Six-Minute Walk Test In Young Healthy University Players: Gender Difference And Anthropometric Correlates

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Abstract:
Distance covered (6MWD, m) in the six-minute walk test (6MWT) is a valid and simple aerobic endurance test. However, data is scarce in young, healthy Indian university players. Hence, the study was conducted to evaluate gender differences and anthropometric correlates of 6MWD.
Forty-four healthy university players (31 males) volunteered. Height (HT, cm), weight (WT, kg), bioelectric impedance-based body fat percentage (BF), waist circumference (WC, cm), hip circumference (HC, cm), waist-hip ratio (WHR), waist-height ratio (WHtR), and resting heart rate (rHR, bpm) were the studied parameters. The 6MWT was conducted as per the American Thoracic Society's guidelines.
Males had significantly higher HT, WT, and 6MWD (730.91 ± 64.21 m vs. 680.82 ± 75.59 m) but lower WHtR and BF than females. The cut-offs for lower and higher 6MWD for males (20–27 years) and females (21–24 years) were: 690.15 m, 776.18 m and 620.97 m, 736.85 m, respectively. Gender differences in 6MWD might be related to differences in HT, WHtR, and BF.
There was a significant positive correlation of 6MWD with HT (6MWD = 4.899 HT – 109.882, r^2 = .182, SEE = 59.055) in males, and a negative correlation with WC (6MWD = –10.705 WC + 1500.573, r^2 = .540, SEE = 53.5597), WHtR (6MWD = –1173.879 WHtR + 1261.002, r^2 = .344, SEE = 63.939), and age (6MWD = –59.485 Age + 2021.524, r^2 = .476, SEE = 57.127) in females.
Controlling for gender (1 = male, 2 = female), a significant negative correlation of 6MWD was found with BMI, WC, HC, and WHtR. Significant prediction equations generated with the highest adjusted r^2 (adj. r^2) for gender and an anthropometric variable were: 6MWD = –16.934 BMI – 47.334 Gender + 1145.523, adj. r^2 = .293, SEE = 59.483, 6MWD = –726.651 WHtR – 21.035 Gender + 1082.032, adj. r^2 = .229, SEE = 62.1296.
The results showed not only the anthropometric basis of the gender gap in 6MWD but also the significant correlates and predictors of 6MWD, hinting at the possible role of these easily measurable anthropometric variables in training monitoring and talent identification. The results provide a platform for future well-designed studies to generate normative reference values for 6MWD.
Keywords: *Six-Minute Walk Distance, Functional Exercise Capacity, Aerobic Endurance, Healthy Young University Player, Indian Normative Data*

INTRODUCTION

The six-minute walk test (6MWT) is a commonly used test for assessing functional exercise capacity and physical function. It is simple, easy to administer, safe, inexpensive, well-tolerated, and time-efficient, requiring no specialized equipment or highly skilled personnel. Moreover, it more closely reflects quality of life and activities of daily living compared to most physical fitness tests or peak oxygen consumption measurements (1–4).Although primarily used for individuals with cardiorespiratory conditions, physical dysfunction, or elderly and frail populations, the 6MWT has also been applied to healthy individuals (3, 5) and relatively younger populations (1, 6). Adapted from Cooper's 12-minute run test for maximal oxygen consumption (VO_2max) (1), the 6MWT serves as a valid submaximal exercise test for assessing cardiorespiratory fitness, aerobic endurance (5, 7), and is an independent predictor of mortality and morbidity. It is also useful for monitoring cardiopulmonary rehabilitation and exercise interventions (2, 4, 7, 8). Despite its many advantages, there is limited research on the use of the 6MWT among healthy young Indian populations, particularly among athletes. While the negative impact of increased adiposity on cardiorespiratory fitness and 6MWT distance (6MWD) is known (3, 8, 9), the quantitative association between anthropometric variables and 6MWD, as well as gender differences in young Indian university players, remains unexplored. Additionally, no universally accepted normative reference values for 6MWD exist for this demographic. Hence, the present study aimed to: Evaluate differences in 6MWD and selected anthropometric indices (including adiposity measures) between young, healthy male and female university players, and assess the anthropometric correlates of 6MWD in this population.

