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Research Article

EVALUATION OF THE SOLDIER'S PHYSICAL FITNESS TEST RESULTS (STRENGTH ENDURANCE) IN RELATION TO ACE GENOTYPE

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Abstract

Purpose: The aim of this study was to reveal the relationship between the soldier's physical ability tests and the ACE gene variables as a criterion to be considered in the selection of operational duties and to provide positive contributions to the planning of soldiers' training loads or efforts, specific to the needs of the individual.
Methods: The study group consisted of 223 male subjects of non-elite Turkish army recruits. All subjects participating in the research study did not regularly deal with any sports activities as professionally, and homogenous working conditions were established by providing the same type of feeding, resting and loading parameters for the subjects in the camp center. The study group had undergone similar workout routine per day and 6 days a week for 12 weeks. Mean age of the subjects was 24 ± 1.7, body weight was 72 ± 2.5 kg, and height was 175 ± 1.4 cm. ACE gene polymorphisms were examined by PCR method.
Results: All ACE genotype groups except pull up for II and DD genotypes have shown significant improvements in the 12-week workout period as compared to the entry levels ($P < 0.05$). The dispersion of genotypes in the whole group was 15 % II, n = 32; 48.3 % ID, n = 105; 36.7 % DD, n = 76.
Conclusion: In this study, all three genotypes showed improvement in baseline and final values; It was evaluated that ID genotype has the significant difference among three genotypes in terms of push-up scores. On the other hand, the development in both DD and II genotypes was limited compared to ID genotype.

Keywords: *genetics, polymorphism, muscular endurance.*

Introduction

Genes are DNA sequences of varying lengths located on the chromosome that carries the hereditary characters of the cells, the codes of proteins, enzymes and other molecules necessary for their lives. They are also examining biochemical and physiological events and their progress in the right direction. The right sequence of genetic variables facilitates top-level development for a high level of physical performance.
The small changes in the information transmitted by the genes from the generation-to-generation are the differences between the individuals. The properties encoded in DNA sequences or chains that cause differences between individuals also define the limits of physical ability. The genetic heritage allows some to run for a long time, while causing fatigue for others due to the lack of oxygen in the muscles during running [1].
There are about 200 genes to be associated with athletic ability. The most studied gene related to athletic ability is the Angiotensin Converting Enzyme (ACE) gene. The ACE gene is responsible for the regulation of the blood pressure and body fluids. The level of plasma ACE is determined and controlled by the ACE gene.
A common mutation in the ACE gene is an insertion/deletion polymorphism at 287 base pairs. This polymorphism has DD, ID, and II alleles. The presence of the 287-bp fragment results in significant alterations in serum ACE levels-insertion (I allele) and absence-deletion (D allele) polymorphism. The lowest ACE levels were found in II genotypes while the highest ACE levels in serum and in the tissue [2] were found in the subjects with DD

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genotypes. It is assumed that ACE DD and II polymorphisms may explain why people respond differently to the same training workout.
Due to increased vasoconstriction in people with high ACE activity there is not enough blood flow to the muscle tissue. In this respect, the long duration endurance performance of such individuals is observed at low level; whereas short duration endurance performance [3], strength and power development are observed at medium and high level [4]. Besides, individuals with low ACE activity have a high level of endurance performance and exercise efficiency due to the rich blood circulation [1].
The relationship between genetics and physical performance was first settled on the basis of research conducted on soldiers [1, 5]. The level of physical performance must be at a certain level for soldiers to achieve their operational duties.
Walking for miles under difficult conditions, performing long periods of time with heavy loads, reaching targets on time, crawling for hours in challenging terrain and being able to act quickly and safely under stress in operational duties are highly complex activities requiring high physical effort. In this respect, the military field performance is dominated by aerobic endurance (low intensity, long duration activities), anaerobic endurance (high intensity, short duration activities) and strength endurance (long duration power performance without fatigue) [6, 7].
Papadimitriou et al., found that many champions have the same gene type at the Olympic level, indicating the importance of choosing the right genotype for success at elite level [8]. This study reflects a strong relationship between the gene type and physical performance. Genetic variants that lead to physical performance improvement can also reveal operational abilities in different intensity and volumes.
In different types of terrain, it is necessary to demonstrate high level of resilience in order to be able to continue operation without being tired for long periods with heavy loads on the back. However, in short-term operational activities, speed and agility are more essential parameters to be able to accomplish the mission.
The ACE gene variables can facilitate the identification and individual adaptation of the dominant energy systems needed by the soldiers in relation to the duration and intensity of operational activities. Determination of individual dominant energy systems that require physical performance used in different military disciplines may increase both individual and team success. It is a fact that soldiers can function with a healthy body; however, the choice of soldiers with the necessary level of physical performance so as to achieve challenging tasks is crucial for both the success of the operation and the performance of the individual.
Physical ability tests at certain periods are used to measure physical fitness level of soldiers in order to ensure that they are capable at all times. In these tests, physiological differences between individuals (body composition, rate of muscle fiber type etc.) are often overlooked. Individuals with low levels of aerobic endurance due to their genetic makeup may not succeed in long-term duties [9]. In such cases, although one is able to perform a healthy function, he / she can face problems in terms of operation.
The aim of this study was to reveal the relationship between the soldier's physical ability tests and the ACE gene variables, as a criterion to be considered in the selection of operational duties and to provide positive contributions to the planning of soldiers training loads or efforts specific to the needs of the individual.

