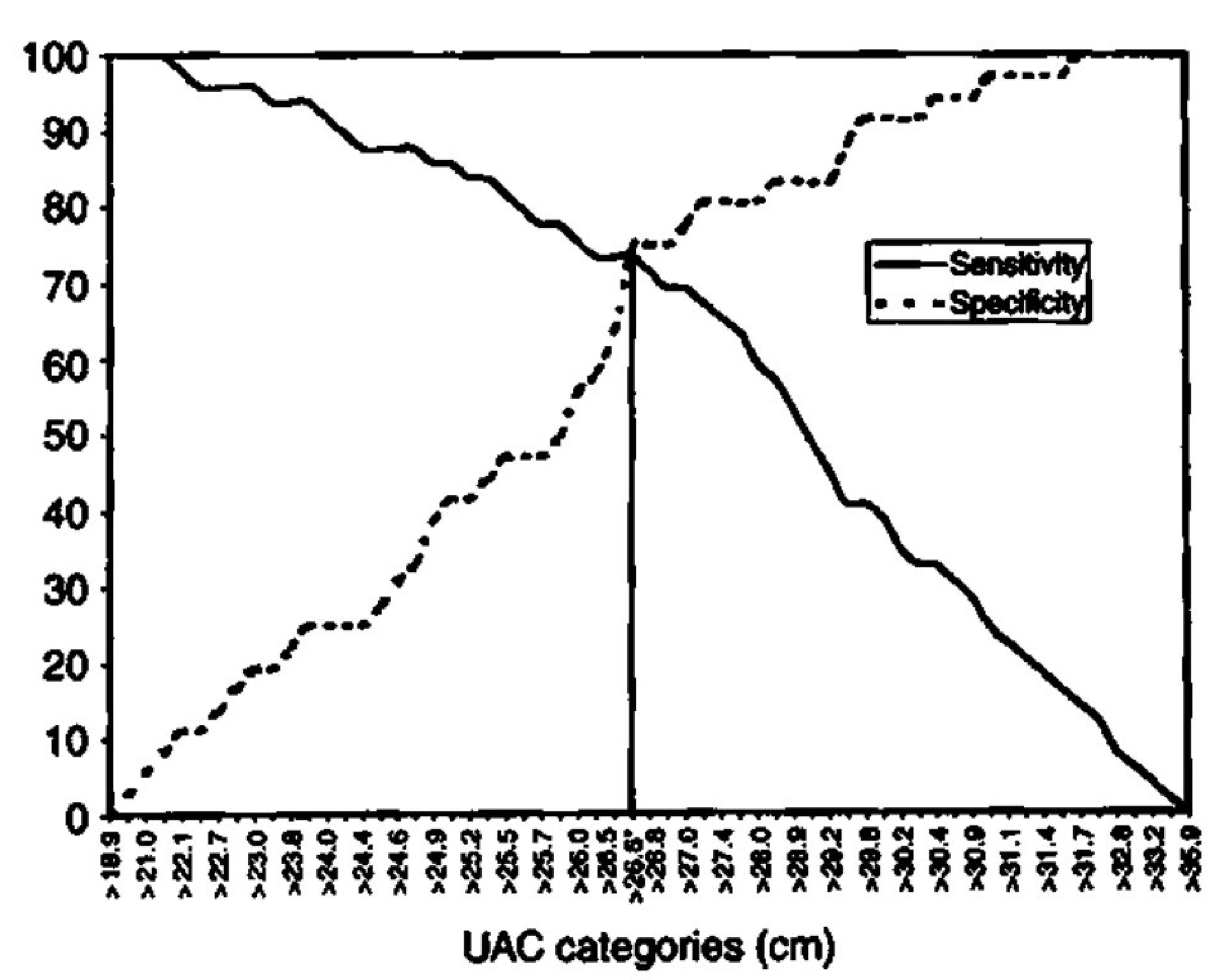


Figure 2 The line diagram of sensitivity and specificity at different upper arm circumference (UAC) categories.

presented in Table 5. The cutoff value >26.6 cm (obtained from ROC curve analysis) for UAC has been used for diagnosis of CVD risk condition. Again the cutoff value of >90 cm (Tan *et al.*, 2004) for WC has been used for the same

Table 5 Contingency table for distribution of the individuals with lower extremity amputation according to the cutoff points of UAC (predicted in this study), waist circumference and presence/absence of CVD risk condition; and comparison of validity of UAC with waist circumference to predict CVD risk condition

	CVD risk condition			*Sensitivity*	*Specificity*	*Efficiency*	*Agreement statistics (k)*
	Present	*Absent*	*Total*				
UAC (cm)							
>26.6	36	9	45	73.5[a]	75.0[a]	74.1[a]	0.5
⩽26.6	13	27	40				
Total	49	36	85				
Waist circumference (cm)							
>90	29	5	34	59.2[a]	86.1[a]	70.6[a]	0.4
⩽90	20	31	51				
Total	49	36	85				