MATERIALS AND METHODOLOGY:

This cross-sectional study was conducted at the Sports-Exercise Medicine and Sciences: Lifestyle and Performance Medicine Lab (Health and Physiological Medicine: Clinical and Interventional Physiology), Department of Physiology, Institute of Medical Sciences (IMS), Banaras Hindu University (BHU), Varanasi, India, following institutional ethical approval. The study participants comprised apparently healthy university players and physical education students from various sports disciplines including athletics, badminton, basketball, cricket, football, gymnastics, hockey, kabaddi, karate, kho-kho, taekwondo, volleyball, wushu and yoga. Eligible participants were aged 20-27 years, had at least one year of structured training in their respective sports, and had competed at state/national level or inter-college/university tournaments. Exclusion criteria included any neuromusculoskeletal injuries or pathologies, medical illnesses, addictions, medications affecting exercise capacity, or being deemed medically unfit by a sports medicine physician. All participants provided informed consent after being thoroughly briefed about the study procedures, potential risks and benefits.A practice session of the physical test was done 2days before the actual testing day. They were instructed to avoid any strenuous exercise or physical activity for at least 48hours before the actual testing day, on which the participants were asked to come after a relaxing night sleep of 7-8hours. They were asked to have a light breakfast with no caffeinated drink at least 2hours before the testing. All the measurements and tests were done between 9am to 11am by the same investigator.After a brief relevant history taking and medical examination, following anthropometric and adiposity indices were measured: height (HT in cm) using a stadiometer, weight (WT in kg) and percentage body fat (BF) using a bioelectric impedance-based body composition analyser (TANITA BC-545N), waist circumference (WC in cm) and hip circumference (HC in cm) using a non-elastic flexible measuring tape. BMI, waist-hip ratio (WHR) and waist-height ratio (WHtR) were calculated. Among the adiposity indices, BMI and BF were used as general measures of adiposity whereas WC, WHR and WHtR were used as measures of abdominal or central adiposity (8, 10).

After a supine rest of about 15-20min, resting heart rate (rHR in bpm) was measured. 6MWT was conducted indoors in a straight, flat and hard corridor with a walking course of 30m, as per the standardized protocol of the American Thoracic Society, with an aim to walk as far distance as possible in the six-minute duration (4). The distance walked during the six minutes (6MWD in m) was calculated by multiplying the number of turns with 30m and adding the extra distance walked which was less than 30m after the last turn. All the participants were provided verbal encouragement by the same investigator every min, using the standardized statements which were same for all the participants (1, 4). Estimated VO2max (eVO2max) was also calculated using the earlier published regression equation (5).

Statistical Analysis:

Normality testing of the data was done using Shapiro-Wilk test. Independent t-test or Mann-Whitney U test (for non-normally distributed parameters) was used for comparison of the studied parameters. Mean±standard deviation (SD) along with minimum (Min.) and maximum (Max.) values were given. Medians±quartile deviations (QDs) were also given for parameters which are not normally distributed. The correlation of 6MWD with studied variables were done using Pearson Correlation or Spearman Correlation (for non-normally distributed variables). Partial correlation (parametric or non-parametric based on the normality testing) was used to assess the correlation of 6MWD with studied variables after controlling for gender in combined data consisting of male and female players. Regression analyses were done with 6MWD as DV (dependent variable) and statistically significant correlates of 6MWD as IVs (independent variables) separately in both the gender; and also with gender (1=male, 2=female) and a selected anthropometric variable together as the IVs. All the analyses were done using SPSS (Statistical Package for the Social Sciences) version 20. P-value of <.05 was set for statistical significance.

