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# Fitness performance across ranked body composition groups assessed by different methods

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### Abstract
**Background:** Body composition (BC) is a valuable indicator of performance both across and within certain sporting events. However, the specific relationship between BC and fitness performance (FP) is less understood.
**Purpose:** The purpose of this study was to examine the relationship between BC, assessed by different methods, and FP in a population of college students.
**Methods:** This cross-sectional research used data from 131 college students attending a rural university. BC was assessed using five different methods: 1) body mass index (BMI), 2) percent body fat (PBF) by skinfold technique (SF), 3) PBF by circumference method (CM), 4) PBF by handheld bioelectric impedance (HH), and 5) waist circumference (WC). Fitness test outcome measures included 1) maximal oxygen consumption (VO2max) from the Queens College Step Test, 2) 1-repetition maximum bench press (BP) scores, 3) maximum repetition push-up (PU) scores, and 4) sit-and-reach (SR) flexibility scores. Analysis of variance (ANOVA) was used to examine mean FP differences across BC tertiles.
**Results:** In the overall analysis, VO2max was indirectly related to BC tertile in all BC measures. BP was directly related to BC tertile only in BMI and WC tests. PU was indirectly related to BC tertile only in SF, CM, HH, and WC tests. SR was not significantly different across BC tertile in any BC test. These results were not consistent across sex groups.
**Conclusion:** Results from this study show clear differences in FP across ranked BC groups. Furthermore, these differences were not consistent across BC method and not consistent across sex groups.

**Keywords:** Health-related fitness, human performance, ANOVA, college health

### Introduction
Body composition (BC) is a strong predictor of human performance both across and within certain sporting events [1]. For example, in NCAA Division I football players, increased body weight has been shown to be directly related to muscular strength performance [2]. Additionally, higher amounts of body fat in NCAA Division I football players has been shown to be indirectly related to power clean, vertical jump, and sprinting performance. Other studies have shown BC and performance associations in basketball players [3, 4], swimmers [5, 6], baseball players [7, 8], wrestlers [9, 10], volleyball players [11, 12], and golfers [13]. Despite this large body of evidence, the specific relationship between BC and fitness performance (FP) in college students is less understood. The purpose of this study was to examine the relationship between BC and FP in a population of college students. An additional purpose was to determine if identified relationships were consistent across different BC methods.

### Methods
#### Participants and design
Data for this research came from a cross-sectional measurement study where 131 college students attending a rural public university volunteered to participate in a series of health-related fitness tests. Students were recruited by campus flyers and word-of-mouth and offered free fitness evaluation in exchange for their participation. Study components and protocols were reviewed and approved by the university system's institutional review board (IRB).

**Body Composition (BC) Measures**

BC was assessed using five different methods: 1) body mass index (BMI), 2) percent body fat (PBF) by skinfold technique (SF), 3) PBF by circumference method (CM), 4) PBF by handheld bioelectric impedance (HH), and 5) waist circumference (WC). BMI ($kg/m^2$) was assessed by measuring height with a wall-mounted stadiometer and measuring weight with an electronic floor scale. PBF by SF was assessed using the Siri equation and sex-specific body density formulas inputting the sum of 3 skinfold sites [14]. PBF by CM was assessed by using the U.S. Navy procedure which included measuring height and waist, hip, and neck circumferences in women and measuring height and abdomen and neck circumferences in men [15, 16]. PBF by HH was assessed with an Omron handheld device and followed manufacturer's procedures [17]. Finally WC was measured the same for women and men, at the narrowest location between the umbilicus and xiphoid process [18].

**Fitness Performance (FP) Measures**

Fitness outcome measures included tests from the other four components of health-related fitness: cardiorespiratory (CR) fitness, muscular endurance (ME), muscular strength (MS), and flexibility (FL) [19]. CR fitness was assessed by indirectly measuring maximal oxygen consumption (VO2max) from the Queens College Step Test [20]. MS was assessed using the 1-repetition maximum (1RM) bench press (BP) test [21]. ME was assessed using the maximum repetition push-up (PU) test [18]. Finally, FL was assessed using the sit-and-reach (SR) flexibility test [18].