Methods

Participants

The study group consisted of 223 male subjects of non-elite Turkish army recruits. All subjects have provided written consent to participate in the study and appropriate ethics committee approval has also been granted. The male subjects participating in the research study did not regularly deal with any sports activities as professionally, and homogenous working conditions were established by providing the same type of feeding, resting and loading parameters for the subjects in the camp center. Mean age of the subjects was 24 ± 1.7, body weight was 72 ± 2.5 kg , and height was 175 ± 1.4 cm.

Training schedule

The workout program consisted of low and medium intensity aerobic training (30-45-60 min.), strength endurance training (circuit & combat training with fully equipped military dressing, swimming (free time activity), and hurdling course (military pentathlon obstacles). All subjects were given a similar training program for 3 months; 5 days a week circuit training for muscular endurance and 6 days a week medium & long duration runs alternately.
Circuit training consists of pull-ups, sit-ups, push-ups, barbells lift, rope climbing, squat jumps, core exercise, obstacle run, pliyometric drills (high knee, hopping, jumping, depth jump, medicine ball and grenade throwing),

The subjects were given a 15 minute core training for the development of muscular endurance after having a long 45-60 minute low-intensity run before breakfast at 06:00 in the morning. Subjects were given three meals daily with approximately 3000 calories.
Subjects participated in theoretical and applied military training after morning sports and breakfast, and participated in strength endurance exercise programs between 14:00 and 16:30. The camp center is an open area where the forest is merged with the sea.The average temperature is around 18-24 degrees.

Exercise tests
Initial and final measurements of strength endurance (push-ups, sit-ups & pull-ups) tests were carried out in the gym. The test duration was recorded in two minutes and test applications were conducted individually. The participants were given a 15-minute break between tests. The muscular endurance tests were recorded by determining the maximum number of repetitions made within 2 minutes.

Genetic analysis
Each subject provided a written consent to participate in the study and appropriate ethics committee approval was granted. Peripheral venous blood of subjects receiving the approvals were collected on K2EDTA scrapers and stored at -20 ° C until used for DNA isolation. All molecular analyses were carried out in the Molecular Medicine Research Laboratory of the Department of Pediatrics, Ege University Medical Faculty Hospital.
"Genomic DNA was extracted from 200 l of EDTA- anticoagulated peripheral blood leucocytes using the QIAmp Blood Kit (QIAGEN, Ontario, Canada, Cat. no:51,106). Amplification of DNA for genotyping the ACE I/D polymorphism was carried out by polymerase chain reaction (PCR) in a final volume of 15 l containing 200 M dNTP mix, 1.5 mM MgCl2, 1£ Buffer, 1 unit of AmpliTaq® polymerase (PE Applied Biosystems) and 10 pmol of each primer. The primers used to encompass the polymorphic region of the ACE were 5-CTGGAGACCACTCCCATCCTTTCT-3 and 5 -ATGTGG CCATCACATTCGTCAGAT-3" (Rigat et al., 1992) [10]. "DNA is amplified for 35 cycles, each cycle comprising denaturation at 94°C for 30 s, annealing at 50°C for 30 s, extension at 72°C for 1 min with final extension time of 7 min. The initial denaturizing stage was carried out at 95°C for 5 min. The PCR products were separated on 2.5% agarose gel and identified by ethidium-bromide staining. Each DD genotype was confirmed through a second PCR with primers specific for the insertion sequence" (Shanmugam et al., 1993) [11]. "The samples with II and DD homozygote genotypes and ID heterozygote genotype were selected at random. These samples were then purified by PCR products purified system (Genomics, Montage PCR, Millipore) and directly sequenced by the ABI 310 Genetic Analyzer (ABI Prisma PE Applied Biosystems)" (Berdeli et al., 2005) [12].