RESULTS:

On comparison, male players had significantly higher HT, WT, 6MWD and eVO2max but lower WHtR and BF (Table 1). The percentile values of 6MWD in both the gender is given in Table 3. Less than 25th percentile value was considered as low 6MWD, between 25th to 75th as average 6MWD, and more than 75th percentile value as high 6MWD (11) in the studied subjects, which were:

a) Male players: (i) Low 6MWD: <690.15m, (ii) Average 6MWD: 690.15m to 776.18m, and (iii) High 6MWD: >776.18m

b) Female players: (i) Low 6MWD: <620.97m, (ii) Average 6MWD: 620.97m to 736.85m, and (iii) High 6MWD: >736.85m

When each of the significantly different anthropometric variable between male and female players (Table 1) along with gender were used as IVs for predicting 6MWD, following equations were generated:

(a) 6MWD=2.601HT-7.230Gender+291.677; r2=.153, adjusted r2=.111, p-value=.033, standard error of the estimate (SEE)=66.689, Durbin-Watson (DW)=1.980; and the semi-partial r2 and p-value of IVs, Gender and HT were .084% and .843, and 4.58% and .143 respectively.

(b) 6MWD=-2.491WT-78.251Gender+968.389; r2=.161, adjusted r2=.120, p-value=.028, SEE=66.378, DW=2.003; and the semi-partial r2 and p-value of IVs, Gender and WT were: 16%, and .008, and 5.38% and .112 respectively.

(c) 6MWD=-726.651WHtR-21.035Gender+1082.032; r2=.265, adjusted r2=.229, p-value=.002, SEE=62.1296, DW=1.969; and the semi-partial r2 and p-value of IVs, Gender and WHtR were 1.54% and .360, and 15.76% and .005 respectively.

(d) 6MWD=-7.044BF+50.436Gender+798.194; r2=.194, adjusted r2=.155, p-value=.012, SEE=65.046, DW=2.066; and the semi-partial r2 and p-value of IVs, Gender and BF were 1.82% and .341, and 8.70% and .041 respectively.

With the exception of WT, the unique contribution by gender in the total variance of 6MWD over and above that by HT, WHtR and BF were statistical non-significant, indicating the possible important role of these variables for the gender difference in 6MWD in the studied subjects.

The correlations of 6MWD with age and the studied anthropometric variables are given in Table 2. Only HT correlated positively and significantly with 6MWD among the males. Age, WC and WHtR correlated negatively and significantly with 6MWD among the females. In addition to WC and WHtR, BMI and HC correlated negatively and significantly with 6MWD in the combined group consisting of both males and females, controlling for the effect of gender.

Regression analyses were then done with each of the significant correlate of 6MWD in male and female players separately, and the following equations were generated:

(a) In Male, 6MWD=4.899HT-109.882; r2=.182, p-value=.017 and SEE=59.055

(b) In Females:

i. 6MWD=-59.485Age+2021.524; r2=.476, p-value=.009 and SEE=57.127

ii. 6MWD=-10.705WC+1500.573; r2=.540, p-value=.004 and SEE=53.5597

iii. 6MWD=-1173.879WHtR+1261.002; r2=.344, p-value=.035 and SEE=63.939

The scatter plots are shown in Fig. 1.

Regression equations were also generated for predicting 6MWD with gender and one of the anthropometric variables as IV, and the highest adjusted r2 was found to be associated with the below equation:

(a) 6MWD=-16.934BMI-47.334Gender+1145.523; r2=.326, adjusted r2=.293, p-value<.001, SEE=59.483, DW=1.825; and the semi-partial r2 and p-value of gender and BMI were 9.55% and .021, and 21.902% and .001 respectively.

After BMI, the next highest adjusted r2 was found when gender and WHtR were used as IVs, and the equation is already given in the initial part of result section. Scatter plots between 6MWD and the predicted 6MWD (p6MWD) using these two equations with the highest adjusted r2 are given in Fig. 2.

