Prediction of Six-Minute Walk Performance among Healthy North Indian Adult Males: The Influence of Obesity Indices

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ABSTRACT

Introduction: Six-minute walk test (6MWT) is an easy evaluation method for functional capacity and treatment efficacy. No universally acceptable standard predicting equation for the distance walked in 6MWT (6MWD) exists for Indians. Hence the study was an attempt in understanding significant predictors of 6MWD and influence of obesity indices on it.

Material and Methods: Physical activity (PAR); anthropometric variables like height (HT), weight (WT), including obesity indices like waist-hip ratio (WHR); resting heart rate and blood pressure (rHR and rBP); and 6MWD and heart rate recovery (HRR) were evaluated in 40 healthy adult North Indian males.

Results: 6MWD had significant negative correlation with age, WT, obesity indices, rHR and rBP; and positive correlation with HRR and PAR. Subjects with increased obesity indices had lower 6MWD and HRR, and higher rHR and rBP. Among the generated equations, 6MWD=10.52+6.06(HT)-2.4(WT)+26.87(PAR)-358.84(WHR) had the highest adjusted R^2(96.23%) with all the four predictors having significant unique contribution.

Conclusions: Subjects with increased obesity indices had lower 6MWD & HRR, and higher rHR & rBP. HT, WT, PAR and WHR were the significant predictors of 6MWD. Hence, decreasing weight and WHR, and increasing physical activity would result in improvement of six-minute walk performance.

Keywords: Six-minute walk distance, prediction equation, adiposity, heart rate recovery.

INTRODUCTION

Six-minute walk test (6MWT) is an easy, inexpensive submaximal test for functional capacity, which is safer, better tolerated and more reflective of activities of daily living as compared to other walk tests.[1] The distance walked in 6MWT (6MWD) has a very high correlation with formal measures of quality of life,[2] and is an independent predictor of both morbidity and mortality.[3] Similarly heart rate recovery (HRR), which measures the rate of decline of heart rate following maximal or submaximal exercise to resting level,[4] is also a powerful predictor of morbidity and all-cause mortality.[5] Both 6MWD and HRR have been shown to affect negatively by obesity.[6,7]

Since normative database on 6MWD is important in identifying extent of functional capacity alterations from normal and hence assessing treatment efficacy,[8] many studies have published predicting equations for 6MWD for normal population.[9-11] The relative paucity of such data in Indian scenario inspired us to conduct the present study, evaluating significant predictors of 6MWD in normal North Indian adult males.

MATERIALS AND METHODS

The present cross-sectional study was conducted under the Department of Physiology, Himalayan Institute of Medical Sciences, Swami Rama Himalayan University, Dehradun. Forty healthy males of 28-40 years with no history of addiction were the volunteers. The study was approved by the Institute ethical committee, and a well-informed written consent was taken from all the subjects.

Study Protocol

The subjects were requested to report in the department at around the same time in the morning after light breakfast. No tea, coffee or heavy physical activity was allowed for atleast 2 hours before the reporting time. After taking medical and personal history, various anthropometric variables like heights (HT in cm) and body weights (WT in kg) were recorded. Physical activity recall questionnaire scale (PAR) was used to assess physical activity.[12] Obesity indices recorded were divided into:

a. General obesity indices: body mass index (BMI in kg/m^2) and percentage body fat (%BF).[13] An impedance body composition analyzer (Omron, model HBF-375) was used to measure %BF.
b. Abdominal obesity indices: waist circumference (WC in cm) and waist-hip ratio (WHR).[13] A flexible and non-stretching measuring tape was used to measure WC,

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HC (hip circumference in cm) as per WHO guidelines.[14] WHR was calculated as WC:HC.

Heart rate (rHR in bpm) using a hear rate monitor (Polar FT1/FT2), and blood pressure (rSBP and rDBP in mmHg) using a blood pressure apparatus (model no. EW 254 DC6V) were measured after a rest of 10 minute in sitting position. 6MWT was conducted following the standard methodology, with constantly motivation throughout the testing.[1] After 6MWT, the distance walked (6MWD in m) was measured. HRR at 1st(HRR-1 in bpm) and 2nd(HRR-2 in bpm) minute after 6MWT was calculated by subtracting post 6MWT heart rate at 1st minute and 2nd minute from post 6MWT heart rate at 0th minute respectively with the subjects sitting passively. Polar hear rate monitor (Polar FT1/FT2) was used for the same.

