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Accuracy of physical self-description among chronic exercisers and non-exercisers

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Abstract

This study addressed the role of chronic exercise to enhance physical self-description as measured by self-estimated percent body fat. Accuracy of physical self-description was determined in normal-weight, regularly exercising and non-exercising males with similar body mass index (BMI)'s and females with similar BMI's (n=42 males and 45 females of which 23 males and 23 females met criteria to be considered chronic exercisers). Statistical analyses were conducted to determine the degree of agreement between self-estimated percent body fat and actual laboratory measurements (hydrostatic weighing). Three statistical techniques were employed: Pearson correlation coefficients, Bland and Altman plots, and regression analysis. Agreement between measured and self-estimated percent body fat was superior for males and females who exercised chronically, compared to non-exercisers. The clinical implications are as follows. Satisfaction with one's body can be influenced by several factors, including self-perceived body composition. Dissatisfaction can contribute to maladaptive and destructive weight management behaviors. The present study suggests that regular exercise provides a basis for more positive weight management behaviors by enhancing the accuracy of self-assessed body composition.

Introduction

Exercise programs designed to reduce body fatness may improve self-esteem because obese individuals tend to have negative attitudes about their bodies.¹⁻³ Exercise, whether or not it leads to reduced body fatness also may be important, as physical fitness is related to physical self-concept,⁴ and exercise interventions may enhance physical self-concept.^{5,6}

Regular participation in exercise programs

may increase the accuracy of physical self-concept derived from physical self-description.^{7,8} Although previous research supports the impact of exercise on the accuracy of physical self-descriptions, other possibilities exist. For example, it has been reported that normal-weight subjects more accurately assess their body size when compared with obese subjects who are more likely to overestimate their size.² Individuals of normal-weight are more likely to exercise than are those who are obese, but exercise in the Garner *et al.*² study and others of a similar nature was not imperative. As such, it is possible that alternative weight loss interventions such as a healthful diet, medications, or even bariatric surgery might offer similar or increased physical self-concept benefits when compared with exercise.

The purpose of the present study was to assess the relationship between chronic exercising and physical self-description (self-estimated percent body fat). Accuracy of physical self-description was determined in normal-weight exercising and non-exercising males and females with similar body mass index (BMI). It was hypothesized that controlling for BMI, exercising subjects would provide more accurate self-estimates of their body fat percentage. Support for this hypothesis would, in turn, provide a basis for subsequent research to determine if exercise, regardless of its direct impact on body fatness, contributes to a self-concept reflecting more accurate self-description.

Materials and Methods

Participants

A total of 87 individuals volunteered to participate (42 males and 45 females), of whom 23 males and 23 females were classified as chronic exercisers (see below). Participants reported to the Exercise Physiology Laboratory on one occasion where they: i) received an explanation of the study procedures which were approved by the University Institutional Review Board (IRB #5947) as being in accordance with the ethical standards of human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008; ii) read and signed an IRB approved Informed Consent document; iii) completed the Physical Readiness Activity Questionnaire (PAR-Q); iv) answered the following questions simply to determine if they met or did not meet the definition of a chronic exerciser, defined as participants who exercised regularly a minimum of three days a week for 30 minutes per session for at least the past six consecutive months (note: this data was simply coded *yes* they met the definition of a chronic exerciser or *no* they did not meet the

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definition of a chronic exerciser): a) How long (weeks, months, years) have you been exercising continuously? b) How many days a week do you exercise? c) How much time each day do you exercise? and, v) asked if they had ever had their body composition tested before.

Descriptive statistics for age, height, body mass, and BMI, are listed in Table 1. No participant had ever had their body composition tested prior to this study.