Statistical analysis
Statistical analyses were performed using SPSS for Windows version 10 (SPSS Inc., Chicago, IL, USA). Methods applied were frequencies, descriptive statistics, and means. Statistical significance was set at the $P < 0.05$ level. The mean differences between groups that have been split on two within-subject factors that are ACE genotype group and time were compared with two-way repeated measures ANOVA. The post hoc analysis was conducted with Least Significant Difference method (LSD). The differences between pre-test and post-test values within each ACE genotype group were observed and analyzed by box-plot and paired t-test respectively.

Results

The entire of 223 subjects started exercise training, and all of them completed the 12-week boot camp training program. ACE genotype was determined in 223 subjects who form the basis of this report. The dispersion of genotypes in the whole group was 15 % II, n = 32; 48.3 % ID, n = 105; 36.7 % DD, n = 76. This did not diverge from substantially from those estimated by the Hardy–Weinberg equilibrium. There was no significant deviation in the distribution of genotypes in the complete group in comparison to those stipulated by the Hardy-Weinberg equilibrium. All ACE genotype groups except pull up for II and DD genotypes have shown significant improvements in the 12-week workout period as compared to the entry levels.

Effect of genotypes on the strength endurance test performance

Pull-up

The changes in pull-up are presented below.

Table 1: Effect of ACE genotype on pull-up performance gains during basic training (*P < 0.05).

Genotype	n	Pre	Post	Training Effect (within subject) P Value	Genotype Effect (between subject) P value
II	28	5.25±3.67	5.50±3.69	0.103	0.446
ID	109	4.90±3.23	5.13±2.897		
DD	86	4.77±3.43	4.99±3.03		

The mean pull-up scores achieved, both at the beginning and at the end of basic training, were highest for subjects with genotype II, intermediate for subjects with genotype ID, and lowest for subjects with genotype DD. However, these differences were not statistically significant by one-way ANOVA.

It is revealed that subjects do not show a statistically significant increase in pull-up over the training although there is an improvement from pre-training to post-training by two way repeated measure ANOVA. Also, the genotype does not have a significant effect on this improvement. The P value for the interaction between gain in pull-up score and genotypes is 0.745.

Push-up

Table 2: Effect of ACE genotype on push-up performance gains during basic training (*P < 0.05).

Genotype	n	Pre	Post	Training Effect (within subject) P Value	Genotype Effect (between subject) P value
II	28	42.96±11.075	66.61±21.26	0.000	0.938
ID	109	43.16±11.61	72.9±20		
DD	86	44.69±10.20	64.97±22.418		

The mean push-up scores achieved. It is seen that at the beginning of the training, it was highest for subjects with genotype DD, intermediate for subjects with genotype ID and lowest for subjects with genotype II. However, at the end of the training both at the beginning and at the end of basic training, were highest for subjects with ACE genotype II, intermediate for subjects with genotype ID, and lowest for subjects with genotype DD. These differences were statistically significant by one-way ANOVA.

It is revealed that subjects show a statistically significant increase in push-up over the training by two way repeated measure ANOVA. Also, the genotype has a significant effect on this improvement. The P value for the interaction between gain in push-up score and genotypes is 0.00. When it is compared to find out which genotype has the highest improvement by LSD method, and seen in Table 3 that ID genotype has the most significant gain in push up score.

Table 3: Comparison of ACE genotype on push-up performance gains (*P < 0.05).

(I) gene	(J) gene	P value
II	ID	0.004
	DD	0.389
ID	II	0.004
	DD	0.005
DD	II	0.389
	ID	0.005

Sit-up

Table 4: Effect of ACE genotype on sit-up performance gains during basic training (*P < 0.05).

Genotype	n	Pre	Post	Training Effect (within subject) P Value	Genotype Effect (between subject) P value
II	28	54.36±8.69	60.36±11.21	0.009	0.846
ID	109	56.45±8.14	65.53±14.46		
DD	86	55.50±9.87	63.40±14.806		

