# Demographic and Anthropometric Factors Predicting the Grip Strength and Endurance in Adolescent Tennis Players

## Adolesan Tenis Oyuncularında Kavrama Kuvveti ve Dayanıklılığı Etkileyen Demografik ve Antropometrik Faktörler

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**ABSTRACT Objective:** Grip strength and endurance is an important indicator of performance in tennis sport. The aim of this study was to determine the demographic and anthropometric predictors of handgrip strength and endurance in adolescent tennis players. **Material and Methods:** Ninety-eight tennis players (62 boys-36 girls, age: 12.27±1.85 years) who had more than 1 year of playing tennis participated in the study. Height and body weight were measured and body mass index (BMI kg/m2) was calculated. A computerised digital handgrip analyser was used to measure the maximal grip strength and endurance. Data were analysed using a stepwise forward multiple regression analysis. **Results:** Means of the maximum grip strength and endurance were measured as 19.8 kg (95% CI: 18.5 to 21.1) and 22.5 kg (95% CI: 20.9 to 24.1), respectively. Analysis of the data revealed that height was the primary independent correlate of grip strength, explaining 44% of the total variance in dominant handgrip strength ($R^2$=0.44, p<0.01). Forty-eight percent of the total variance in dominant handgrip endurance was explained by body weight ($R^2$=0.48, p<0.01). **Conclusion:** The results of this study indicate that cofactors such as gender, age, height, body weight and BMI provided a highly accurate prediction of grip strength and endurance. This study can be used in a practical application in sports anthropometry for the selection of talents in tennis.

**Key Words:** Hand strength; endurance; tennis; adolescent

**ÖZET Amaç:** Kavrama kuvveti ve dayanıklılık tenis sporunda performansın önemli göstergelerindendir. Bu çalışmanın amacı, adölesan tenis oyuncularında kavrama kuvveti ve dayanıklılığı etkileyen demografik ve antropometrik faktörleri belirlemektir. **Gereç ve Yöntemler:** Bu çalışmaya 1 yıldan fazla süredir düzenli tenis oynayan 98 tenis oyuncusu (62 erkek-36 kız, yaş: 12,27±1,85 yıl) dahil edildi. Boy uzunluğu, vücut ağırlığı ölçüldü ve beden kitle indeksi (BKİ kg/$m^2$) hesaplandı. Maksimal kavrama kuvveti ve dayanıklılığı bilgisayarla monitorize dijital kavrama analiz cihazı ile değerlendirildi. Verilerin analizinde çoklu regresyon analizi kullanıldı. **Bulgular:** Ortalama kavrama kuvveti ve dayanıklılığı 19,8 kg (%95 güven aralığı: 18,5 ile 21,1) ve 22,5 kg (%95 güven aralığı: 20,9 ile 24,1) ölçüldü. Verilerin analiz sonuçlarına göre, boy uzunluğu kavrama kuvvetini etkileyen birincil faktördür ($R^2$=0,44, p<0,01). Vücut ağırlığı ise dayanıklılığı etkileyen en önemli faktör olarak bulundu ($R^2$=0,48, p<0,01). **Sonuç:** Yapılan bu çalışmanın sonucunda cinsiyet, yaş, boy uzunluğu, vücut ağırlığı ve BKİ gibi kofaktörlerin kavrama kuvveti ve dayanıklılığı etkilediği bulundu. Bu sonuçlara göre, adolesanların tenis sporuna yönlendirilmesinde spor antropometrisi pratik bir uygulama olarak kullanılabilir.

**Anahtar Kelimeler:** Kavrama kuvveti; kassal dayanıklılık; tenis; adolesan

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Handgrip strength can be defined as the muscular strength and force that strength athletes can generate with their hands. Handgrip is an important component of the strength for some sports such as, rock climbing, tennis, volleyball and baseball.[1-4] Grip strength has often been used

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as an indicator of overall physical strength, health, performance of hand and forearm muscles, and nutritional status.[5-7] In addition, grip strength measurements were included in the several motor ability test batteries, which are recommended for demonstrating physical fitness of children.[8,9] Grip strength is a physiological variable which is affected by number of factors including age, gender, hand dominance, motivation and position of extremity during test.[9-14] Despite the grip strength is extremely important for understanding the physical development of adolescents, most of the previous studies emphasized grip strength only for adults.[15-18]

Isometric muscular endurance is known as the ability to sustain a percentage of the maximal isometric strength for a certain time. Using the state of the art technologies such as electronic dynamometers, which enable the continuous monitoring and quantification of muscular force throughout repetitive and static activities, it is possible to accurately analyse the grip endurance. Handgrip strength and endurance is required for various movements such as serves, forehand and backhand strikes in tennis, which indicates the assessment of handgrip strength is an important issue for tennis players.[2,19] Although there are many studies explaining the importance of the grip strength, there is no study explaining the effect of grip endurance for tennis performance. In addition, there are a few studies investigating the grip endurance.[20,21] To our knowledge, this is the first study that examining the grip endurance and its demographic, anthropometric predictors in adolescent tennis players.

