

The College at Brockport: State University of New York Digital Commons @Brockport

Kinesiology, Sport Studies and Physical Education
Faculty Publications

Kinesiology, Sport Studies and Physical Education

2009

Prediction of Upper Body Strength By Using Grip Strength Test in Division II American College Football Players' Grip Strength

Bülent Ağbuğa
Pamukkale University

Ferman Konukman
The College at Brockport, fkonukma@brockport.edu

Ilker Yilmaz
Anadolu Üniversitesi

Follow this and additional works at: https://digitalcommons.brockport.edu/pes_facpub

 Part of the [Kinesiology Commons](#)

Repository Citation

Ağbuğa, Bülent; Konukman, Ferman; and Yilmaz, Ilker, "Prediction of Upper Body Strength By Using Grip Strength Test in Division II American College Football Players' Grip Strength" (2009). *Kinesiology, Sport Studies and Physical Education Faculty Publications*. 82. https://digitalcommons.brockport.edu/pes_facpub/82

Citation/Publisher Attribution:

Spor Bilimleri Dergisi Hacettepe J. of Sport Sciences 2009, 20 (1), 16–23

This Article is brought to you for free and open access by the Kinesiology, Sport Studies and Physical Education at Digital Commons @Brockport. It has been accepted for inclusion in Kinesiology, Sport Studies and Physical Education Faculty Publications by an authorized administrator of Digital Commons @Brockport. For more information, please contact kmyers@brockport.edu.

Prediction of Upper Body Strength By Using Grip Strength Test in Division II American College Football Players' Grip Strength

Amerikan Kolej Futbol II. Ligindeki Futbol Oyuncularının Üst Beden Kuvvetinin El Kavrama Kuvveti Testini Kullanarak Tahmini

Araştırma Makalesi

¹Bülent AĞBUĞA, ²Ferman KONUKMAN, ³İlker YILMAZ

¹Pamukkale Üniversitesi, Spor Bilimleri ve Teknolojisi Yüksekokulu

²State University of New York, Dept. of Kinesiology, Sport Studies & Physical Education

³Anadolu Üniversitesi, Beden Eğitimi ve Spor Bölümü

ABSTRACT

The purpose of this study was to investigate if the grip strength could be used to predict upper body strength of college football players through comparing dominant grip strength and upper body strength of college football players. Forty-one Division II National Collegiate Athletic Association football players (24 defensive players and 17 offensive players) participated in the present study. A grip strength dynamometer was used to measure grip strength of football players and the one-repetition maximum (1RM) bench press was used to measure participants' upper body strength. Each player had undergone a minimum of eight weeks of heavy resistance training during the winter off-season conditioning program prior to measurement. None of the participants had a serious pre-existing injury that could hinder their performance throughout the study, and participants in the study had the ability to understand and perform bench press and grip strength tests. The Pearson product-moment coefficients of correlation and a simple regression were computed to determine

ÖZET

Bu araştırmanın amacı, Amerikan kolej futbol oyuncularının dominant el kavrama kuvvetleri ile üst beden kuvvetlerini karşılaştırarak, el kavrama kuvvetlerinin üst beden kuvvetlerini tahmin etmede kullanılıp kullanılmayacağını incelemektir. Kırk bir II. Küme Amerikan Milli Kolej Atletik Birliği futbol oyuncuları (24 savunma ve 17 hücum oyuncusu) bu çalışmaya katılmıştır. Katılımcıların kavrama kuvvetlerini belirleyebilmek için bir el kavrama dinamometresinden ve üst beden kuvvetinin tespiti için bir tekrarlı maksimum bench press testinden (1RM) yararlanılmıştır. Testlerin uygulama aşamasında katılımcıların herhangi bir ciddi sağlık sorunları ve sakatlanma problemleri olmamıştır. El kavrama kuvveti ve 1RM bench press arasındaki ilişkinin belirlenmesinde Pearson Product Correlation ve Simple Regression analizleri kullanılmış, oyuncuların pozisyonlarına göre kuvvetlerinde farklılık olup olmadığı ANOVA ile belirlenmiştir. İstatistik analizlerinde futbol oyuncularının kaldırdıkları ağırlık

relationship between 1RM bench press and grip strength. One-way analyses of variance (ANOVA) were conducted to test the differences in upper body and grip strength among offensive and defensive college football players and their player positions by using their relative strength. Notably, strength scores were divided by body weights to express bench press and grip strength relative to weight. The results of this study showed that grip strength test did not predict the upper body strength of college football players when we used the 1RM bench press strength test as a standard test to measure upper body strength of players ($\beta = .248$, $p = .118$).

Key Words

Upper body strength, Grip strength, Strength tests, American football players.

lar kendi beden ağırlıklarına bölünmek suretiyle elde edilen rölatif kuvvet sonuçları kullanılmıştır. Bu araştırmanın sonucu, el kavrama kuvvetinin, 1RM bench press kuvvet testi kullanılarak elde edilen üst beden kuvvetini tahmin etmede yeterli olmadığını göstermiştir ($\beta = .248$, $p = .118$).