DISCUSSION:

In the studied players, the males were significantly taller, heavier and had lower WHtR and BF. The male players also walked significantly more distance than female players in six minutes, and hence had more estimated VO2max. On an average, 6MWD of female player (680.82±75.59m) was 93.15% of that of male player (730.91±64.21m), and was 6.85% lower. (Table 1). An earlier study among healthy active 18-30years Asians reported female's 6MWD

(624.9±49.01m) to be 94.8% of that of male subjects (659.2±43.02m), and was 5.2% lower (1). Another study in young Nigerian healthy adults of 23.2±3.58years (18-35 years) reported 6MWD of 608.2±207.79m in males, and 565.9±69.49m in females (11). The above authors have reported 25th and 75th percentile cut-off for 6MWD in healthy females in the age group of 20-25years as 564.9m and 654m (11), which were lower than the cut-off values given in Table 3 for the studied females; i.e., 620.97m and 736.85m. Similar values for males of 20-30years in the present study were 690.15m and 776.18m (Table 3), and the values which the above authors got were 573.4m and 672m for 20-25years, and 545.1m and 670.1m for 26-30years healthy males (11). The values of 25th and 75th percentile in the present study were higher, as all the participants were active players who have presented their sports in various platforms and hence were presumably more aerobically fit. The estimated maximal oxygen consumption (eVO2max), a marker of cardiorespiratory fitness or aerobic capacity, of the studied players were 51.62±3.31ml/kg/min for males and 46.13±3.89ml/kg/min for females respectively using regression equation described earlier (5, 10). Since the equation was derived from healthy working-aged adults of 25 to 59 years (5), which was different from the participants' characteristics of the present study, eVO2max was not subjected for further analysis. On an average, eVO2max of female player was 89.36% of that male player, and was 10.64% lower. This is, however, higher than the reported range of an average female's VO2max of 70-75% of that of male after the puberty (2). The gender difference in 6MWD has been reported earlier due to taller height, more physical activity and more skeletal muscle mass in males (1, 2). In the present study, the observed gender difference might be related with the significant gender differences in anthropometric parameters, specially related with HT, WHtR and BF. Being a male gender (due to gender-specific physiological advantages and more aerobic capacity) and having a taller height are some of the factors which increase 6MWD (4). It is understandable that taller individuals not only normally have longer legs and hence more stride length and longer pass, but also usually have more vital capacity, both of which are associated with increased 6MWD (1-3, 11). In the present study, however, significant positive correlation was found between 6MWD and HT only in males (Table 2). Similar relationship was reported earlier in a study, although in a different set of population (3). In the studied males, 1cm increase in HT would increase 6MWD by 4.899m (Fig. 1). Another factor which usually negatively affects 6MWD is the increased adiposity (2, 8), which may increase the workload at a fixed exercise amount, and may reduce the performance (3). This might be one of the factors for the gender difference in 6MWD in the studied subjects in which the females had significantly higher BF and WHtR (Table 1). Interesting the males had significantly higher WT and also higher WC and WHC (although statistically non-significant). Significantly higher HT and lower WHtR and BF among the males might have compensated for the above. Similar to this study, an earlier study reported higher HT and WT with more 6MWD in males as compared to females (1). When the effect of gender was controlled statistically, negative correlation of 6MWD was found with various indices of adiposity like BMI, WC, HC, WHR, WHtR and also with WT, although the p-values dropped to statistical level only in case of BMI, WC, HC and WHtR (Table 2). In fact, BMI and WHtR accounted for 21.902% and 15.76% of the 6MWD variance respectively, over and above that by gender, which were highest among the studied anthropometric variables in such regression analyses (Fig. 2). However, when analysis was done separately, correlation coefficients of only WC and WHtR were statistically significant in females. The pattern of fat distribution in females might negatively affect 6MWD, perhaps by reducing gait efficiency in females (2, 12). Even though statistically non-significant, negative correlations of 6MWD were observed with BMI (in both the gender), WC (non-significant in males), HC (in both the gender), WHR (in females), WHtR (non-significant in males), BF (in both the gender) and also with WT (in both the gender) (Table 2). Significant negative correlation of 6MWD with BMI, and non-significant correlation with WT in male and female healthy individuals have been reported earlier (1). In the females, 1cm and 0.1 unit increase in WC and WHtR would result in reduction of 6MWD by 10.705m and 117.3879m respectively (Fig. 1). In a general sense, these findings suggested the possible negative association of increased adiposity and weight on 6MWD. Earlier study reported negative association of 6MWD with various adiposity indices, although the studied population was middle age (36.95±3.84years) healthy north Indian males (8). Among the females, 6MWD correlated negatively with age, with 1year increase in age would result in reduction of 6MWD by 59.485m (Fig. 1). Perhaps females with more age had also more anthropometric variables which associated negatively with 6MWD, like WC and WHtR. However, no significant relation was there among males, and in combined data controlling for gender (Table 2). The minimal effect of age on 6MWD has been reported earlier (6). Nevertheless, the aging related decrease in aerobic capacity starting in mid-teens for females, and mid-twenties for males, due to the reduction in function of cardiorespiratory and other organ systems, is well established (2, 9, 11). Although the correlation of rHR with 6MWD was negative in male, female and combined group (controlling for the gender), but it was not statistically significant (Table 2). Resting heart rate has been reported to be negatively associated with 6MWD (6) and cardiorespiratory fitness, which may be due to the aerobic fitness - associated increased parasympathetic and decreased sympathetic activity (9). Similar non-significant negative correlation of rHR with 6MWD in both male and female active healthy 18-30 years old individuals was found earlier also (1).