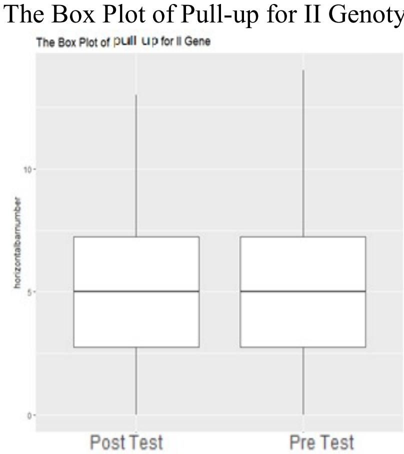
The mean sit-up scores achieved, at the beginning and at the end of basic training, were highest for subjects with ACE genotype ID, intermediate for subjects with genotype DD, and lowest for subjects with genotype II. However, these differences were not statistically significant by one-way ANOVA.
It is revealed that the performance gains in sit up are statistically significant over the training by two way repeated measure ANOVA (P=0.09). However, the gains realized were not significantly affected by genotype (P = 0.846). The P value for the interaction between gain in sit-up score and genotypes is 0.36.

Checking Significance of the Improvement on the Performance within Each Genotypes
The best way to find out whether the improvement within each gene is significant or not is paired t-test because we have two samples where observations in one sample can be paired with observations in the other sample. The assumptions for this test are as follows:

1. The data are continuous (not discrete).
2. The data, i.e., the differences for the matched-pairs, follow a normal probability distribution.
3. The sample of pairs is a simple random sample from its population. Each individual in the population has an equal probability of being selected in the sample.

It is validated that the whole dataset satisfies these assumptions. However, it is always good to use visual tools to have an idea about the samples before conducting analysis. For this purpose, box plot for each sample is drawn before paired t-test.

* The Box Plot of Pull-up for II Genotype



It is seen that there is no big difference between pre-test and post-test for II gene visually.

Graph 1: The box-plot of pull up for II genotype.

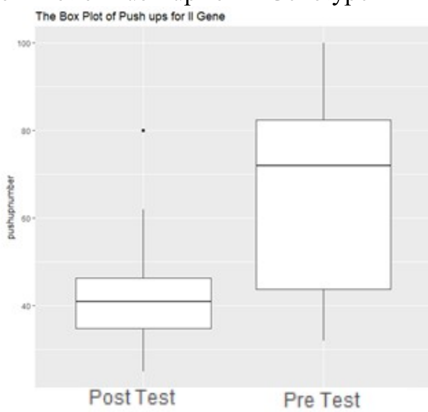
In both samples, there are 28 observations and the average pull-up numbers for pre-test and post-test samples are 5.25±3.67 and 5.50±3.69 respectively.

Table 5: Difference between pre-test and post-test for pull-up for II genotype (*P < 0.05)

Mean (Pre-Post)	Std. Deviation	t	df	Sig.
-0.250	0.701	-1.888	27	0.07

As shown in the Table 5, there is no significant difference between pre-test and post-test for pull-up for II gene since p value is greater than 0.05, which is significance level. In other words, there is no significant improvement in the number of pull-up for II gene.

* The Box Plot of Push-up for II Genotype



It is seen that the median value of post-test is greater than the median value of pre-test of push-up.

Graph 2: The box-plot of push up for II genotype.

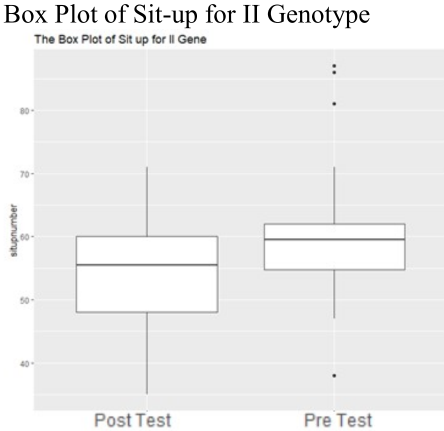
In both samples, there are 28 observations and the average push-up numbers for pre-test and post-test samples are 5.25±3.67 and 5.50±3.69 respectively.

Table 6: Difference between pre-test and post-test for push-up for II genotype (*P < 0.05).

Mean (Pre-Post)	Std. Deviation	t	df	Sig.
-23.643	18.231	-6.862	27	0.00

As shown in the Table 6, there is significant difference between pre-test and post-test for push-ups for II gene since p value is less than 0.05which is significance level. In other words, the improvement in the number of push-up for II genotype is statistically significant.

* The Box Plot of Sit-up for II Genotype



It is seen that the median value of post-test is greater than the median value of pre-test of sit-up.

Graph 3: The box-plot of sit-up for II genotype.

In both samples, there are 28 observations and the average push-up number for pre-test and post-test samples are 54.36±8.69 and 60.36±11.21 respectively.

Table 7: Difference between pre-test and post-test for sit-up for II genotype (*P < 0.05).