STATISTICAL ANALYSIS

SPSS (Statistical Package for Social Science) version 19 was used for data analysis. For directly measured and derived variables, standard descriptive statistics were determined. Pearson's correlation was used to study association between 6MWD and various variables (Spearman's correlation, in case of ordinal variable). Unpaired t-test was used for comparison of interested parameters among the studied subgroups divided as per various obesity indices cut-off values. Various equations were generated for predicting 6MWD using multiple linear regression analysis, after avoiding multicollinearity and serial correlation, and such that most of the independent variables ß-weights were significant. Semi-partial correlation R^2 was used to assess the effect of a particular independent variable above and beyond others on predicting 6MWD. Statistical significance was chosen at p-value (2-tailed)≤0.05.

RESULTS

Descriptive statistics of the studied subjects are given in Table 1.

6MWD was found to have significant negative correlation with all the obesity indices, apart from age, weight and resting cardiovascular variables. Although it had significant positive correlation with HRR-1, HRR-2 and PAR (Table 2). The negative effect of increased obesity indices on 6MWD was also evident from Table 3. When the subjects were grouped as per the obesity indices cut-off values: BMI: ≥23 Kg/m^2 and ≥25 Kg/m^2,[15] %BF: >25%,[16] WC: ≥90cm and ≥102 cm and WHR: ≥0.9;[14] the subgroups with lower obesity indices had higher 6MWD, in addition to higher HRR-1, HRR-2 and lower resting cardiovascular parameters, which were statistically significant, with few exceptions (Table 3).

Among all regression equations (Table 4), model (a) had the largest adjusted R^2 (96.54%). In this, WHR uniquely accounted only 1% of the total variance in 6MWD over and beyond those explained by HT, WT, PAR, HRR-2 and rHR. Among the equations having all the independent variables statistically significant (Table 4(d),(e) and (f)), model (d) had the largest adjusted R^2 (96.23%). In this also, only WHR among all the obesity indices was found included in the model with a uniquely contribution of 1.44% of the total variance (96.23%) in 6MWD over and beyond those contributed by HT, WT and PAR. However, in the equation with both general (%BF) and abdominal obesity indices (WHR), %BF contributed more unique variance out of the total variance (95.82%) in 6MWD than WHR (4% vs 1.44%), after controlling the overlapping effect of HT, PAR, WHR and each other (Table 4(e)).

In all the models, height uniquely accounted for the largest share of the total variance in 6MWD (exception: Table 4(g) and (h)), even though it was not a significant correlate of 6MWD (Table 2). This was followed by weight, except in Table 4(f) and (g); and PAR. Among the HRR variables, only HRR-2 was found included in the regression equations in which it contributed uniquely and significantly .36% and 1.44% of the total variance in 6MWD after controlling the overlapping effect of other independent variables, including

Parameters	Mean±SD	Min.-Max.
PAR	4.00±.50#	2.00-4.00
Age (years)	36.95±3.84	28.00-40.00
Height (cm)	171.24±6.02	155.00-177.00
Weight (kg)	72.31±10.60	49.70-88.90
BMI (kg/m^2)	24.61±2.98	16.80-29.24
%Body Fat (%)	23.15±6.69	7.40-31.90
WC (cm)	99.14±6.97	82.60-108.00
WHR	.92±.05	.86-1.09
rHR (bpm)	83.85±5.03	74.00-92.00
rSBP (mmHg)	124.90±5.78	110.00-134.00
rDBP (mmHg)	81.20±4.72	72.00-88.00
HRR-1 (bpm)	19.55±1.80	17.00-24.00
HRR-2 (bpm)	40.07±3.02	35.00-46.00
6MWD (m)	637.33±55.32	516.00-729.00

#Median±Quartile deviation; SD=Standard Deviation; Min.=Minimum; Max.=Maximum.

Table-1: Descriptive Statistics of the studied subjects (n=40).

Variables	6MWD (m)
PAR#	.74**
Age (years)	-.41**
Weight (kg)	-.53**
BMI (kg/m^2)	-.80**
%Body Fat (%)	-.85**
WC (cm)	-.73**
WHR	-.88**
rHR (bpm)	-.56**
rSBP (mmHg)	-.62**
rDBP (mmHg)	-.56**
HRR-1 (bpm)	.82**
HRR-2 (bpm)	.86**

Pearson's correlation.#Spearman's correlation.** p–value≤0.01:highly significant.

Table-2: Significantly correlated variables with six-minute walk distance among the studied subjects (n=40).