**Statistical Analysis**

Subjects were categorized into one of three tertile groups where larger tertiles represented greater BC values (i.e., larger BMI and WC values and greater PBF values). Analysis of variance (ANOVA) was used to examine mean FP differences across BC tertiles [22]. Follow-up contrasts were performed to test for linear and quadratic trends. Significance was set to $p<.05$ for all tests. All analyses were performed using SAS version 9.4 [23].

**Results**

Table 1 contains descriptive statistics (ranges) for BC tertiles for each BC method. Inspecting BMI only, the tertiles approximately represent normal weight, overweight, and obese categories [24]. Table 2 displays ANOVA results for males. Male VO2max scores showed a significant (ps<.001) indirect linear trend (i.e., as BC increased, VO2max decreased) in all five BC methods. Male BP scores showed a significant (ps<.01) direct linear trend in BMI and WC measures only. Male PU scores showed a significant (ps<.05) indirect linear trend in all BC methods except BMI. And male SR scores showed no significant (ps>.05) differences or trends in any BC method.

Table 3 displays results for the female ANOVA procedures. Female VO2max scores showed a significant (ps<.05) indirect linear trend in all BC methods except WC. Female PU scores showed only a significant (ps<.05) negative quadratic trend in SF, CM, and HH methods. Finally, female BP and SR scores showed no significant (ps>.05) differences or trends in any BC method.

Combined results for males and females (N=131) are shown in Table 4. This table first T-score transformed fitness scores to control for sex. Overall, VO2max showed a significant (ps<.001) indirect linear trend in all BC measures. Overall, BP showed a significant (ps<.05) direct linear trend only in BMI and WC tests. Overall, PU showed a significant (ps<.01) indirect linear trend in SF, CM, HH, and WC tests. Finally, overall, SR was not significantly (ps>.05) different across BC tertile in any BC test.

**Table 1:** Body composition measure ranges across tertiles.

| | **Tertile** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| | 18.8-24.0 | 24.1-27.7 | 27.8-41.6 |
| Overall (N=131) | 4.4-12.2 | 12.4-20.3 | 20.6-24.6 |
| BMI ($kg/m^2$) | 7.0-15.2 | 15.3-24.4 | 24.5-41.9 |
| HH (%) | 4.6-16.6 | 16.7-22.9 | 23.0-39.0 |
| WC (cm) | 60.0-77.0 | 77.5-84.5 | 84.8-122.0 |
| Males (N=87) | 1 | 2 | 3 |
| BMI ($kg/m^2$) | 20.8-25.0 | 25.2-28.4 | 28.5-41.6 |
| SF (%) | 4.4-9.8 | 10.1-15.4 | 15.9-31.2 |
| CM (%) | 7.0-13.8 | 13.9-17.7 | 17.9-37.6 |
| HH (%) | 4.6-12.9 | 13.2-20.3 | 20.4-35.4 |
| WC (cm) | 71.5-81.3 | 82.0-87.8 | 88.0-122.0 |
| Females (N=44) | 1 | 2 | 3 |
| BMI ($kg/m^2$) | 18.8-21.9 | 22.0-25.8 | 26.0-33.2 |
| SF (%) | 14.5-20.2 | 20.6-25.6 | 26.2-34.6 |
| CM (%) | 7.1-24.4 | 24.5-29.9 | 30.0-41.9 |
| HH (%) | 14.7-20.0 | 20.8-24.5 | 24.9-39.0 |
| WC (cm) | 60.0-69.8 | 70.0-73.9 | 75.0-94.0 |