CONCLUSION:

The male players significantly walked more distance in six minutes than females, and were, on an average, taller, heavier with lesser WHtR and BF. The cut-off value for low, average and high 6MWD in the studied male and females were: 690.15m and 776.18m, and 620.97m and 736.85m respectively. These anthropometric differences, specially in HT, WHtR and BF, might explain at least in parts, the gender difference in 6MWD. Correlation and regression analyses of 6MWD with the studied anthropometric variables also highlighted the importance of them in both the gender. HT was positively and significantly correlated with 6MWD in males. One cm increase in HT would result in 4.899m increase in 6MWD. In females, significant negative correlation of 6MWD was there with WC, WHtR and also with age. One cm, 0.1unit and 1year increase in WC, WHtR and age would result in decease of 6MWD by 10.705m, 117.3879m and 59.485m respectively. Controlling for the effect of gender, in addition to WC and WHtR, significant negative correlation of 6MWD was found with BMI and HC. Gender along with BMI together accounted for the highest percentage of variance in 6MWD ($r2=.326$, adjusted $r2=.293$) followed by gender with WHtR ($r2=.265$, adjusted $r2=.229$), in regression analyses using one studied anthropometric variable each with gender as IVs. In a nutshell, the study suggested the possible negative effect of various adiposity related anthropometric variables on 6MWD.

Limitations:

Small-sized convenience sample is a major limitation of this study. Inclusion of physiological parameters including blood pressure, recovery heart rate with the use of directly measured value of VO2max and dual-energy X-ray absorptiometry based body composition variables might have improved the result of the study. Inclusion of individuals from diverse age group, specially master athletes and older individuals might have improved the applicability of the result. Nevertheless, the current study laid the foundational platform for future well design studies in this area.

Practical Applications:

The result highlighted easily measurable anthropometric difference as a factor for gender difference in 6MWD. The significant association of various anthropometric and adiposity indices with the measured 6MWD highlighted the importance of them for training monitoring, reducing gender gap, improving functional exercise capacity, and also perhaps for talent identification. The cut-off for “low”, “average” and “high” 6MWD for the studied young university players were generated, and this might be useful for generating future normative reference values in a large sampled, well-designed study for Indian players.

