The relationships of waist and mid-thigh circumference with performance of college golfers

Seungbum Son, PhD1), Kunho Han1), Wi-Young So, PhD2)*

1) Golf Teaching Major, College of Science and Technology, Konkuk University, Republic of Korea
2) Sports and Health Care Major, College of Humanities and Arts, Korea National University of Transportation: 50 Daehak-ro, Chungju-si, Chungbuk 380-702, Republic of Korea

Abstract. [Purpose] Our aim was to evaluate the relationships between waist and mid-thigh circumference, used as proxy measures of trunk and lower limb strengths, respectively, and selected parameters of driver and putting performance in Korean college golfers. [Subjects and Methods] The participants were 103 college golfers (81 male, 20 to 27 years old). Measurements of body composition, waist and mid-thigh circumference, and grip strength, as well as assessment of golf performance, including driver distance, driver swing speed, putting accuracy, and putting consistency, were performed at the golf performance laboratory at Konkuk University in Chungju-si, Republic of Korea. Average round score was obtained from 10 rounds of golf completed during the study period. The relationships between strength measures and golf performance were evaluated by partial correlation analysis, with adjustment for age, golf experience, and body mass index. [Results] Waist circumference did not correlate with any of the performance variables in both males and females. Mid-thigh circumference correlated with putting consistency (r = 0.364) in males and with putting consistency (r = 0.490) and accuracy (r = 0.547) in females. No other significant correlations between waist and mid-thigh circumference and golf performance were identified. [Conclusion] Lower limb strength may be an important component of putting performance. Further studies are needed to fully characterize the contributions of trunk strength to performance.

Key words: Golf performance, Mid-thigh circumference, Waist circumference

INTRODUCTION

Improving golf performance has been a focus of research and development across various fields of sport expertise, including material engineering1), golf course design2), and sport exercise and training3–6). Performance in golf, as with other infield sports, such as baseball, for which concentration is required for accurate performance, has been shown to be closely related to physical conditioning4). A high level of fitness is also an essential component for injury prevention in these sports7). Therefore, many studies are aiming to evaluate muscle strength and aerobic and anaerobic fitness levels in expert golfers.

As the strength of a muscle is closely related to its cross-sectional area, in both health and disease8–10), circumference measurements are commonly used as a proxy index of strength. As an example, measurements of the circumferences of the waist and mid-thigh have been used as proxy indexes of changes in trunk and lower limb strengths as indexes of changes in chronic diseases, such as diabetes and hypertension9–12). Another recent study reported a positive correlation between mid-thigh circumference and cardiovascular fitness13). Based on this evidence, it is reasonable to predict a positive relationship between mid-thigh circumference and lower limb muscle strength. Thus, the mid-thigh circumference may be useful for evaluating the contribution of lower limb strength to golf performance. In a similar fashion, we predicted that waist circumference can be used to evaluate the contribution of trunk strength to golf performance. Therefore, the aim of this study was to evaluate...
the relationships between waist and mid-thigh circumference, used as proxy measures of trunk and lower limb strengths, respectively, and selected parameters of driver and putting performance in college golfers in Korea.

**SUBJECTS AND METHODS**

The participants were 103 college golfers (males, 81) aged 20 to 27 years. All anthropometric measures and assessment of golf performance were conducted at the golf performance laboratory at Konkuk University in Chungju-si, Republic of Korea. The study conformed to the principles outlined in the Declaration of Helsinki and received clearance from the Institutional Review Board of the Korea National University of Transportation (KNUT IRB-14). All participants provided informed consent.

The following anthropometric measures were obtained for all participants: body weight and percent body fat, which together provide an index of body composition, basal metabolic rate, grip strength, and waist and mid-thigh circumference. The following selected variables of golf performance were measured: average round score, driver distance, driver swing speed, putting accuracy, and putting consistency.

Body composition (i.e., percent body fat and basal metabolic rate) was measured using standard impedance methods (InBody 570, Biospace, Seoul, Republic of Korea), based on the recommendations of the book *Applied Body Composition* (SPSS Inc., Chicago, IL, USA), with the mean of 10 trials used for analysis for each variable. Putting accuracy and putting consistency were calculated using a Sam PuttLab (Sam PuttLab, ver. 2010, Science & Motion Sports GmbH, Ruesselsheim, Germany) with the mean percentage (%) used for analysis. Waist and mid-thigh circumference were obtained by measuring tape (cm). Measurements of waist circumference were obtained at the half-distance between the lower costal margin and the iliac crest, with the participants standing with their feet 25 cm apart. Mid-thigh circumference was measured at the half-distance between the greater tuberosity and the lateral condyle of the femur. For all measurements, the tape was held snugly to the limb, without compressing any underlying soft tissues.

Measurements are presented as the mean ± standard deviation. The relationships between the circumference of the waist and mid-thigh and measured performance variables were evaluated by partial correlation analysis, adjusting for effects of age, golf career, and BMI. Statistical significance was set at p < 0.05. All analyses were performed using SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA).