**Note:** 1st tertile corresponds to the lowest 33.3% of individuals in terms of BC score.

**Table 2:** Fitness scores across body composition (BC) tertiles for males (N=87).

| | Composition (BC) Tertile | | | | | | Omnibus | Trend |
|---|---|---|---|---|---|---|---|---|
| **Measure** | **1** | | **2** | | **3** | | ***p*** | ***p*** |
| BMI (kg/m$^2$) | | | | | | | | |
| $VO2_{max}$ | 41.39$^{a,b}$ | (7.97) | 36.27$^{a}$ | (7.09) | 32.97$^{b}$ | (7.06) | <.001 | <.001 |
| BP | 202.14$^{a}$ | (40.45) | 225.21$^{b}$ | (66.67) | 269.29$^{a,b}$ | (74.08) | <.001 | <.001 |
| PU | 38.46 | (16.32) | 35.16 | (15.91) | 32.68 | (15.76) | .402 | .180 |
| SR | 29.89 | (9.56) | 27.56 | (9.34) | 29.66 | (7.70) | .541 | .923 |
| SF (%) | | | | | | | | |
| $VO2_{max}$ | 40.81$^{a}$ | (7.03) | 38.20$^{b}$ | (8.04) | 31.54$^{a,b}$ | (6.15) | <.001 | <.001 |
| BP | 226.09 | (68.77) | 235.00 | (61.82) | 234.83 | (73.21) | .850 | .626 |
| PU | 44.76$^{a,b}$ | (15.77) | 33.97$^{a}$ | (14.99) | 27.55$^{b}$ | (12.41) | <.001 | <.001 |
| SR | 30.66 | (7.37) | 29.41 | (10.77) | 26.90 | (8.01) | .262 | .109 |
| CM (%) | | | | | | | | |
| $VO2_{max}$ | 41.86$^{a}$ | (8.02) | 36.54$^{a}$ | (6.15) | 32.34$^{a}$ | (7.19) | <.001 | <.001 |
| BP | 214.16 | (64.44) | 242.00 | (55.92) | 238.79 | (79.05) | .235 | .169 |
| PU | 43.64$^{a,b}$ | (15.70) | 34.57$^{a}$ | (16.52) | 28.38$^{b}$ | (12.00) | .001 | <.001 |
| SR | 30.13 | (8.42) | 29.88 | (9.20) | 26.97 | (8.93) | .325 | .182 |
| HH (%) | | | | | | | | |
| $VO2_{max}$ | 41.27$^{a}$ | (7.04) | 38.20$^{b}$ | (7.16) | 31.20$^{a,b}$ | (6.62) | <.001 | <.001 |
| BP | 211.61 | (48.15) | 244.88 | (75.04) | 238.28 | (72.55) | .142 | .135 |
| PU | 42.11$^{a}$ | (16.06) | 37.40$^{b}$ | (15.76) | 26.93$^{a,b}$ | (12.44) | <.001 | <.001 |
| SR | 29.75 | (9.53) | 30.68 | (8.68) | 26.50 | (8.16) | .168 | .167 |
| WC (cm) | | | | | | | | |
| $VO2_{max}$ | 41.22$^{a,b}$ | (7.86) | 36.51$^{a}$ | (7.11) | 32.80$^{b}$ | (6.96) | <.001 | <.001 |
| BP | 210.00$^{a}$ | (44.93) | 230.06 | (71.83) | 255.67$^{a}$ | (75.86) | .030 | .008 |
| PU | 37.70$^{a}$ | (15.76) | 39.89$^{b}$ | (16.03) | 29.13$^{a,b}$ | (14.62) | .023 | .035 |
| SR | 28.68 | (8.24) | 30.04 | (9.51) | 28.35 | (9.13) | .757 | .886 |

**Note:** Values reported as means (SD). Omnibus test is for one-way analysis of variance (ANOVA). Trend test is for ANOVA linear contrasts. Means with same lettered superscript are significantly different by Fisher's LSD. 1$^{st}$ tertile corresponds to the lowest 33.3% of individuals in terms of BC score.