In this study, we investigated demographic and basic anthropometric predictors of handgrip strength and endurance in adolescent tennis players. We hypothesized that basic anthropometric variables are better predictors of handgrip strength and endurance when compared to demographic variables in adolescent tennis players.

## MATERIAL AND METHODS

98 consecutive tennis players were included from the Ankara Tennis Club. Criteria of being a subject in our study are that to have no pain or disability in the upper extremities as well as to be played tennis regularly at least for one year. The tennis players were involved in at least three tennis practices per week (6 h per week) at least for one year, which covers a regular tennis training and physical conditioning training including co-ordination, speed and strength exercises. The strength training was focused on preventive neuromuscular control (functional stabilization training), strength training techniques and core strength. The study was approved by Hacettepe University Faculty of Medicine, Medical, Surgical, and Drug Research Ethical Board (HEK 09/133). A written informed consent was obtained from all participants or the participant's legal guardians. The sample size was estimated based on statistical considerations.[22] According to Tabachnick and Fidell, a rule of thumb for testing R-square ($R^2$) is to have $N >= 50 + 8m$, where m = number of independent variables.[22] Thus, a minimum sample size of 90 is required for the study. Possible predicting factors for the grip strength and endurance were identified using a forward stepwise model. The following independent variables were used to predict the grip strength and grip endurance: Age, gender, height, body weight, and body mass index (BMI) of subjects.

We used a socio-demographic questionnaire in order to establish the descriptive characteristics of the study population. The grip strength and endurance was measured using MIE Digital Grip analyser (MIE Medical Research Ltd, Leeds, UK), which is adjustable to accommodate all hand sizes, and made of a special lightweight, stiff aerospace alloy. A digital display unit attached to the dynamometer and connected to a PC was used for real time monitoring of subject's biofeedback. Data collection and arrangements were executed using WinCAS software (Copyright 2002 MIE Medical Research Ltd.). All subjects were tested after 3 minutes of independent warm-up.

Maximal isometric grip strength and grip endurance tests were sequentially conducted for the each hand of the subjects. The subjects performed two or three preliminary trials for familiarization with the recording procedure and the instrument. All tests were administered between 9 and 12 a.m before exercise time of the players. The test was performed in the sitting position while the shoul-

der of the tested arm was adducted, the elbow was flexed at 90°, the forearm and wrist were set in neutral position.[21] Each subject was completed all tests in the following order: dominant hand maximal isometric grip strength, the other hand maximal isometric grip strength, dominant hand grip endurance and the other hand grip endurance.

For a maximal isometric grip strength test, subjects were encouraged to perform maximal contractions successively three times with 5 seconds duration and 2 seconds interval. Verbal encouragements were performed for increasing motivation of the tested subjects. The average of the three measurements was calculated and results were recorded in kilograms. The dynamometer is calibrated before each measurement.

The grip endurance tests were started with measuring the participant's maximal isometric grip strength. A force equivalent to 50% of the maximal force was taken into consideration and monitored by MIE instrument. The subjects were then instructed to squeeze the handle until they reached a level within the range of 45-55% of their own maximal force and to hold the handle at this level as long as possible.

The Statistical Package for the Social Sciences (SPSS for Windows 13.0) was used to perform data analyses. Characteristics of the participants were summarized with descriptive statistics, including frequencies, percentages, means, and standard deviations (SD). The regression coefficients and $R^2$ values were computed by stepwise forward multiple regression procedure. Height, weight, BMI, gender and age variables were used as independent variables for the regression. A p-value less than 0.05 were considered as significant in all of the statistical analyses.

## RESULTS

A brief literature review reveals that there is a statistically significant difference between dominant and non-dominant hands on hand grip strength.[23,24] In our study population, 92 participants were right hand dominant and 5 were left hand dominant. To avoid confounding, we did not included left hand dominant participants in regression analyses and one of the participants could not have completed the data sets available for the final statistical analysis.

The demographic and clinical characteristics of the study population were presented on Table 1. The mean of the maximum grip strength and endurance were measured as 19.8 kg (95% CI: 18.5 to 21.1) and 22.5 kg (95% CI: 20.9 to 24.1), respectively.

A stepwise forward multiple regression analysis was conducted among predictors of the grip strength. The height was the primary independent correlate of the grip strength, explaining 44% of the total variance in the dominant handgrip strength ($R^2$=0.44, P<0.01). Additional 6% and 2% of the variance were explained by gender ($R^2$=0.06, P<0.01), and by age ($R^2$=0.02, P<0.05), respectively. Any other variables wasn't observed as significant predictors of dominant handgrip strength (Table 2). 48% of the total variance in the dominant handgrip endurance was explained by the body weight ($R^2$=0.48, P<0.01). Smaller parts of the variance in the dominant handgrip endurance were explained by age ($R^2$=0.06, P<0.01) and by gender ($R^2$=0.01, P<0.05) (Table 3).