**RESULTS**

The characteristics of the subjects are presented in Table 1. The results of the partial correlation coefficient analyses between waist and mid-thigh circumference and measured outcome variables of golf performance are reported in Table 2. Waist circumference did not correlate with any of the performance variables in both males and females (p > 0.05). Mid-thigh circumference correlated with putting consistency (r = 0.364, p = 0.001) in males and with putting consistency (r = 0.490, p = 0.033) and accuracy (r = 0.547, p = 0.015) in females. No other significant correlations between waist and mid-thigh circumference and golf performance were identified (p > 0.05).

**DISCUSSION**

The purpose of this study was to examine the relationships between waist and mid-thigh circumference and sport performance of Korean college golfers. A significant association between mid-thigh circumference and putting performance was identified, for both males and females. As we had predicted *a priori*, a direct relationship between driver distance and swing speed and the circumference of the waist or mid-thigh was not identified. This absence of a specific relationship between waist and mid-thigh circumference and driver performance likely indicates the importance of the whole body’s contribution to driving the ball, including the trunk, legs, and arms, in combination with the characteristics of the golf club and overall motor control.

The relationship between mid-thigh circumference and putting performance may reflect the specific importance of lower limb strength and stability to putting. The possible role of lower limb strengthening in improving putting performance is meaningful to the development of golfers, as lower limb strength is likely to be of benefit to overall performance in the short
game around the green. While driver distance is an important component of golfing, short-game performance contributes significantly to the overall golf score.\textsuperscript{16) Biomechanical and controlled studies are required to fully characterize the relationship between lower limb strength and golf performance, as well as to evaluate the role of lower limb strengthening in the training of golfers.

The limitations of our study should be noted in the interpretation of outcomes. First and foremost, the participants were recruited from only one university in Chungju-si, Republic of Korea, and therefore may not be fully representative of all college golfers in Korea. As well, the standard deviations for some variables were high within our relatively small group of participants, which could limit identification of statistical significance. Therefore, while our results provide evidence of a possible role of lower limb strength on putting performance, further studies are needed to fully characterize the contributions of trunk and lower limb strengthening to performance of expert college golfers.

Table 1. Characteristics of the study group

| Variables                        | Male (n = 81)       | Female (n = 22)      | Total (n = 103)      |
|----------------------------------|---------------------|----------------------|----------------------|
| Age (years)                      | 22.4 ± 2.1          | 21.7 ± 1.4           | 22.2 ± 2.0           |
| Golf career (years)              | 6.1 ± 3.4           | 6.6 ± 3.3            | 6.2 ± 3.4            |
| Height (cm)                      | 176.7 ± 5.6         | 162.6 ± 4.7          | 173.7 ± 7.9          |
| Weight (kg)                      | 78.6 ± 17.3         | 60.2 ± 10.4          | 74.7 ± 17.7          |
| Body mass index (kg/m\textsuperscript{2}) | 25.1 ± 4.9         | 22.7 ± 3.0           | 24.6 ± 4.6           |
| Basal metabolic rate (kcal)      | 1,708.8 ± 133.6     | 1,288.0 ± 91.5       | 1,618.9 ± 213.9      |
| Body fat (%)                     | 19.2 ± 7.0          | 28.4 ± 6.4           | 21.2 ± 7.8           |
| Grip strength (kg)               | 44.7 ± 6.8          | 27.6 ± 4.9           | 41.1 ± 9.5           |
| Average round score (stroke)     | 83.2 ± 6.2          | 83.0 ± 5.3           | 83.1 ± 6.0           |
| Driver distance (yards)          | 257.1 ± 28.9        | 192.6 ± 21.8         | 243.3 ± 38.2         |
| Driver swing speed (mph)         | 103.7 ± 7.6         | 84.7 ± 5.6           | 99.6 ± 10.6          |
| Putting accuracy (%)              | 73.3 ± 26.6         | 78.6 ± 18.0          | 74.5 ± 25.1          |
| Putting consistency (%)           | 87.4 ± 13.7         | 89.5 ± 10.6          | 87.9 ± 13.1          |
| Waist circumference (cm)          | 85.5 ± 11.7         | 75.8 ± 8.0           | 83.4 ± 11.7          |
| Mid-thigh circumference (cm)      | 57.7 ± 5.7          | 51.2 ± 6.0           | 56.3 ± 6.3           |