**Table 3:** Fitness scores across body composition (BC) tertiles for females (N=44).

| **Measure** | **Body Composition (BC) Tertile** | | | | | | **Omnibus** | **Trend** |
|---|---|---|---|---|---|---|---|---|
| | **1** | | **2** | | **3** | | ***p*** | ***p*** |
| BMI (kg/m$^2$) | | | | | | | | |
| $VO2_{max}$ | 32.20$^{a}$ | (7.38) | 33.61$^{b}$ | (7.32) | 26.18$^{a,b}$ | (5.46) | .011 | .019 |
| BP | 85.00$^{a}$ | (19.64) | 103.21$^{a}$ | (18.67) | 99.10 | (28.55) | .089 | .101 |
| PU | 26.47 | (12.36) | 29.29 | (8.68) | 22.93 | (11.56) | .309 | .386 |
| SR | 32.83 | (7.59) | 34.14 | (8.49) | 36.10 | (8.04) | .539 | .272 |
| SF (%) | | | | | | | | |
| $VO2_{max}$ | 36.29$^{a}$ | (5.95) | 30.58$^{a}$ | (5.33) | 24.51$^{a}$ | (5.81) | <.001 | <.001 |
| BP | 100.67 | (20.08) | 98.67 | (26.96) | 86.79 | (22.50) | .240 | .118 |
| PU† | 26.47 | (10.67) | 30.60$^{a}$ | (10.91) | 21.07$^{a}$ | (10.25) | .065 | .179 |
| SR | 33.47 | (7.40) | 36.33 | (8.15) | 33.21 | (8.52) | .508 | .933 |
| CM (%) | | | | | | | | |
| $VO2_{max}$ | 32.23$^{a}$ | (7.91) | 33.51$^{b}$ | (6.77) | 26.16$^{a,b}$ | (5.49) | .011 | .020 |
| BP | 88.21 | (23.01) | 100.00 | (17.42) | 98.00 | (28.96) | .369 | .271 |
| PU† | 25.71 | (11.72) | 29.80 | (9.52) | 22.93 | (11.56) | .238 | .499 |
| SR | 33.21 | (7.94) | 33.97 | (8.11) | 35.83 | (8.18) | .668 | .388 |
| HH (%) | | | | | | | | |
| $VO2_{max}$ | 35.31$^{a}$ | (7.40) | 31.31$^{b}$ | (6.08) | 25.48$^{a,b}$ | (5.31) | .001 | <.001 |
| BP | 93.93 | (18.83) | 102.00 | (26.71) | 90.67 | (24.49) | .411 | .713 |
| PU† | 27.29 | (11.50) | 31.47$^{a}$ | (10.58) | 19.80$^{a}$ | (8.25) | .011 | .054 |
| SR | 35.57 | (5.45) | 33.30 | (9.06) | 34.30 | (9.09) | .753 | .675 |
| WC (cm) | | | | | | | | |
| $VO2_{max}$ | 32.52 | (7.49) | 30.83 | (7.18) | 28.68 | (7.49) | .394 | .178 |
| BP | 91.15 | (24.51) | 95.94 | (22.67) | 99.00 | (24.87) | .689 | .393 |
| PU | 29.31 | (11.74) | 25.63 | (10.30) | 24.00 | (11.45) | .447 | .215 |
| SR | 35.12 | (7.21) | 31.63 | (8.21) | 36.63 | (7.98) | .203 | .613 |

**Note:** Values reported as means (SD). Omnibus test is for one-way analysis of variance (ANOVA). Trend test is for ANOVA linear contrasts. Means with same lettered superscript are significantly different by Fisher's LSD. 1$^{st}$ tertile corresponds to the lowest 33.3% of individuals in terms of BC score. † This fitness measure showed significant ($p<.05$) quadratic trend across tertiles.