Protocol

Participants were weighed hydrostatically to determine body composition (% body fat). This procedure involved sitting in a chair suspended from a scale in a tank of warm water (33°C) approximately 4 feet deep. The participant was instructed to lean forward into the water, submerge completely and fully exhale over a period of approximately 15-sec. while the researcher recorded the weight. Once the weight was recorded, participants were signaled to resurface. This procedure was repeated for a minimum of four trials; during each trial, participants were encouraged to take their time and relax. The highest measured underwater weight was used for data analysis using the Siri equation. Residual lung volumes were estimated from age and height prediction equations.⁹

Then without knowledge of the results of the hydrostatic weighing, participants answered the following question related to self-perceived body composition (fat and muscle mass): *Today, if you were to stand in front of a mirror without anyone around you in the*

comfort of your own home and you were completely honest with yourself and had to make a best guess, what percentage of your body would you estimate to be fat?

Descriptive statistics for measured percent body fat and self-estimated percent body fat are listed in Table 1. Males and females classified as chronic exercisers were leaner than non-exercisers and males were leaner than females overall.

Statistical analyses

There is considerable debate as to the most appropriate manner to demonstrate degree of agreement between two measures. Among the recommended statistical techniques are: Pearson product-moment correlation; determination of confidence intervals for mean differences in conjunction with a Bland-Altman plot; and regression analyses. Bland and Altman argue against using the Pearson product-moment correlation as a measure of agreement.¹⁰ Likewise, Hopkins¹² argues against using the Bland-Altman plots as a measurement of agreement. Owing to controversy,¹⁰⁻¹² as to the most appropriate measure, all three methods were employed in the present study.

Results

Figure 1 illustrates the relationship (*i.e.* degree and pattern) between measured and self-estimated percent body fat for all participants (males and females, chronic exercisers and non-exercisers). Typically only the effective range is plotted on a scatter diagram. In this case, the maximum and minimum *x* (self-estimated percent body fat, horizontal *x*-axis) and *y* (measured percent body fat, vertical *y*-axis) values across the groups was used to establish the plot ranges to allow visual analysis of cluster groupings.

Visual inspection of the scatter plots reveals two key points. First, the dispersion of scores for non-exercisers appears far greater than for exercisers, for both males and females. Second, the dispersion of scores for exercising males and females appears approximately the same and exhibits a linear pattern.

Histograms for self-estimated and measured percent body fat for male and female, chronic exercisers and non-exercisers, were visually inspected. The shape of the histograms appeared normal providing evidence that the data are normally distributed. The corresponding correlation coefficients between measured and self-estimated percent body fat for each group are as follows: exercising males ($r=0.81$; $P<0.05$), non-exercising males ($r=0.67$; $P<0.05$), exercising females ($r=0.80$; $P<0.05$), and non-exercising females ($r=0.50$; $P<0.05$). The degree of association between

measured and self-estimated percent body fat for exercising males and females appears to be approximately equal and greater than for non-exercising participants. The correlations between measured and self-estimated percent body fat for the exercising groups meets the benchmark for criterion based concurrent validity of $r=0.80$ or greater.¹³ Furthermore, the coefficient of determination (CD), a measure of common variance between measured and self-estimated percent body fat is 66% and 64% for exercising males and females, respectively.

The relationship between the difference and the means of the two methods (measured per-

cent body fat and self-estimated percent body fat) for males and females, exercisers and non-exercisers is illustrated in Bland-Altman plots (Figure 2). Per Bland and Altman,^{10,11} two methods are in agreement when the mean difference between the methods is approximately zero and that 95% of the differences are within ± 2 standard deviations of the mean difference (assuming that ± 2 standard deviations of the mean difference is not clinically important). In order to employ the Bland-Altman methods, the differences (measured percent body fat – self-estimated percent body fat) must be normally distributed. Histograms for differences for male and female, chronic exercisers and non-

Table 1. Physical characteristics of participants (mean \pm standard deviation)