Data are presented as the mean ± SD

Table 2. Partial correlation analysis between measured variables of golf performance and the circumferences of the waist and mid-thigh

| Variables                        | Male (n = 81)       | Female (n = 22)      |
|----------------------------------|---------------------|----------------------|
| WC (cm)                           | Grip strength       | 0.062                | <0.001               |
|                                  | Average round score | 0.100                | 0.023                |
|                                  | Driver distance     | 0.018                | 0.252                |
|                                  | Driver swing speed  | 0.012                | 0.235                |
|                                  | Putting accuracy     | 0.001                | −0.027               |
|                                  | Putting consistency  | 0.067                | 0.165                |
|                                  | Grip strength       | −0.034               | −0.287               |
|                                  | Average round score | −0.084               | −0.093               |
|                                  | Driver distance     | 0.137                | 0.197                |
|                                  | Driver swing speed  | 0.130                | 0.162                |
|                                  | Putting accuracy     | 0.205                | 0.547*               |
|                                  | Putting consistency  | 0.364**              | 0.490*               |

| Variables                        | Male (n = 81)       | Female (n = 22)      |
|----------------------------------|---------------------|----------------------|
| WC (cm)                           | Grip strength       | 0.062                | <0.001               |
|                                  | Average round score | 0.100                | 0.023                |
|                                  | Driver distance     | 0.018                | 0.252                |
|                                  | Driver swing speed  | 0.012                | 0.235                |
|                                  | Putting accuracy     | 0.001                | −0.027               |
|                                  | Putting consistency  | 0.067                | 0.165                |
|                                  | Grip strength       | −0.034               | −0.287               |
|                                  | Average round score | −0.084               | −0.093               |
|                                  | Driver distance     | 0.137                | 0.197                |
|                                  | Driver swing speed  | 0.130                | 0.162                |
|                                  | Putting accuracy     | 0.205                | 0.547*               |
|                                  | Putting consistency  | 0.364**              | 0.490*               |

*p < 0.05 and **p < 0.01; tested by partial correlation analysis after adjusted age, golf career, and body mass index. WC: waist circumference; MC: mid-thigh circumference
ACKNOWLEDGEMENT

This paper was supported by Konkuk University in 2016.

REFERENCES

1) Roach RL: Iron golf club with improved mass properties and vibration damping. J Acoust Soc Am, 2012, 132: 643. [CrossRef]
2) Baris RD, Cohen SZ, Barnes NL, et al.: Quantitative analysis of over 20 years of golf course monitoring studies. Environ Toxicol Chem, 2010, 29: 1224–1236. [Medline]
3) Coleman SG, Rankin AJ: A three-dimensional examination of the planar nature of the golf swing. J Sports Sci, 2005, 23: 227–234. [Medline] [CrossRef]
4) Doan BK, Newton RU, Kwon YH, et al.: Effects of physical conditioning on intercollegiate golfer performance. J Strength Cond Res, 2006, 20: 62–72. [Medline]
5) Stevenson EJ, Hayes PR, Allison SJ: The effect of a carbohydrate-caffeine sports drink on simulated golf performance. Appl Physiol Nutr Metab, 2009, 34: 681–688. [Medline] [CrossRef]
6) Lee JC, Lee SW, Yeo YG, et al.: Effects of special composite stretching on the swing of amateur golf players. J Phys Ther Sci, 2015, 27: 1049–1051. [Medline] [CrossRef]
7) Grimshaw PN, Burden AM: Case report: reduction of low back pain in a professional golfer. Med Sci Sports Exerc, 2000, 32: 1667–1673. [Medline] [CrossRef]
8) Maughan RJ, Watson JS, Weir J: Strength and cross-sectional area of human skeletal muscle. J Physiol, 1983, 338: 37–49. [Medline] [CrossRef]
9) Kim D, Nam S, Ahn C, et al.: Correlation between midhigh low-density muscle and insulin resistance in obese non-diabetic patients in Korea. Diabetes Care, 2003, 26: 1825–1830. [Medline] [CrossRef]
10) Aasen G, Fagertun H, Tonstad S, et al.: Leg fat mass as measured by dual X-ray absorptiometry (DXA) impacts insulin resistance differently in obese women versus men. Scand J Clin Lab Invest, 2009, 69: 181–189. [Medline] [CrossRef]
11) Yoon JH, So WY: Relationship between hypertension status and physical fitness, including cardiovascular function, in Korean men. J Men's Health, 2013, 10: 28–36. [CrossRef]
12) Kim JH, So WY: Associations between weight status and different types of physical fitness variables in Korean men: a community-based study. J Men's Health, 2013, 10: 60–64.
13) Ko SS, Chung JS, So WY: Correlation between waist and mid-thigh circumference and cardiovascular fitness in Korean college students: a case study. J Phys Ther Sci, 2015, 27: 3019–3021. [Medline] [CrossRef]
14) Heyward VH, Wagner DR: Applied body composition assessment, 2nd ed. Human Kinetics, 2004.
15) Jensky-Squires NE, Dieli-Conwright CM, Rossuello A, et al.: Validity and reliability of body composition analysers in children and adults. Br J Nutr, 2008, 100: 859–865. [Medline] [CrossRef]
16) Son SB: The study of performance factors for effective sponsorship determination of golf players. Korean J Phys Educ, 2010, 49: 227–236 (in Korean).