**Table 4:** Fitness scores across body composition (BC) tertiles for all participants (N=131).

| Measure | Body Composition (BC) Tertile | | | | | | Omnibus | Trend |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | *P* | *P* |
| BMI ($kg/m^2$) | | | | | | | | |
| $VO2_{max}$ | 54.27[a] | (9.82) | 51.22[b] | (9.42) | 44.61[a,b] | (8.22) | <.001 | .001 |
| BP | 45.63[a,b] | (6.84) | 50.33[b] | (9.35) | 53.94[a] | (11.48) | <.001 | .001 |
| PU | 51.23 | (10.43) | 51.42 | (9.52) | 47.38 | (9.63) | .100 | 071 |
| SR | 49.74 | (10.38) | 48.65 | (10.25) | 51.60 | (9.23) | .378 | 387 |
| SF (%) | | | | | | | | |
| $VO2_{max}$ | 55.43[a] | (8.99) | 52.23[b] | (8.74) | 42.47[a,b] | (7.22) | <.001 | .001 |
| BP | 49.91 | (9.66) | 50.66 | (9.95) | 49.43 | (10.44) | .844 | 822 |
| PU | 53.89[a] | (10.19) | 49.86 | (9.41) | 46.33[a] | (9.01) | .002 | 001 |
| SR | 50.68 | (8.69) | 51.25 | (11.63) | 48.08 | (9.23) | .286 | 226 |
| CM (%) | | | | | | | | |
| $VO2_{max}$ | 55.13[a] | (10.09) | 50.24[a] | (8.23) | 44.74[a] | (8.84) | <.001 | <.001 |
| BP | 47.26[a] | (9.31) | 51.45[a] | (7.96) | 51.22 | (11.87) | .088 | 063 |
| PU | 53.63[a] | (10.41) | 49.79 | (9.35) | 46.66[a] | (9.06) | .004 | .001 |
| SR | 50.50 | (9.55) | 50.81 | (9.70) | 48.70 | (10.69) | .568 | .402 |
| HH (%) | | | | | | | | |
| $VO2_{max}$ | 55.94[a] | (9.25) | 50.52[a] | (8.27) | 43.55[a] | (8.28) | <.001 | .001 |
| BP | 48.16 | (7.58) | 51.86 | (11.05) | 50.02 | (10.78) | .225 | .383 |
| PU | 53.36[a] | (10.03) | 51.69[b] | (9.74) | 44.99[a,b] | (8.16) | <.001 | <.001 |
| SR | 50.99 | (9.36) | 51.83[a] | (10.98) | 47.22[a] | (9.08) | .069 | .075 |
| WC (cm) | | | | | | | | |
| $VO2_{max}$ | 54.77[a] | (9.76) | 49.97[a] | (9.20) | 45.37[a] | (8.81) | <.001 | <.001 |
| BP | 46.79[a] | (7.59) | 50.34 | (10.14) | 52.80[a] | (11.06) | .017 | .005 |
| PU | 52.18[a] | (9.95) | 51.19[b] | (9.68) | 46.68[a,b] | (9.59) | .021 | .009 |
| SR | 49.78 | (9.57) | 49.90 | (10.23) | 50.32 | (10.29) | .965 | .801 |

**Note:** Measures in this table were first T-score transformed to control for sex. Values reported as means (SD). Omnibus test is for one-way analysis of variance (ANOVA). Trend test is for ANOVA linear contrasts. Means with same lettered superscript are significantly different by Fisher's LSD. 1st tertile corresponds to the lowest 33.3% of individuals in terms of BC score.

## Discussion

The purpose of this study was to examine the extent to which BC relates to FP in college students. The results clearly support that ranked BC groups (tertiles) can predict the performance of certain health-related fitness tests. In the overall analysis, including both sexes, over half of the omnibus ANOVA models indicated significant performance differences across tertiles. Each of these models, as well, showed a significant linear trend (i.e., as BC changed, so did FP). The most consistent finding, in the overall analysis, was that BC had an indirect relationship with VO2max, across all five BC methods. These results are consistent with the current exercise science knowledge. That is, individuals with greater PBF and larger BMI values, are likely to have larger body mass. Additionally, individuals with larger body mass, are more likely to perform poorer on cardiorespiratory tests as compared to their smaller body mass counterparts [25].