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Conflicts of Interest:

The authors expressed no conflicts of interest.

Parameters	Mean±SD (Min.-Max.)		P-value
	Male (n=31)	Female (n=13)	
Age^ (years)	22.53±1.46 [22±.5] (20.00-27.00)	22.54±.88 [22±.5] (21.00-24.00)	.667
HT^ (cm)	171.63±5.60 [171±4.5] (164.00-184.00)	155.15±6.60 [155.5±3](142.00-168.50)	<.001**
WT (kg)	63.91±7.14 (52.60-79.40)	52.61±5.30 (43.80-63.10)	<.001**
BMI^ (kg/m2)	21.69±2.07 [21.37±1.66] (19.09-26.32)	21.85±1.74 [21.38±1.19] (19.55-25.74)	.690
WC (cm)	77.90±6.50 (69.00-90.50)	76.58±5.19 (69.50-84.50)	.518

HC^ (cm)	92.60±7.85 [93±5] (61.00-102.50)	93.96±3.26 [94.5±2] (87.50-98.50)	.690
WHR^	.846±.097 [.821±.026] (.765-1.295)	.815±.055 [.814±.045] (.728-.899)	.348
WHtR	.454±.040 (.397-.546)	.494±.038 (.446-.553)	.004**
BF (%)	16.71±3.22 (10.70-24.20)	30.98±2.36 (28.40-34.90)	<.001**
rHR^ (bpm)	69.01±8.14 [67±6.5] (58-90)	72.93±8.26 [71±6.5] (62-88)	.119
6MWD (m)	730.91±64.21 (601.81-852.84)	680.82±75.59 (559.23-823.10)	.030*
pVO2max (ml/kg/min)	51.62±3.31 (42.24-57.14)	46.13±3.89 (37.49-53.30)	<.001**

Independent t-test, ^Mann-Whitney U test [Median±QD]; *p-value<.05, **p-value<.01;
SD=standard deviation, QD=quartile deviation, Min.=minimum value, Max.=maximum value.
Table 1. Comparison of the studied parameters between the male and female players.

Variables	(r-value, p-value)		
	Male players (n=31)	Female Players (n=13)	Combined group (controlling for gender)# (n=44)
Age (years)	(.197, .297)^	(-.690, .009**)	(-.053, .737)^
HT (cm)	(.386, .032*)^	(-.133, .665)	(.227, .143)
WT (kg)	(-.172, .354)	(-.475, .101)	(-.246, .112)
BMI (kg/m2)	(-.353, .051)^	(-.473, .103)	(-.391, .010*)^
WC (cm)	(-.193, .298)	(-.735, .004**)	(-.314, .040*)^
HC (cm)	(-.287, .118)^	(-.414, .159)	(-.393, .009**)
WHR	(.003, .985)^	(-.534, .060)	(-.182, .242)^
WHtR	(-.349, .054)	(-.587, .035*)	(-.420, .005**)
BF (%)	(-.318, .082)	(-.323, .281)	(-.246, .111)^
rHR (bpm)	(-.099, .595)^	(-.391, .187)	(-.196, .208)^

Pearson Correlation, ^Spearman Correlation/Non-parametric correlation, #Partial Correlation;
*p-value<.05, **p-value<.01
Table 2. Correlates of 6MWD in male players, female players and in combined group (controlling for gender)

Gender	Mean±SD [Median±QD] (Min.-Max.)	Percentiles of 6MWD						
	Age (years)	5th	10th	25th	50th	75th	90th	95th
Male (n=31)	22.53±1.46 [22±.5] (20.00-27.00)	604.82m	640.85m	690.15m	744.24m	776.18m	827.89m	845.93m
Female (n=13)	22.54±.88 [22±.5] (21.00-24.00)	559.23m	577.34m	620.97m	680.15m	736.85m	806.18m	–