Anahtar Kelimeler

Üst beden kuvveti, El kavrama kuvveti, Kuvvet testleri, Amerikan futbol oyuncularını.

INTRODUCTION

Strength is one of the most important ingredients of playing success (Bompa, 1996; Wilson, 1994) and strength training is a critical part of athletic preparation because an organized program can lead to development of muscular strength of athletes (Fleck and Kraemer, 1997).

Many sports require athletes to have high levels of muscular strength (Wilson, 1994). The assessment of strength, therefore, is recognized by coaches as necessary for evaluation of football players' athletic potential. The assessment of strength must be accurate. Accurate assessment of strength is especially fundamental for both occupational functional capacity evaluation and appropriate athletic and rehabilitation exercise prescription (Brown and Weir, 2001).

Strength is normally measured by the maximal amount of weight an individual can move in one repetition of a movement or in one isometric contraction (Baechle, 1994). To compare the strength of athletes, the relative strength, however, is usually calculated (Zatsiorsky, 1995). Football requires a solid, unshakeable foundation of strength. Not only you must be strong enough to move your own body weight, you have got to be able to do it quickly. Therefore, relative strength is an important quality to develop for increased power and

speed. Notably, evidence from a number of different types of research as well as observational data indicates that relative strength is strongly related to sports performances that rely on speed and motor skills (Fry et al., 1991). Furthermore, examining strength differences among player positions will be useful for coaches, athletic trainers, and fitness professionals. Barker et al. (1993), for example, studied a Division I AA university football team and divided the players into starters and non-starters. Based on the 1RM squat, normalized by body mass, Barker et al. (1993) statistically divided the team into 3 relative strength group levels: high, moderate and low. A continuum is evident as stronger players also had higher vertical jumps compared to moderate- and low-level relative strength groups.

It has been shown that relative upper body strength scores of defensive college football players are greater than those of offensive players (Agbuga et al., 2009; Berg et al., 1990).

Although there are other kind of tests which measure upper body strength like push ups or dynamometer, the one repetition maximum (1RM) is the most popular way to assess dynamic strength and most used field test for evaluating muscular strength (Bryzcki, 1993). Measuring 1RM provides

a trial-and-error method of manipulating the load until a maximal effort is achieved (Kuramoto and Payne, 1995). However, this can be time consuming and may increase the possibility of injury including fractures, torn ligaments, and the growth plates of young participants (Mayhew et al., 1999). As a result, many coaches and strength specialists have applied submaximal testing to estimate the 1RM strength in the bench press. Although performing 1RM bench press is a commonly used procedure, there have been other methods and other muscle groups employed to predict the 1RM.

In many sports like wrestling, tennis, badminton, football, basketball, handball, and baseball, some degree of grip strength is necessary to be successful in preventing injuries. For American football players, for example, Turbeville et al. (2003) indicated that significantly more injuries occurred to the upper body than to the lower body (61% versus 39%, respectively, $p < 0.05$). Injuries to the arm, wrist, and hand accounted for 67% (26 of 39) of the upper body injuries. The strength of ones grip plays a key role in injury prevention and overall strength development (Budoff, 2004; Fry et al., 2006; Tietjen-Smith et al., 2005). Measurement of grip strength can also be an important component in body strength evaluation and can provide us a quick assessment of athlete's upper body strength. Grip strength is correlated with the strength of the upper extremity, general body strength and some anthropometric measurements (Rantanen, 1992) and therefore is often accepted as an objective measure of upper extremity function (Balogun et al., 1991; Bohannon, 1997). The most common method of assessment for grip strength is the use of a handheld dynamometer. Handheld grip strength dynamometry is used to measure the muscular force generated by flexor mechanism of the hand and forearm. While running, blocking, tackling, and kicking are the major portions of the game, catching and carrying the ball is becoming increasingly important, so grip strength tends to be one of the most neglected aspects of strength training in American football.

Grip strength has been thought of as a possible predictor of overall body strength, but little

if any research that correlated the two was found. Caterisano et al. (2001), for example, found that grip strength correlated with a 1RM bench press in untrained and trained college age males and females. The correlation was high ($r=0.76$ males, $r=0.74$ females) between the grip strength and the bench press 1RM in the untrained male and female groups. The correlation between the grip strength and the bench press 1RM, however, was lower in the trained male and female athletes (r values as follows: 0.65 for the power lifters, 0.56 for the women's soccer, 0.44 for the football players). Results from this study imply that the existence of a significant correlation between grip strength and 1-RM bench press depends on the type of resistance training typical of the individual being tested. Tietjen-Smith et al. (2005) also found a direct correlation in grip strength and overall body strength in old females. Moreover, Fry et al. (2006) found a correlation between grip strength and performance in American Men Junior Weightlifting. More studies, however, are necessary for other sports and populations. Therefore, the purpose of this study, specifically, were (1) to investigate if the grip strength could be used to predict upper body strength of college football players and (2) to compare grip strength and upper body strength of college football players according to their positions in the football field.