These findings, however, were less consistent in other fitness tests and other BC methods. BMI and WC were the only BC measures that predicted BP performance in the overall analysis. This relationship also showed a direct linear trend (i.e., as BC increased, so did FP). These findings would appear to make sense, in that, larger individuals with greater body mass would be more capable of lifting heavier loads. Additionally, the PBF methods of BC assessment may be less predictive of BP performance because low PBF can be seen in both anaerobically fit (i.e., weight trained) and aerobically fit (i.e., runners) individuals [26]. In terms of overall ME, all BC measures except for BMI indirectly predicted PU performance. Similarly, these finding may be explained by the fact that any PU test performance is to some degree a function of an individual's body weight. That is, individuals with larger body mass have to push downward with a greater force, creating a bias toward lighter individuals performing better. Finally, overall, BC was not predictive of SR performance in any BC assessment method. These findings are less understood in the exercise sciences, however, similar findings have been reported [27].

There were several differences in the BC and FP relationship seen between the sex groups. Most noteworthy was the three negative quadratic trends seen in the female SF, CM, and HH BC methods with PU performance. Each of these outcomes showed the middle BC tertile as the highest PU performing group. This would indicate that relatively low and high PBF is a disadvantage in terms of ME among females. This may be explained by considering two different factors. One, the absolute amounts of lean mass seen on females in the first tertile may be much lower than that seen in the other tertiles. Therefore, less muscles mass would suggest lower performing PU scores. Two, as mentioned above, the PU test itself may be biased against heavier individuals. Given these two possible explanations, the middle tertile may consist of females with just enough muscle mass and just the right body mass to perform well on ME events.

The most significant limitation of this study is its cross-sectional design. Cross-sectional designs are a result of collecting data at one point in time [28]. Therefore, it is not possible to generalize any cause-and-effect relationships from these findings. That is, it is not correct to infer in any way that changing a college student's BC (from any assessment method) will change their performance on any fitness test. It is suggested, that a longitudinal research design be implemented, in order to study such cause-and-effect associations.

## Conclusions

Results from this study show clear differences in FP across ranked BC groups. Furthermore, these differences were not consistent across BC method and not consistent across sex groups. Practitioners using BC data to predict FP should be aware of these inconsistencies.