	Male		Female	
	Exercised (n=23)	Non-exercised (n=19)	Exercised (n=23)	Non-exercised (n=22)
Age (years)	25.6 \pm 6.2	23.6 \pm 6.0	23.4 \pm 4.9	25.4 \pm 7.7
Height (cm)	176.7 \pm 5.6	180.0 \pm 7.9	165.2 \pm 7.4	165.1 \pm 5.9
Mass (kg)	86.5 \pm 11.7	89.0 \pm 21.3	62.0 \pm 8.5	62.5 \pm 8.4
Body mass index (kg/m ²)	27.8 \pm 4.1	27.3 \pm 5.1	22.7 \pm 2.5	22.9 \pm 2.9
Percent body fat	18.4 \pm 7.0	22.0 \pm 8.1	22.3 \pm 6.1	25.1 \pm 5.8
Estimated percent body fat	16.5 \pm 7.5	20.3 \pm 9.7	22.8 \pm 6.6	26.3 \pm 7.7
Absolute difference (not mean)	3.7 \pm 3.1	5.8 \pm 4.6	3.1 \pm 2.7	5.7 \pm 4.0

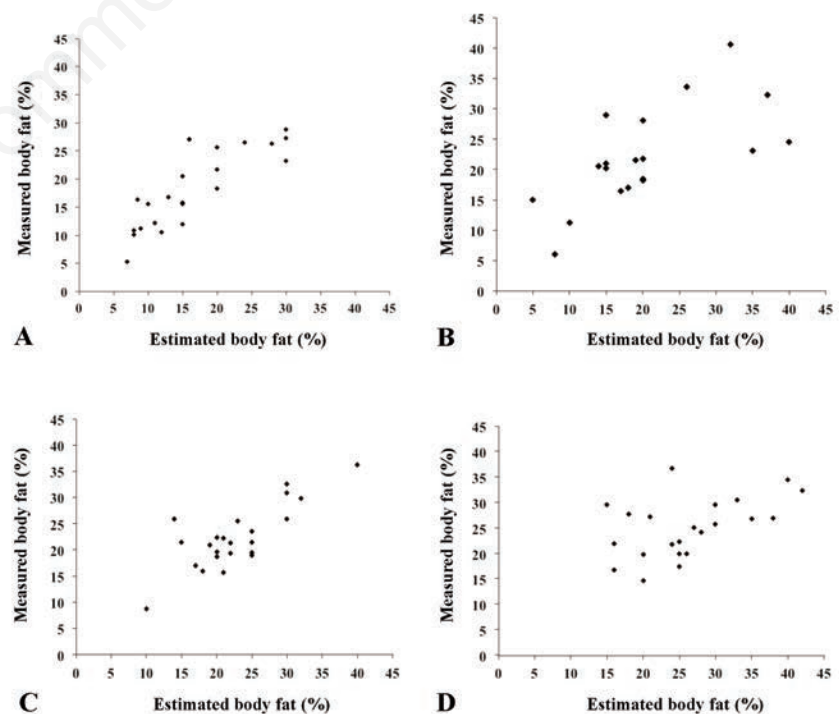


Figure 1. Scatter diagrams comparing self-estimated percent body fat with hydrostatically measured percent body fat for males and females who are chronic exercisers and non-exercisers: A) exercised males; B) non-exercised males; C) exercised females; D) non-exercised females.

exercisers, were visually inspected. The shape of the histograms appeared normal providing evidence that the data are normally distributed.

The mean difference and lower and upper limits of agreement (d_m : LL, UL, respectively) for each group are as follows: exercising males (1.87: -7.02, 10.75), non-exercising males (1.70: -12.94, 16.34), exercising females (-0.48: -8.62, 7.66), and non-exercising females (-1.19: -15.18, 12.79). The mean differences were acceptable and 95% of the differences were within ± 2 standard deviations of the mean difference for each group. However, the limits of agreement (e.g. $d_m \pm 2$ sd) for non-exercising males and females are unacceptably large. It appears that only exercising males and females meet the Bland-Altman criteria for agreement.

