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Original Article

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

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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

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INTRODUCTION

Improving golf performance has been a focus of research and development across various fields of sport expertise, including material engineering[1)], golf course design[2)], and sport exercise and training[3–6)]. 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 conditioning[4)]. A high level of fitness is also an essential component for injury prevention in these sports[7)]. 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 disease[8–10)], 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 hypertension[9–12)]. Another recent study reported a positive correlation between mid-thigh circumference and cardiovascular fitness[13)]. 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

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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 measurements 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 Assessment*[14]. The resistance values of the arms, trunk, and legs were measured at frequencies of 1, 5, 50, 256, 512, and 1,024 kHz, using 8 tactile electrodes, 2 in contact with the palm and thumb of each hand, and 2 in contact with the anterior and posterior aspects of the sole of each foot[15]. Prior to impedance measurement, participants were instructed to not consume any drink or food for 4 h, to not exercise for 12 h, and to not urinate immediately before testing. Participants wore light clothing, and all metal items, which could interrupt the electronic current during the measurement, were removed. The body mass index (BMI) for each participant was calculated as weight (kg) divided by height (m) squared (kg/m^2). Grip strength was measured with a hand grip dynamometer (GRIP-D, Takei, Japan), with the elbow in the extended position. The peak value obtained over 3 trials, recorded to the nearest tenth of a kg, was used for analysis. The average round score (i.e., number of strokes in a round) was determined from 10 rounds of golf played during the study period. Driver distance (yards) and swing speed (mph) were recorded using a FlightScope X2 golf simulator (FlightScope X2, ver. 8.0.6, FlightScope, Orlando, FL, 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

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^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)
		r	r
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
MC (cm)	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

game around the green. While driver distance is an important component of golfing, short-game performance contributes significantly to the overall golf score[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.

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