## References


1. Baechle TR, Earle RW. National Strength & Conditioning Association (US). Essentials of strength training and conditioning. Champaign, IL: Human Kinetics. 2008, 395-6.
2. Miller TA, White ED, Kinley KA, Congleton JJ, Clark MJ. The effects of training history, player position, and body composition on exercise performance in collegiate football players. Journal of strength and conditioning research/National Strength & Conditioning Association. 2002; 16(1):44-9.
3. Nikolaidis PT, Asadi A, Santos EJ, Calleja-González J, Padulo J, Chtourou H, Zemkova E. Relationship of body mass status with running and jumping performances in young basketball players. Muscles, ligaments and tendons journal. 2015; 5(3):187.
4. Taylor LW, Wilborn C, Roberts MD, White A, Dugan K. Eight weeks of pre-and postexercise whey protein supplementation increases lean body mass and improves performance in Division III collegiate female basketball players. Applied Physiology, Nutrition, and Metabolism. 2015; 41(3):249-54.
5. Roelofs EJ, Smith-Ryan AE, Trexler ET, Hirsch KR. Seasonal effects on body composition, muscle characteristics, and performance of collegiate swimmers and divers. Journal of athletic training. 2017; 52(1):45-50.
6. Cochrane KC, Housh TJ, Smith CM, Hill EC, Jenkins ND, Johnson GO, *et al*. Relative contributions of strength, anthropometric, and body composition characteristics to estimated propulsive force in young male swimmers. The Journal of Strength & Conditioning Research. 2015; 29(6):1473-9.
7. Carvajal W, Ríos A, Echevarría I, Martínez M, Miñoso J, Rodríguez D. Body type and performance of elite Cuban baseball players. MEDICC review. 2009; 11(2):15-20.
8. Rossi FE, Landreth A, Beam S, Jones T, Norton L, Cholewa JM. The Effects of a Sports Nutrition Education Intervention on Nutritional Status, Sport Nutrition Knowledge, Body Composition, and Performance during Off Season Training in NCAA Division I Baseball Players. Journal of sports science & medicine. 2017; 16(1):60.
9. Ratamess NA, Hoffman JR, Kraemer WJ, Ross RE, Tranchina CP, Rashti SL, Kelly NA, Vingren JL, Kang J, Faigenbaum AD. Effects of a competitive wrestling season on body composition, endocrine markers, and anaerobic exercise performance in NCAA collegiate wrestlers. European journal of applied physiology. 2013; 113(5):1157-68.
10. Kern BD, Robinson TL. Effects of β-alanine supplementation on performance and body composition in collegiate wrestlers and football players. The Journal of Strength & Conditioning Research. 2011; 25(7):1804-15.
11. Mielgo-Ayuso J, Zourdos MC, Calleja-González J, Urdampilleta A, Ostojic SM. Dietary intake habits and controlled training on body composition and strength in elite female volleyball players during the season. Applied Physiology, Nutrition, and Metabolism. 2015; 40(8):827-34.
12. CopiC N, Dopsaj M, IvanoviC J, NešiC G, JariC S. Body composition and muscle strength predictors of jumping performance: differences between elite female volleyball competitors and nontrained individuals. The Journal of Strength & Conditioning Research. 2014; 28(10):2709-16.
13. Jang JH, Jee YS, Oh HW. Frequency-effect of playing screen golf on body composition and golf performance in middle-aged men. Journal of exercise rehabilitation. 2014; 10(5):271.
14. Garber CE, Glass SC. ACSM's resource manual for guidelines for exercise testing and prescription. L. A. Kaminsky, & K. A. Bonzheim (Eds.). Baltimore, MD: Lippincott Williams & Wilkins, 2006.
15. Hodgdon JA, Beckett MB. Prediction of percent body fat for US Navy women from body circumferences and height. Naval Health Research Center San Diego Ca, 1984.
16. Hodgdon JA, Beckett MB. Prediction of percent body fat for US Navy men from body circumferences and height. Naval Health Research Center San Diego Ca, 1984.
17. Omron Fat Loss Monitor. Model HBF-306C. Omron Healthcare Co., Ltd, 2012.
18. American College of Sports Medicine. ACSM's guidelines for exercise testing and prescription. Lippincott Williams & Wilkins, 2013.
19. American College of Sports Medicine, editor. ACSM's health-related physical fitness assessment manual. Lippincott Williams & Wilkins, 2013.
20. McArdle WD, Katch FI, Katch VL. Exercise physiology: nutrition, energy, and human performance. Lippincott Williams & Wilkins, 2010.
21. Haff G, Triplett NT. Essentials of strength training and conditioning. 4th edition. Human Kinetics, 2016.
22. Tabachnick BG, Fidell LS. Using multivariate statistics, 5th. Needham Height, MA: Allyn & Bacon, 2007.
23. Cody RP, Smith JK. Applied statistics and the SAS programming language. 5th Edition. Pearson, 2006.
24. Centers for Disease Control and Prevention (CDC. Vital signs: state-specific obesity prevalence among adults---United States, 2009. MMWR. Morbidity and mortality weekly report. 2010; 59(30):951.
25. Raven P, Wasserman D, Squires W, Murray T. Exercise Physiology. Nelson Education, 2012.
26. Richens B, Cleather DJ. The relationship between the number of repetitions performed at given intensities is different in endurance and strength trained athletes. Biology of sport. 2014; 31(2):157.
27. Arslan E, Yilmaz I, Aras Ö. Relationship between body composition and flexibility in elite female basketball players and women who regularly exercise for fitness: A pilot study. Fizyoterapi Rehabilitasyon. 2009; 20:83-88.
28. Matthews TD, Kostelis KT. Designing and conducting research in health and human performance. John Wiley & Sons; 2011.