Data were also analyzed using linear regression methods recommended by Hopkins¹² for each group (Table 2). All four groups exhibited a significant linear relationship ($P < 0.05$) between measured and perceived percent body fat. However, perfect agreement between two measures only exists when: $b_0 = 0$, $B = 1$, $R = 1$, and $SEE = 0$. Agreement between measured percent body fat and self-estimated percent body fat was most closely approximated by the exercising males and females (see regression variables Table 2). The aforementioned regression variables were essentially equal for exercising males and females and exhibited a clear separation from their non-exercising counterparts (Table 2). Plots of residuals versus predicted values were constructed in order to determine if the error was comparable for all participants in each group. No evidence of heteroscedasticity (non-uniformity) of error was visible for any group.

Discussion

The purpose of this study was to examine the relationship between exercise chronicity and physical self-description, assessed by estimated percent body fat. It was hypothesized that controlling for BMI, exercising subjects would more accurately self-estimate their percent body fat. Support for this hypothesis is as follows: first, based on the results of Bland-Altman plots and regression analysis, agreement between measured and self-estimated percent body fat was more accurate for exercisers compared to non-exercisers, independent of gender. Second, chronic exercise was associated with estimated percent body fat at an accuracy level comparable to that of commonly accepted field tests.

Another approach to examining agreement is to compare the absolute difference between measured and self-estimated percent body fat.

In a sense, this is an error score, the smaller the difference the lower the error (e.g. higher agreement). While this approach does not identify bias or non-uniformity of error between the measures, it does give practical insight to the agreement between the measures in the absence of bias and non-uniformity of error. Absolute differences (regardless of whether a person overestimated or underestimated percent body fat, absolute differences are computed using integers irrespective of positive or negative values) between measured and self-estimated percent body fat are listed in Table 1 for each group. Absolute differences in percent body fat for exercising males and females were 3.7 ± 3.1 and 3.1 ± 2.7 , respectively, while their non-exercising counterparts were 5.8 ± 4.6 and 5.7 ± 4.0 , respectively. There is a clear separation between the absolute differences for exercisers as compared to non-

exercisers. Independent t-tests were conducted to compare absolute differences for exercisers as compared to non-exercisers for both males and females. Absolute differences for exercisers were significantly lower than non-exercisers for both males ($P = 0.039$) and females ($P = 0.005$). Of particular importance are the small absolute differences for those who exercise, given that skin fold measures, bioelectrical impedance analysis, anthropometric regression equations, and near infrared body composition analysis generally are minimally $\pm 3.5\%$ or more of the hydrostatically measured percent body fat.¹⁴⁻¹⁹

Inaccurate self-assessment of body composition has been observed among those with eating disorders,^{20,21} and the drive to diet excessively may be influenced by the degree of discrepancy between real versus imagined ideal body size, particularly in adult women.²²

Table 2. Regression results.

	b_0	B	R	R ²	P	SEE
Male exercised	5.85	0.76	0.81	0.66	<0.05	4.16
Male non-exercised	10.54	0.56	0.67	0.45	<0.05	6.16
Female exercised	5.53	0.74	0.80	0.64	<0.05	3.77
Female non-exercised	15.26	0.37	0.50	0.25	<0.05	5.17

b_0 , y-intercept; B, unstandardized coefficient; R, correlation coefficient; R², coefficient of determination; P, significance level; SEE, standard error of estimate.