Cut-off		Parameters (Mean±SD)					
		6MWD (m)	HRR-1 (bpm)	HRR-2 (bpm)	rHR (bpm)	rSBP (mmHg)	rDBP (mmHg)
BMI (Kg/m^2)	≤22.9 (n=9)	694.33±31.71	21.44±1.81	43.33±1.73	80.89±3.79	121.33±7.21	79.78±5.70
	≥23 (n=31)	620.77±49.52	19.00±1.39	39.13±2.64	84.71±5.07	125.94±4.97	81.61±4.42
	p-value	<.001**	<.001**	<.001**	.04*	.03*	.31
	≤24.9 (n=17)	682.59±30.67	20.88±1.76	42.35±2.12	81.76±5.09	121.53±6.84	79.06±4.53
	≥25 (n=23)	603.87±44.59	18.57±1.04	38.39±2.44	85.39±4.49	127.39±3.16	82.78±4.30
	p-value	<.001**	<.001**	<.001**	.02*	.004**	.01**
%BF (%)	≤25 (n=22)	675.41±31.84	20.59±1.68	41.82±2.20	82.36±4.88	122.27±6.45	79.91±4.64
	>25 (n=18)	590.78±39.97	18.28±.89	37.94±2.51	85.67±4.72	128.11±2.32	82.78±4.45
	p-value	<.001**	<.001**	<.001**	.04*	.001**	.05*
WC (cm)	<90 (n=8)	701.38±25.28	21.50±1.93	43.50±1.77	80.25±3.49	121.00±7.63	79.75±6.09
	≥90 (n=32)	621.31±48.81	19.06±1.41	39.22±2.65	84.75±4.99	125.88±4.90	81.56±4.36
	p-value	<.001**	<.001**	<.001**	.02*	.03*	.34
	<102 (n=28)	660.86±39.79	20.14±1.72	41.18±2.36	83.00±5.16	123.71±6.10	80.07±4.63
	≥102 (n=12)	582.42±47.61	18.17±1.11	37.50±2.91	85.83±4.28	127.67±3.89	83.83±3.95
	p-value	<.001**	.001**	<.001**	.1	.05*	.02*
WHR	<0.9 (n=14)	690.71±26.13	21.36±1.60	43.00±1.66	80.71±4.36	120.29±6.74	78.71±4.81
	≥0.9 (n=26)	608.58±44.31	18.58±.95	38.50±2.34	85.54±4.60	127.38±3.19	82.54±4.18
	p-value	<.001**	<.001**	<.001**	.003**	.002**	.01**

Unpaired t-test.*p–value≤0.05:significant;**p–value≤0.01:highly significant.SD=Standard Deviation

Table-3: Comparison of six-minute walk distance, heart rate recovery, resting heart rate and blood pressure among the studied subjects based on various cut-off values of obesity indices.

Sl. No.	Regression equations	Adjusted R^2 (%)	Semi-Partial correlation R^2(%) for significant predictors	F-value (df)	p-value
(a)	6MWD=-232.29+5.77(HT)-2.13(WT)+24.59(PAR)-299.81(WHR)+3.46(HRR-2)+1.05(rHR)	96.54	HT(12.96),WT(2.89), PAR(2.25),WHR(1), HRR-2(.36)	182.20** (6,33)	<.001
(b)	6MWD=-230.47+5.76(HT)-2.12(WT)+24.62(PAR)-299.98(WHR)+3.46(HRR-2)+1.05(rHR)-.03(Age)	96.43	HT(11.56),WT(2.56), PAR(2.25),WHR(1), HRR-2(.36)	151.46** (7,32)	<.001
(c)	6MWD=-37.73+5.84(HT)-2.26(WT)+24.42(PAR)-330.59(WHR)+1.46(HRR-2)	96.25	HT(12.96),WT(3.24), PAR(2.25),WHR(1.21)	201.15** (5,34)	<.001
(d)	6MWD=10.52+6.06(HT)-2.4(WT)+26.87(PAR)-358.84(WHR)	96.23	HT(16.81),WT(4.41), PAR(3.61),WHR(1.44)	249.65** (4,35)	<.001
(e)	6MWD=329.83+3.66(HT)-3.15(%BF)+25.77(PAR)-364.32(WHR)	95.82	HT(14.44),%BF(4), PAR(3.24),WHR(1.44)	224.46** (4,35)	<.001
(f)	6MWD=293.15+4.66(HT)-557.22(WHR)-1.61(WT)+4.43(HRR-2)	93.74	HT(10.89),WHR(4.41), WT(1.96),HRR-2(1.44)	147.05** (4,35)	<.001
(g)	6MWD=-421.21-5.57(WT)+8.31(HT)+1.01(Age)	78.41	WT(56.25),HT(47.61)	48.23** (3,36)	<.001
(h)	6MWD=429.66-5.67(Age)+2.44(HT)	20.06	Age(15.21)	5.89** (2,37)	.006

Multiple linear regression.** p–value≤0.01:highly significant.df=degree of freedom.