Table 3. Percentile values of 6MWD in male (20 to 27 years) and female (21 to 24 years) players

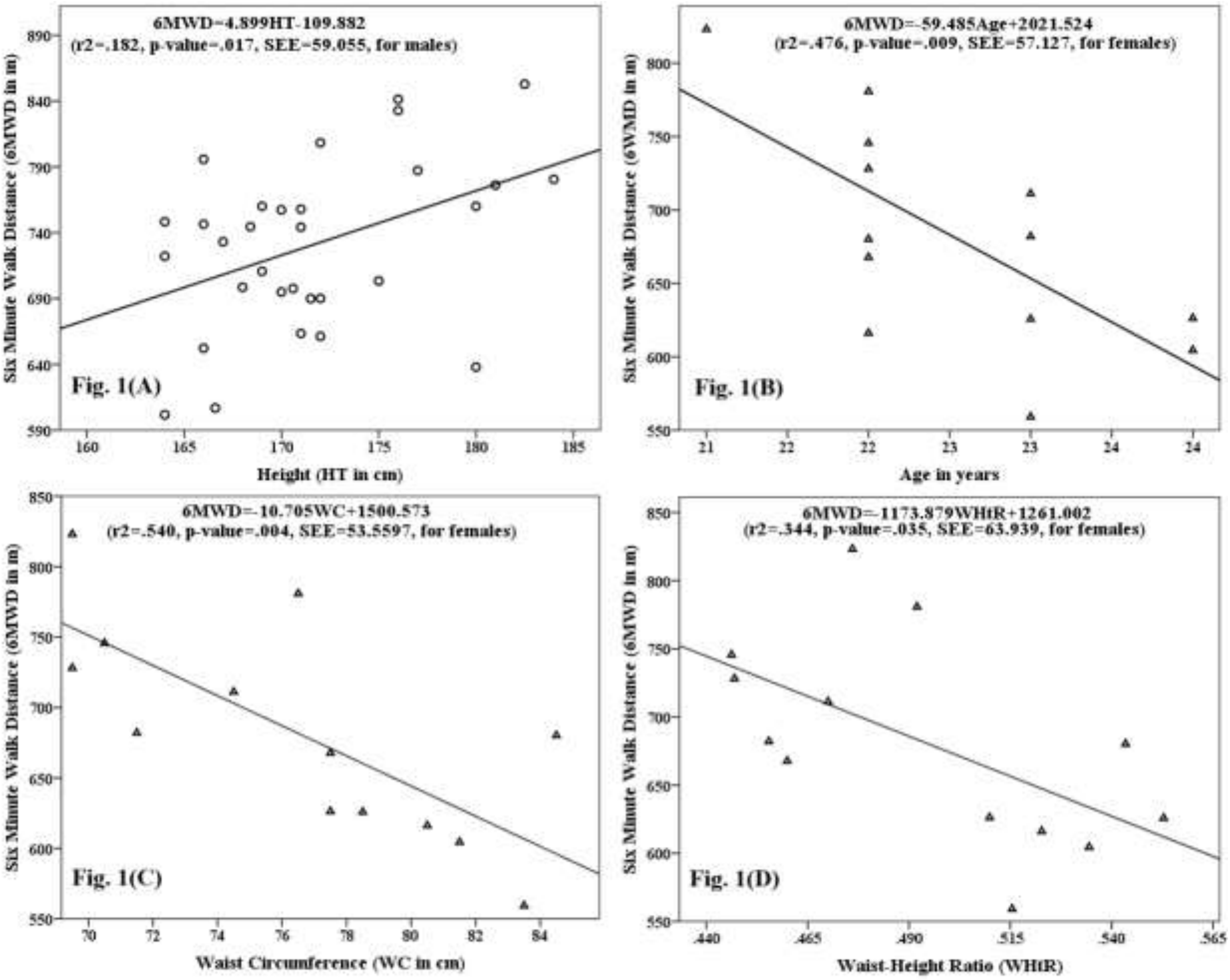

Fig. 1. Scatter plots between 6MWD and: (A) height (HT) in males [6MWD=4.899HT-109.882; r2=.182, p-value=.017, standard error of the estimate (SEE)=59.055], (B) age in females [6MWD=-59.485Age+2021.524; r2=.476, p-value=.009, SEE=57.127], (C) waist circumference (WC) in females [6MWD=-10.705WC+1500.573; r2=.540, p-value=.004, SEE=53.5597], and (D) waist-height ratio (WHtR) in females [6MWD=-1173.879WHtR+1261.002; r2=.344, p-value=.035, SEE=63.939]

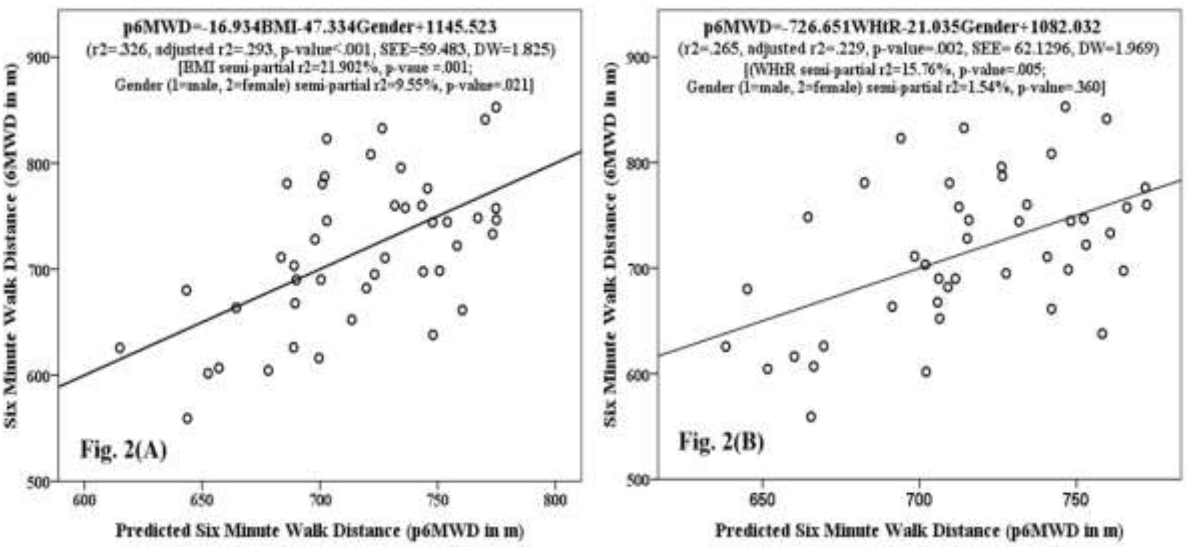

Fig. 2. Scatter plots between 6MWD and predicted 6MWD (p6MWD). 6MWD was predicted using: (A) p6MWD=-16.934BMI-47.334Gender+1145.523 [r2=.326, adjusted r2=.293, p-value<.001, standard error of the estimate (SEE)=59.483, Durbin-Watson (DW)=1.825] in which semi-partial r2 and p-value of BMI and Gender (1=Male, 2=Female) are 21.902% and .001, and 9.55% and .021 respectively, and (B) p6MWD=-726.651WHtR-21.035Gender+1082.032 [r2=.265, adjusted r2=.229, p-value=.002, SEE=62.1296, DW=1.969] in which semi-partial r2 and p-value of WHtR and Gender (1=Male, 2=Female) are 15.76% and .005, and 1.54% and .360 respective

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