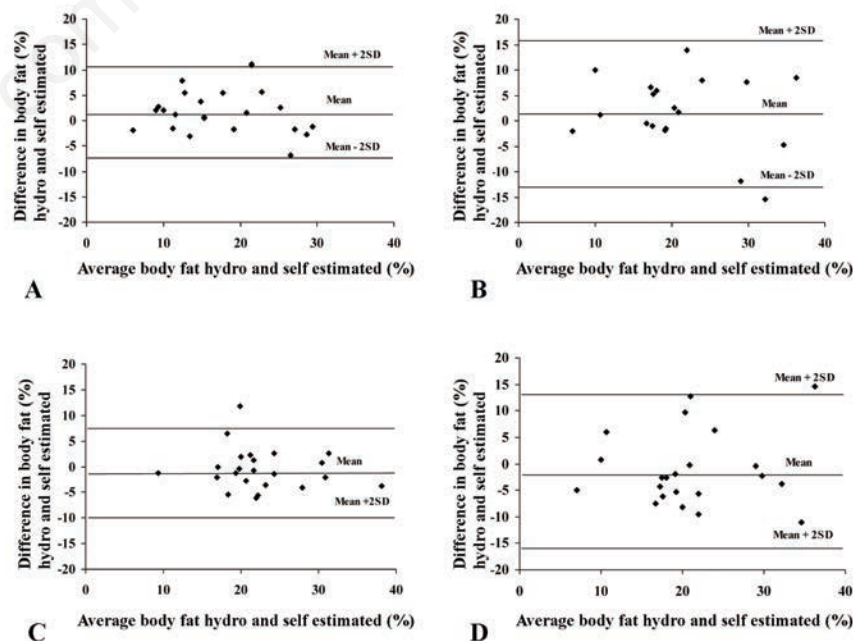


Figure 2. Bland-Altman plot comparing self-estimated percent body fat with hydrostatically measured percent body fat for males and females who are chronic exercisers and non-exercisers: A) exercised males; B) non-exercised males; C) exercised females; D) non-exercised females.

Inaccurate self-assessed body composition has also been reported in normal-weight individuals as well.²³ A common basis for these errors is open to debate, but some research suggests it is the body weight relative to the height (the BMI) that creates error in self-assessment.²⁴ The present study controlled for BMI, and the findings suggest that self-assessment of body composition is more strongly related to exercise chronicity than BMI.

The present findings suggest the possibility that exercise per se can promote a more accurate physical self-concept derived from a more accurate physical self-description. One may speculate that exercisers become more familiar with their body over time and pay more overall attention to physical state factors, thereby increasing accuracy of self-assessment. They may also have more opportunities for self-assessment (*e.g.* mirrors in the exercise room).

In turn, accurate self-assessment may be important with regard to the perception of one's self, and in particular the degree of body satisfaction/dissatisfaction. It has been reported that body fatness strongly influences how women view themselves in terms of body satisfaction or dissatisfaction, and that a significant inverse relationship exists between body fatness and physical self-concept.²⁵ In addition, obese subjects tend to overestimate their size and that such overestimations typically exceed 15%.²⁶ Moreover, a study by Rhodes and O'Neil reported that obese women not only tend overestimated their size, but also reported feeling heavier than they actually were.²⁷ Whereas this study suggests that even in individuals with higher percent body fat, exercisers have improved self-concept over non-exercisers of similar body fat levels.

Logically, it could be asserted that the appropriate approach to altering body dissatisfaction and a negative self-concept, and the overestimating of one's size, is to lose weight. However, the present data suggest that engaging in chronic exercise may increase the accuracy of self-description, which in turn may influence how one views oneself. Exercise may, in other words, drive self-perception in a positive direction even before the first pounds are lost. This could be an encouraging message to those who work with overweight and obese individuals, endeavoring to improve not only their health, but also their psychological well being.

Conclusions

In conclusion, agreement between measured and self-estimated percent body fat was superior for males and females who exercised chronically, compared to non-exercisers. The

present findings support the role of exercise as an important tool in accurate self-assessment. Also, a positive impact of exercise may be realized whether or not it leads to a reduction in body fatness. Thus, it is suggested that regular exercise per se, and not necessarily the outcomes associated with chronic exercise, may indirectly promote more positive weight management behaviors. This effect may be derived by enhancing the accuracy of self-assessed body composition.

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