Mean (Pre-Post)	Std. Deviation	t	df	Sig.
-6.00	11.885	-2.671	27	0.013

As shown in the Table 7, there is a significant difference between pre-test and post-test for sit-ups for II genotype since p value is less than 0.05 which is significance level. In other words, the improvement in the number of sit-up for II genotype is statistically significant.

The Box Plot of Pull-up for ID Genotype

It is seen that there is no big difference between pre-test and post-test for ID genotype visually.

Graph 4: The box-plot of pull-up for ID genotype.

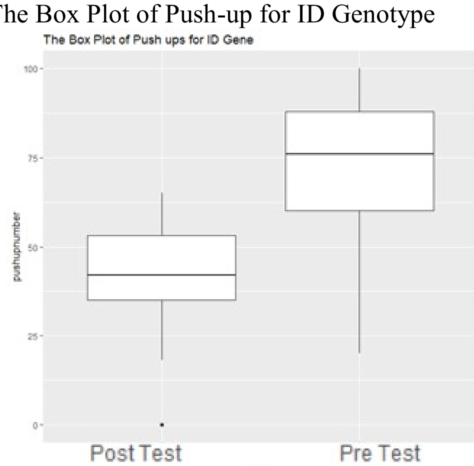
In both samples, there are 109 observations and the average pull-up numbers for pre-test and post-test samples are 4.90±3.23 and 5.13±2.897 respectively.

Table 8: Difference between pre-test and post-test for pull up for ID genotype (*P < 0.05).

Mean (Pre-Post)	Std. Deviation	t	df	Sig.
-0.229	1.024	-2.338	108	0.021

As shown in Table 8, there is significant difference between pre-test and post-test for pull-up for ID gene since p value is less than 0.05 which is significance level. In other words, there is a significant improvement in the number of pull-up for ID genotype.

*The Box Plot of Push-up for ID Genotype



It is seen that the median value of post-test is greater than the median value of pre-test of push-up.

Graph 5: The box-plot of push up for ID genotype.

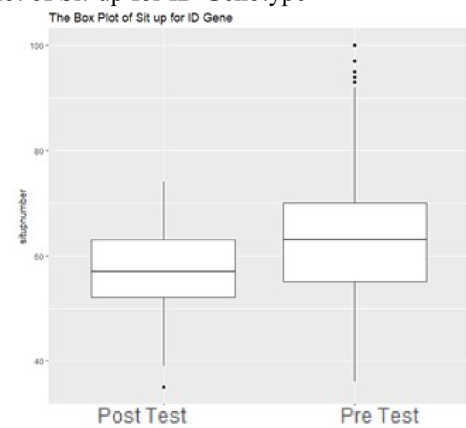
In both samples, there are 109 observations and the average push up number for pre-test and post-test samples are 43.16±11.61 and 72.9±20 respectively.

Table 9: Difference between pre-test and post-test for push up for ID genotype (*P < 0.05).

Mean (Pre-Post)	Std. Deviation	t	df	Sig.
-29.743	14.897	-20.844	108	0.00

As shown in Table 9, there is significant difference between pre-test and post-test for push-ups for ID gene since p value is less than 0.05 which is significance level. In other words, the improvement in the number of push-up for gene ID is statistically significant.

*The Box Plot of Sit-up for ID Genotype



It is seen that the median value of post-test is greater than the median value of pre-test of sit-up.

Graph 6: The box-plot of sit up for ID genotype.

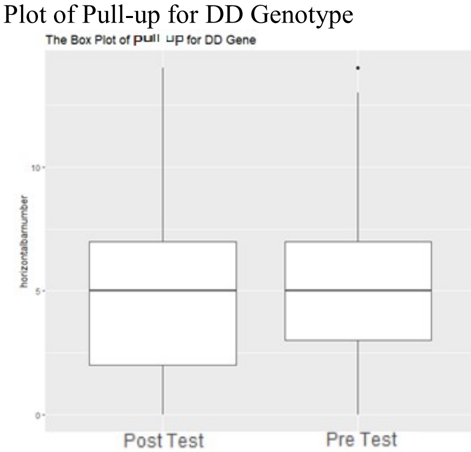
In both samples, there are 109 observations and the average sit-up numbers for pre-test and post-test samples are 56.45±8.14 and 65.53±14.46 respectively.

Table 10: Difference between pre-test and post-test for sit up for ID genotype (*P < 0.05).