Table-4: Regression models for predicting six-minute walk distance (m).

rHR (Table 4(a),(b) and (f)).

Hence, HT, WT and PAR were the most important significant variables for predicting 6MWD. The obesity indices (WHR and %BF) per se only contributed very small unique variance of the total variance in 6MWD.

DISCUSSION

Our study showed highly negative association of 6MWD with obesity indices (Table 2), which was also reported earlier.[6] Among the many causes of reduced 6MWD associated with increased adiposity include relative decrease in skeletal muscle strength and cardio-respiratory capacity, and increase in walking-gait inefficiency and prevalence of co-morbid conditions which might be hindrance to walking.[17] In our study, only WHR and %BF were found as the significant predictors of 6MWD among all the obesity indices, even though the unique variances they contributed out of the to-

tal variance in 6MWD were relatively small (Table 4(a)-(f)). Instead the significant unique contribution of HT, WT and PAR were much higher (Table 4(a)-(g)). It is obvious from our study that decreasing weight, WHR and %BF would result in improving six-minute exercise performance (Table 4), and hence appropriate interventions should be directed in this regard.

There was also highly significant negative correlation of 6MWD with age, resting heart rate and blood pressure in our study (Table 2). Similar finding was also reported earlier.[18] Our study also indicated that subjects with more obesity indices also had higher resting heart rate and blood pressure (Table 3). The association of higher resting heart rate and blood pressure with increased adiposity was reported earlier,[19] and might be due to increase in sympathetic activity, total blood volume, cardiac output, peripheral vascular resistance and renin-angiotension-aldosterone activity.[20,21]

In our study, those who reported higher physical activity, as indicated by PAR[12], were also found to have more 6MWD (Table 2 and 4). Hence increased involvement in regular physical activity and exercise is advised. There was also highly significant positive correlation between 6MWD and HRR variables (Table 2). Similar finding was reported earlier.[22] Our study also showed that HRR-1 and HRR-2 were highly significantly lower among the studied subgroups with increased obesity indices (Table 3). The association of lower heart rate recovery with increased adiposity was also reported earlier.[7]

In our study, Table 4(d) regression model accounted for 96.23% of the total variance in 6MWD. All the predictors in this equation were statistically significant also. Earlier study in healthy North Indian adult males reported an equation with age and height as predictors, explaining 63.9% of total variance in 6MWD.[9] Similar equation in our study had adjusted R^2 of only 20.06% (Table 4(h)). Similarly, another study in healthy Indians, reported a male specific equation with weight, height and age as predictors, having R^2 of 28.8%.[10] Similar equation in western healthy adult males, accounting for 40% of the variance in 6MWD, was also reported.[11] In our study, the equation with weight, height and age accounted for 78.41% of the total variance in 6MWD (Table 4(g)).

However, generalization of the regression equations generated in this study for obtaining non-exercise 6MWD for healthy North Indian adult males should be avoided. The sample size of our study was relatively less. Neither the sample was chosen randomly from all strata of the society or age or physical activity groups, nor other appropriate blinding method used to avoid bias. Our study was confined to an age group of 28-40 years, consisted only of males who performed regular modest physical activity of 10-30 min per week (PAR=2)[12] to heavy physical exercise of less than 30 min per week (PAR=4).[12] Nevertheless, our study did highlight important anthropometric and other predictors of six-minute exercise performance, and served the foundation platform for future large scale study in this field which addressed our shortcomings.

CONCLUSION

6MWD had significant negative correlation with age, weight, obesity indices, resting heart rate and blood pressure; and positive correlation with heart rate recovery and physical activity. Among the subjects, those who were having increased obesity indices had lower 6MWD, heart rate recovery; and higher resting heart rate and blood pressure. The equation 6MWD=10.52+6.06(HT)-2.4(WT)+26.87(PAR)-358.84(WHR) accounted for 96.23% of the total variance in 6MWD.