## DISCUSSION

The findings of this study indicate that body height is the best predictor of handgrip strength (44%, $R^2$ ×100) and grip endurance is influenced by body weight (48%, R2 ×100). Handgrip strength in adults correlated with such anthropometric characteristics as skeletal size, body height and body mass.[25,26] Similar to the adults among the basic anthropometric variables, body height was the strongest factor that influencing the handgrip strength in our adolescents (Table 2).[27] In addition, many researchers have studied effects of demographic and basic anthropomet-

**TABLE 1:** Demographic and clinical characteristics of the study population (N=92).

| Variables | Value |
|---|---|
| Age, mean (SD), years | 12.2 (1.8) |
| Gender-male, n (%) | 60 (65.2) |
| Height, mean (SD), cm | 154.9 (11.6) |
| Weight, mean (SD), kg | 46.5 (12.1) |
| BMI, mean (SD), kg/m$^2$ | 19.1 (2.7) |
| Dominant hand grip strength, mean (SD), kg | 19.8 (6.3) |
| Dominant hand grip endurance, mean (SD), kg | 22.5 (7.9) |

**TABLE 2:** Summary of the stepwise regression analysis for variables predicting the dominant hand's grip strength (N=92).

| | Model 1 | | | Model 2 | | | Model 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **B** | **SE B** | **B** | **B** | **SE B** | **B** | **B** | **SE B** | **β** |
| Height | 0.37 | 0.04 | 0.67** | 0.35 | 0.04 | 0.63** | 0.26 | 0.05 | 0.48** |
| Gender | | | | 3.29 | 0.99 | 0.25** | 3.28 | 0.97 | 0.25** |
| Age | | | | | | | 0.78 | 0.34 | 0.22* |
| Adjusted $R^2$ | | 0.44 | | | 0.50 | | | 0.52 | |
| P-value for F change | | 0.000 | | | 0.001 | | | 0.024 | |

*p < 0.05; ** p < 0.01.

**TABLE 3:** Summary of the stepwise regression analysis for variables predicting the dominant hand's grip endurance (N=92)

| | Model 1 | | | Model 2 | | | Model 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **B** | **SE B** | **B** | **B** | **SE B** | **B** | **B** | **SE B** | **β** |
| Weight | 0.46 | 0.05 | 0.70** | 0.33 | 0.06 | 0.51** | 0.31 | 0.06 | 0.47** |
| Age | | | | 1.37 | 0.39 | 0.32** | 1.39 | 0.38 | 0.32** |
| Gender | | | | | | | 2.50 | 1.18 | 0.15* |
| Adjusted $R^2$ | | 0.48 | | | 0.54 | | | 0.55 | |
| P-value for F change | | 0.000 | | | 0.001 | | | 0.038 | |

*p < 0.05; ** p < 0.01.

ric on handgrip strength and endurance for sport players. Indeed, there is also a strong correlation observed between basic anthropometric and handgrip strength and endurance in athletes. Fallahi et al. confirmed that body height is an important variable for handgrip strength in grip athletes.[28] Studies of Gerodimos et al. showed that a high correlation between handgrip strength and body height during the developmental years in wrestlers.[29] Because of that body height is directly related to the lean body mass, it was correlated with handgrip strength in our findings.[27] This association is probably due to the fact that the height is included in the denominator of the lean body mass formula. The influence of the age on the handgrip strength wasn't high. If we add the age to a stepwise multiple anthropometry model (age, body height, body weight), only the height and age together characterize the handgrip strength in the total group (46%, $R^2 \times 100$). This can be explained by the increment in the percentage of the muscle tissue with the rising age in adolescents as explained by Sartorio et al. for children.[30]

Among the demographic and anthropometric variables, the most important predictor of the grip endurance was the weight (Table 3). Nicolay et al. [20] indicated that in contrast to the grip strength, grip endurance couldn't be predicted by anthropometric measurements due to muscle physiology. Anthropometric variables that we selected were stronger predictors of handgrip endurance than the selected demographic variables (Table 3). The differences between studies can be explained by the effect of regular physical activities and training program of tennis players.[20] Greater weight, and grip endurance help the tennis players to generate more force in a game.

In summary, we attempted to determine the factors predicting handgrip strength and endurance in adolescent tennis players in this study. Our findings are consistent with similar grip strength predictors in adults and supportive of previous investigations that examined grip strength predicting in children.[15,27,30] We found that the height is the most limiting factor for the handgrip strength and grip endurance is influenced by body weight in adolescent tennis players. The limitation of the study was the lack of hand anthropometric measurements, which is one of the factors that affect the grip strength and endurance. These data serve to provide a descriptive profile of handgrip strength

and endurance in tennis players, to assist both coaches and health professionals for talent selection and development of training programs for performance enhancement and rehabilitation.

## CONCLUSION

This study can be utilized in some practical application in order to select talented young tennis players and monitoring the health and performance of the players. Grip strength and grip endurance is a key component to physical performance in many sports. Assessment of grip strength and endurance can provide the practitioner with a cost effective, non-invasive screening tool for evaluating well-being of players. The key finding of the present study is that grip strength and grip endurance in adolescents were influenced by anthropometric factors. Therefore, to predict the grip strength in adolescent, body height should be included and endurance body weight was the best predictors.

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