[a]Difference is not significant between the corresponding value of UAC and WC (binomial test for equality of proportions, $\alpha > 0.05$).
Abbreviations: CVD, cardiovascular disease; UAC, upper arm circumference.

purpose. In order to test the validity of UAC and WC, cross-tabulation of the individuals with LEA have been done using true positive/negative CVD risk condition (vide, Materials and methods). The result shows that 36 out of 49 individuals have been properly diagnosed by UAC; however, WC diagnosed only 29 true positives. The ability of UAC and WC to diagnose CVD risk condition among the individuals with traumatic LEA has been measured in terms of sensitivity, specificity, efficiency and agreement statistics (Cohen's Kappa or *k*). The comparison revealed higher value of sensitivity, efficiency and *k* value for cutoff value of UAC, which can properly diagnose the CVD risk condition. Cutoff value of WC shows the higher value only of specificity for the diagnosis of CVD risk condition. Although results of binomial test of equality of proportions do not show significant difference between UAC and WC in terms of sensitivity, specificity and efficiency for diagnosis of CVD risk condition, the agreement statistic (*k*) shows higher value (0.5) in UAC than that of WC (0.4).

Discussions

This study aimed at studying the prevalence of CVD risk factors among the individuals with traumatic LEA and secondly to test the validity of an alternative anthropometric measurement for screening the CVD risk condition. The methods for data collection were similar (following standard techniques) and all data have been collected by a single investigator. All CVD risk factors used in the present study are generally used and considered in several standard cardiovascular risk assessment studies (Grundy *et al.*, 1999).

The results of the present study show higher mean values of different traits, considered as cardiovascular risk factors, among individuals with above-knee amputation than the individuals with below-knee amputation. In order to identify if CVD risk is associated with the level of amputation, relative risks between two groups of individuals with amputation and odds ratios between the two groups and a control group have been calculated. The prevalence of CVD risks factors have been found relatively high among the individuals with above-knee amputation than the individuals with below-knee amputation. This may be due to the lower physical activity level of the individuals with above-knee amputation than the individuals with below-knee amputation. Earlier studies (Pollitt *et al.*, 2005) have proved the statement; however, in the present study, there is no way to examine the above statement because the data on physical activity level is not available for the individuals with locomotor disability. On the contrary, 'locomotor index' (a measurement of functional outcome) of individuals with LEA shows that a large proportion (42.42%) of individuals with above-knee amputation is dependent on other individuals to perform daily activities, compared to only 26.32% of the individuals with below-knee amputation. Hrubec and Ryder (1980) stated that mortality rate owing to CVD is higher in the individuals with proximal limb amputation than the individuals with distal limb amputation. Therefore, the presence or absence of knee joint among the individuals with amputation may be the key factor behind their physical activity level as well as the risk of CVD.

The ROC curve analysis (Figure 1) shows that UAC has a significant ability to diagnose CVD risk condition. The cutoff value of UAC shows higher degree of agreement for the diagnosis of CVD risk than the cutoff value of WC (for Asian population) as used in the standard literatures, indicating better CVD risk diagnostic ability of UAC for the individuals with traumatic LEA. It is worthwhile to mention that the individuals with LEA are in a greater risk of developing CVD owing to their poor physical activity level (Madan *et al.*, 1998; Resnick *et al.*, 2004). They need diagnosis of CVD risk well in advance for proper medical care and management of the diseases. In such cases, UAC seems to be much more useful in terms of its higher sensitivity and efficiency to diagnose CVD risk condition. Besides, UAC is a very simple measurement and requires simple instrument (a measuring tape) with minimum technical skill. In view of the above, UAC can be used as the first screening technique especially for the individuals with traumatic LEA and clinical examination may be followed afterwards. The studies reveal that the patients suffering from CVD tends to have more adiposity and musculoskeletal development than those who have no CVD (Williams *et al.*, 2000). As the UAC measurement consists of a combination of both adipose and muscle tissue, UAC is very sensitive to determine changes in both adipose and muscular tissues of the body (Briend *et al.*, 1989) and therefore, useful for detecting the CVD risk condition.

The present study is based on a small sample, therefore, it is difficult to draw a final conclusion on the basis of the present result. Further studies are necessary on the issue especially taking more individuals with LEA to establish the validity of UAC for the diagnosis of CVD risk. It is pretty difficult to find out a large number of locomotor disabled individuals with traumatic amputation, in the developing countries like India, because of the absence of properly maintained database. It would be wise to add more cardiovascular risk factors (e.g. more elaborate lipid profile, body fat %, and so on) to re-examine the validity of UAC for CVD risk condition in individuals with LEA. Further studies are also necessary in other populations to obtain a standard cutoff value of UAC for the said purpose.

Acknowledgements

We are grateful to the subjects who participated in the study for their kind help and cooperation. Financial and logistic support was given to this study by the Indian Statistical Institute, Kolkata. Both the authors participated in study design, data analysis and writing the manuscript. AM collected the field data for the present study. No author had any financial or personal conflict of interest in the organization supporting the research.

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