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REFERENCES

1. ATS statement: guidelines for the six-minute walk test. American journal of respiratory and critical care medicine. 2002;166:111-7.
2. Guyatt GH, Thompson PJ, Berman LB, Sullivan MJ, Townsend M, Jones NL, et al. How should we measure function in patients with chronic heart and lung disease? J Chronic Dis. 1985;38:517-24.
3. Cote CG, Pinto-Plata V, Kasprzyk K, Dordelly LJ, Celli BR. The 6-min walk distance, peak oxygen uptake, and mortality in COPD. Chest. 2007;132:1778-85.
4. Dimkpa U. Post-exercise heart rate recovery: an index of cardiovascular fitness. Journal of Exercise Physiology online. 2009;12:10-22.
5. Cole CR, Foody JM, Blackstone EH, Lauer MS. Heart rate recovery after submaximal exercise testing as a predictor of mortality in a cardiovascularly healthy cohort. Ann Intern Med. 2000;132:552-5.
6. Correia de Faria Santarem G, de Cleva R, Santo MA, Bernhard AB, Gadducci AV, Greve JM, et al. Correlation between Body Composition and Walking Capacity in Severe Obesity. PloS one. 2015;10:e0130268.
7. Abu Hanifah R, Mohamed MN, Jaafar Z, Mohsein NA, Jalaludin MY, Majid HA, et al. The correlates of body composition with heart rate recovery after step test: an exploratory study of Malaysian adolescents. PloS one. 2013;8:e82893.
8. Troosters T, Gosselink R, Decramer M. Six minute walking distance in healthy elderly subjects. The European respiratory journal.1999;14:270-4.

9. Vaish H, Ahmed F, Singla R, Shukla DK. Reference equation for the 6-minute walk test in healthy North Indian adult males. The international journal of tuberculosis and lung disease: the official journal of the International Union against Tuberculosis and Lung Disease. 2013;17:698-703.
10. Palaniappan Ramanathan R, Chandrasekaran B. Reference equations for 6-min walk test in healthy Indian subjects (25-80 years). Lung India: official organ of Indian Chest Society. 2014;31:35-8.
11. Enright PL, Sherrill DL. Reference equations for the six-minute walk in healthy adults. American journal of respiratory and critical care medicine. 1998;158:1384-7.
12. Jackson AS, Blair SN, Mahar MT, Wier LT, Ross RM, Stuteville JE. Prediction of functional aerobic capacity without exercise testing. Med Sci Sports Exerc. 1990;22:863-70.
13. Tulloch-Reid MK, Williams DE, Looker HC, Hanson RL, Knowler WC. Do measures of body fat distribution provide information on the risk of type 2 diabetes in addition to measures of general obesity? Comparison of anthropometric predictors of type 2 diabetes in Pima Indians. Diabetes Care. 2003;26:2556-61.
14. World Health Organization.Waist Circumference and Waist-Hip Ratio:Report of a WHO Expert Consultation. Geneva: World Health Organization; 2008.
15. James PT, Leach R, Kalamara E, Shayeghi M. The worldwide obesity epidemic. Obes Res. 2001;9 Suppl 4:228S-33S.
16. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organ Tech Rep Ser. 1995;854:1-452.
17. Donini LM, Poggiogalle E, Mosca V, Pinto A, Brunani A, Capodaglio P. Disability affects the 6-minute walking distance in obese subjects (BMI>40 kg/m(2)). PloS one. 2013;8:e75491.
18. Wanderley FA, Oliveira J, Mota J, Carvalho MJ. Six-minute walk distance (6MWD) is associated with body fat, systolic blood pressure, and rate-pressure product in community dwelling elderly subjects. Archives of gerontology and geriatrics. 2011;52:206-10.
19. Baba R, Koketsu M, Nagashima M, Inasaka H, Yoshinaga M, Yokota M. Adolescent obesity adversely affects blood pressure and resting heart rate. Circulation journal: official journal of the Japanese Circulation Society. 2007;71:722-6.
20. Poirier P, Lemieux I, Mauriege P, Dewailly E, Blanchet C, Bergeron J, et al. Impact of waist circumference on the relationship between blood pressure and insulin: the Quebec Health Survey. Hypertension. 2005;45:363-7.
21. Tuck ML, Sowers J, Dornfeld L, Kledzik G, Maxwell M. The effect of weight reduction on blood pressure, plasma renin activity, and plasma aldosterone levels in obese patients. The New England journal of medicine. 1981;304:930-3.
22. Minai OA, Nguyen Q, Mummadi S, Walker E, McCarthy K, Dweik RA. Heart rate recovery is an important predictor of outcomes in patients with connective tissue disease-associated pulmonary hypertension. Pulmonary circulation. 2015;5:565-76.

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