Mean (Pre-Post)	Std. Deviation	t	df	Sig.
-9.083	13.694	-6.925	108	0.00

As shown in Table 10, there is significant difference between pre-test and post-test for sit-ups for ID genotype since p value is less than 0.05, which is significance level. In other words, the improvement in the number of sit-up for genotype ID is statistically significant.

*The Box Plot of Pull-up for DD Genotype



It is seen that there is no big difference between pre-test and post-test for DD genotype visually.

Graph 7: The box-plot of pull up for DD genotype.

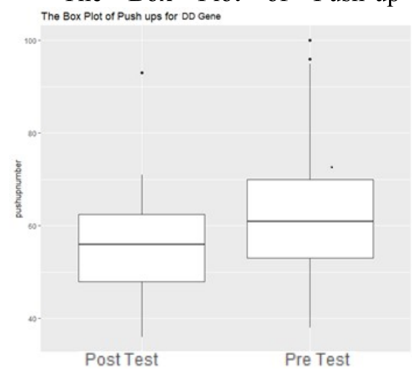
In both samples, there are 86 observations and the average pull-up numbers for pre-test and post-test samples are 4.77±3.43 and 4.99±3.03 respectively.

Table 11: Difference between pre-test and post-test for pull up for DD genotype (*P < 0.05).

Mean (Pre-Post)	Std. Deviation	t	df	Sig.
-0.221	1.305	-1.57	85	0.12

As shown in Table 11, there is significant difference between pre-test and post-test for pull-up for DD gene since p value is greater than 0.05, which is significance level. In other words, there is no significant improvement in the number of pull-up for DD genotype.

*The Box Plot of Push-up for DD Genotype



It is seen that the median value of post-test is greater than the median value of pre-test of push-up.

Graph 8: The box-plot of push-up for ID genotype.

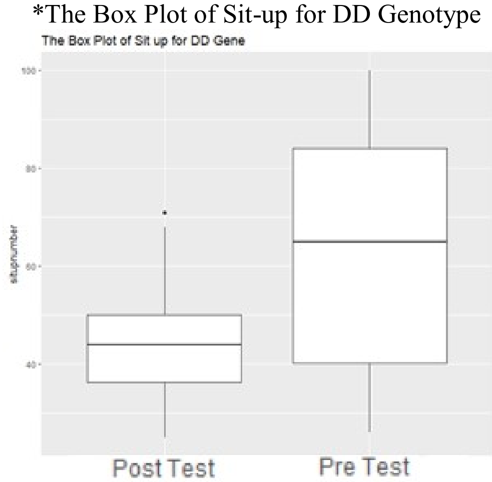
In both samples, there are 86 observations and the average push up numbers for pre-test and post-test samples are 44.69±10.20 and 64.97±22.418 respectively.

Table 12: Difference between pre-test and post-test for push up for DD genotype (*P < 0.05).

Mean (Pre-Post)	Std. Deviation	t	df	Sig.
-20.279	20.689	-9.09	85	0.00

As shown in Table 12, there is significant difference between pre-test and post-test for push-ups for DD genotype since p value is less than 0.05, which is significance level. In other words, the improvement in the number of push-up for genotype DD is statistically significant.

*The Box Plot of Sit-up for DD Genotype



It is seen that the median value of post-test is greater than the median value of pre-test of sit-up.

Graph 9: The box-plot of sit up for DD genotype.

In both samples, there are 86 observations and the average sit-up numbers for pre-test and post-test samples are 55.50±9.87 and 63.40±14.806 respectively.

Table 13: Difference between pre-test and post-test for sit up for DD genotype (*P < 0.05).

Mean (Pre-Post)	Std. Deviation	t	df	Sig.
-7.895	13.922	-5.259	85	0.00

As shown in Table 13, there is significant difference between pre-test and post-test for sit-ups for DD genotype since p value is less than 0.05, which is significance level. In other words, the improvement in the number of sit-up for genotype DD is statistically significant.

Discussion

Human genetic structure may evolve positively or negatively over time due to the influence of environmental factors and behaviors. In order to reveal the physical abilities of individuals, training should be applied according to individuals' genetic structure. Similar training methods and practices will produce more or less similar results on individuals [13]. The training loadings carried out in accordance with the genetics of the elite athletes allow for easier observation of the gene differences. Papadimitru et al., confirmed the relationship between genetic and sportive performance in the elite level sprinter and long distance runner by looking at the ACE and ACTN3 gene variants in elite athletes. [8]. However, the performance results of the different genotypes in similar training loads may not yield the expected change [13]. Scott et al. did not observe a significant relationship between ACE genotype and elite endurance performance in Kenyan long-distance athletes [14].

So far, there has not been a lot of research that has revealed the relationship between ACE genotype and strength endurance. Up to now, a few studies on the subject area have fully clarified the relationship between gene and strength endurance [5]. The relationship between ACE genotype and sportive performance has been positively evaluated in many of the studies conducted so far [15, 16]. It is certain that more time and research are needed to fully understand the consequences of the effects of genes on human physiology and the differences that result from minor but crucial variations among individuals [17, 18].

The relationship between gene and sport performance is generally performed on skills such as speed, power [4], short [3], medium and long duration endurance [18] and obesity related research [19, 20]. In most of the studies, sufficient number and homogeneous working conditions have not been fully achieved [3, 18]. The relationship between environmental factors and lifestyle as well as the genetic differences between individuals affected by exercise adaptation may be misleading in relation to one or more genes [21]. Considering changes in the human organism from one generation to another, sometimes with little breaks or additions to one or more genes in the human organism, it is quite difficult to predict whether the correct matches occur in the targeted gene [17].

Genetic differences can be considerably affected by similar environmental conditions, lifestyle and training practices. Training stimuli or behaviors given to individuals will improve on each genotype, but the development observed in genotypes that provide appropriate adaptation will be a little more advanced [13]. Such comparisons may produce either statistically significant or totally meaningless results. Working with homogeneous groups is an important criterion in order to reach a meaningful result by considering genotype differences and sportive performance development [3]. Similarly, the military lifestyle, which requires a certain level of physical performance, requires mental and psychological competence, as well as the need for speed, strength & endurance. To be able to determine which soldier is faster, stronger and higher endurance capacity is important in terms of military health and business performance efficiency.

The stronger is not always faster and able to have endurance capacity. On the contrary, because of the rate of muscle fiber type (type II) and body weight they have, they produce high rate of power in a short time and get tired very quickly by spending a lot of energy. Individuals with a high level of endurance capacity are able to convert their physiological structures into advantages by using their energies efficiently in long-term activities. The combination of two different physiological behaviors, such as speed and endurance, as well as the strength and endurance capabilities of muscles or energy systems that provide resistance to physical exertions such as lactad threshold training [6] for a maximum of 2 minutes, determine the level of strength endurance that reveals military capability. Considering military disciplines, it is almost impossible for a soldier to be both very fast and able to withstand long-term efforts [7, 22]. Physical fitness tests that measure military capabilities are used for the purpose of revealing medium and long-term endurance ability and strength endurance capability. Long lasting endurance performance and strength endurance capabilities are indispensable physical characteristics of the soldiers on the field. These characteristics are important criteria for healthy and efficient service when the average professional life is 25 to 30 years [7].

The factors that determine the energy used during exercise are the duration and intensity of the exercise. High-intensity and short-term exercises use anaerobic energy systems. However, long-term and low-intensity activities obtain energy from aerobic energy system. [9]. Such performances are generally occurring below 60% of the maximal heart rate. Slow twitch oxidative muscle fibers are dominant muscle fibers used in this type of activities. [9]. Army Physical Fitness Test (APFT) is used to measure strength endurance of soldiers in many countries and it consists of pull-ups, push-ups and sit-ups, which can be done in 2 minutes considering the maximum number of repetition [7]. Strength endurance physical ability tests are short-term anaerobic applications (1-2 minute). When the intensity of the exercise is 60-85% or more, the fast twitch muscle fiber (FT a, FTb) is activated, when the intensity of exercise is 60% or below the maximum heart rate, slow twitch muscle fiber is activated. The first thing to note is the duration of the exercise and the second important parameter is the intensity of the exercise. It is assumed that ACE DD genotypes may be more advantageous in these tests [9].

Considering the muscle fiber type and the duration of the exercise, it should be known that the main parameter measured by strength endurance test is local muscular endurance. The strength endurance test performed in the anaerobic environment aims to measure the tolerance level (fatigue) of the prime mover muscles (pectorals, abdominals and latissimus dorsi) to the lactic acid accumulation. Local muscular endurance is defined as the resistance of muscle or muscle groups to the accumulation of lactic acid in short-term activities [6]. Exercises that provide improved muscular endurance development such as push-ups, sit-ups and pull-ups require additional anaerobic energy provided by the aerobic system. The reason for this is the complete inhibition of blood flow to muscle cells due to pressure or contraction that the active muscles are exposed to during exercise [23]. Type I muscle fibers are activated with low and moderate exercise loads (endurance, strength endurance), whereas type II muscle fibers are activated by low repetition-high intensity loads (strength, speed) [9, 23]. When the intensity of exercise exceeds 60% of the maximum heart rate, slow twitch muscle fibers are activated at the beginning of the exercise (fast twitch muscle fibers are involved in the contraction). The increased fatigue level with the increase in exercise duration reduces the rate of fast twitch muscle fibers to participate in action. [23].

Strength endurance measurement tests are carried out to determine that long-term muscle effort can be sustained by delaying the accumulation of lactic acid at maximum level. The rate of slow-twitch muscle fiber influenced by the genetic structure allows endurance athletes to be successful in long-term activities [24], while the rate of fast twitch muscle fiber enables the strength athletes to be successful in short-term activities [9, 25]. Genetic structure determines skeletal muscle fiber ratios. It was observed that genetic structures of the ACE II, ID & DD genotypes showed the characteristics of type I, type II a, and type II b muscle fibers, respectively [9, 25].

Internal muscles strength, which increases circulation efficiency and lactic acid tolerance due to the increase in capillary number as a result of endurance training, is an important criterion that determines endurance performance development [23]. Researches indicate that D allele provides power-oriented athletic performance [24] and I allele provides a regional increase in muscle efficiency in endurance sports [22, 26]. ACE DD (power-oriented athletes) genotype had lower fatigue index & maximal oxygen uptake, whereas in endurance athletes lactate threshold and energy efficiency were higher [23]. The effect of the I allele on the slow twitch muscle fibers ratio increases the mechanical efficiency of the skeletal muscles [21, 22]. In our study, it was observed that the subjects with ID genotypes were more advantageous in the strength endurance tests than the II & DD genotypes. However, Cerit et al. (2006) found that DD genotypes were better than the others in short duration aerobic endurance development [3].

Zudin et al., observed maximum duration of a standard repetitive elbow flexion exercise (using 15 kg of barbell) before and after during 10 weeks identical military training schedule on the British army recruits. They found significant increase in II and ID genotypes and no significant improvement in (DD) genotypes in their research [28]. Similar results were observed in our study.

It is well known that the response to training is significantly affected by initial fitness level of the subject. Individuals with the lowest level of fitness prior to training tend to show the greatest improvements in performance as a result of training [5]. Sonna et al. reported that the results obtained from this study did not have a significant impact on physical performance, including muscle resistance of ACE ID polymorphism for young American adults from a wide variety of ethnic backgrounds. A study of an ethnically heterogeneous population of US Army recruits did not confirm the association of a greater muscle strength [5]. However, in our study, it is seen that at the beginning of the training performance score (physical ability test results) was highest for subjects with genotype DD, intermediate for subjects with genotype ID and lowest for subjects with genotype II. However, at the end of the training both at the beginning and at the end of basic training, performance scores were highest for subjects with ACE genotype ID, intermediate for subjects with genotype II, and lowest for subjects with genotype DD. In contrast to our study, Shaweta et al. (2010), did not find a significant difference in the physical fitness (push-up 1 minute) and curl-ups development of II, ID, DD genotypes on Indian army triathletes [29].

Studies in this type of military environment are homogeneous environments that determine the sensitivity of genetic studies. The level of significance may be higher than other genetic studies. However, it is evident that studies reflect positively on factors such as initial physical performance level, motivation and military imperative. In such studies, highly motivated individuals at the beginning of the exercise program can reduce their motivation over time. Variables such as individuals who do not have sufficient physical preparation at the beginning of the program obtain better by closing the gap between others within a 12-week period.

Sonna et al. (2001) evaluated the relationship between ACE genotype and strength endurance by observing the results of US army recruits baseline and final push-up and sit-up exercise (Army Physical Fitness test-APFT) results. They observed that the difference between the scores of different genotypes was very small and not statistically significant [5]. However, in our study all ACE genotype groups except pull up for II and DD genotypes have shown significant improvements in the 12-week workout period as compared to the entry levels ($P < 0.05$). On the other hand, it is evaluated that there is no significant difference in the improvements of sit up and pull up scores for all three genotypes ($P > 0.05$). Furthermore, the improvement in push up score of ID genotypes showed statistically significant difference compared to II and DD genotypes ($P < 0.05$).

Conclusion

Relying upon these findings, it is assessed that all ACE genotypes have shown significant improvement in terms of push-up and sit-up scores in the 12-week workout period as compared to the entry levels. It was evaluated that ID genotype has the significant difference among three genotypes in terms of push-up scores. On the other hand, the development in both DD and II genotypes was limited compared to ID genotype.

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Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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