METHOD

Participants: Forty-one Division II National Collegiate Athletic Association (NCAA) college football players participated in the present study. Participants were informed of the experimental risks and signed an informed consent prior to the investigation. The investigation was approved by an Institutional Review Board for use of Human subjects. Participants' ages range from 18 to 30 years with a mean of 20.58 (SD = 2.07). There were 9 defensive linemen, 7 offensive linemen, 8 defensive backs, 7 line backers, 4 receivers, 3 offensive backs, 2 tight ends, and 1 quarter back. Players' weight ranged from 70.20 to 152.80 kg with a mean of 101.76 kg (SD= 22.64). Their height ranged from

163.83 to 207.65 cm with a mean of 182.83 cm (SD = 9.12). None of the participants had a serious pre-existing injury that could hinder their performance throughout the study, and participants in the study had the ability to understand and perform bench press and grip strength tests. Participants were experienced with weight lifting programs prior to the date of bench press test.

Procedures: Each player had undergone a minimum of 8 weeks of heavy resistance training during the winter off-season conditioning program prior to measurement. The off-season program focused on low repetitions and heavy loads and emphasized a periodized methodology for core exercises such as the bench press, squats, deadlifts, and push presses. Participants were measured the week following the last workout of the cycle to allow sufficient recovery to achieve peak performance. All tests were administered between 2 and 5 pm within one week. Each participant completed all tests in the following order: grip strength test and 1RM bench press test. Each participant was required to rest 3 to 10 minutes between tests (Slovak, 1996).

Each participant's weight and height were measured. For height, Novel Products INC., Pat # DES 290237 stadiometer (accurate to ± 1 mm) and for weight, TANITA BWB-G27A Class III scale (accurate to ± 0.1 kg) was used. These instruments are certified by their manufacturers.

Grip strength was measured according to standardized procedures (Guy et al., 1996). A grip strength dynamometer (Stoelting Co, Wood Dale, IL, USA) was used to measure grip strength of football players (accurate to ± 0.5 kg). During the test, they stood with the hand to be tested first at their side, away from their body. The dynamometer was in line with their forearm and held at the level of their thigh. Then, they squeezed the dynamometer as hard as possible without moving their arm; exhale as they squeezed. During the test, they were not let the dynamometer touch their body or any other object. They performed two trials with dominant hand. They rested for about a minute between trials. Finally, they were recorded

the scores for dominant hand to the nearest kilogram. The criterion measure was the best score of the two trials of the mean of dominant hand for grip strength.

The one-repetition maximum (1RM) was used to measure participants' upper body strength. This test requires the individual to lift the heaviest resistance possible one time through a full range of motion (Mayhew et al., 2001). In this test, each participant was required to follow a general warm up prior to testing by jogging a quarter mile and stretching upper and lower extremities. They were also allowed a warm-up that consisted of performing the bench press using light weights of approximately 50 % to 75% of estimated 1RM based on off season. A standard Olympic bar and plates were used for all lifts, and the player used a grip that was slightly wider (approximately 20-30 cm.) than shoulder width (Mayhew et al., 1999). The participants were in the supine position with their feet on the floor and buttocks on the bench during lifting. The participant then lowered the bar in a controlled manner and returned the bar to the starting position. The arms were required to extend fully on each repetition. The bar could not rest on the chest or with arms fully extended for more than two seconds (McGee and Burkett, 2003). After each successful 1RM attempt, the participants were encouraged to add between 5 (2.27 kg) and 10 pounds (4.54 kg), depending on the degree of difficulty of the previous lift. Each participant was required to find his 1RM between 2 and 7 attempts, with 3 to 10 minutes rest between attempts (Slovak, 1996). The greatest weight lifted for each participant was recorded as the 1RM. Relative strength was determined by squeezing the dynamometer and taking the weight lifted and divided by body weight for each individual, respectively.

Data Analysis: Four main statistical analyses were conducted. First, descriptive statistics were conducted to provide general characteristics of participants. Second, the Pearson product-moment coefficients of correlation were computed to determine relationship between 1RM and grip strength. Third, a simple regression was con-

ducted to further examine such relationship. Grip strength served as a predictor variable and 1RM served as a criterion variable. Finally, one-way analyses of variance (ANOVA) were conducted to test the differences in upper body strength among offensive and defensive college football players and their player positions (offensive linemen versus defensive linemen as a group and offensive backs and receivers versus defensive backs as another group) by using their relative strength. One-way analyses of variance (ANOVA) were also conducted to test the differences in grip strength among offensive and defensive college football players and their player positions (offensive linemen versus defensive linemen as a group and offensive backs and receivers versus defensive backs as another group) by using their relative strength. Notably, strength scores were divided by body weights to express bench press and grip strength relative to weight.

RESULTS

In this study, there were 24 defensive players and 17 offensive players for 1RM test. 1RM scores ranged from 83.99 to 183.87 kg with a mean of 123.90 ± 23.81 kg (see Table 1). As can be seen in Table 1, for an alpha level of .05, Pearson product-moment analyses revealed no significant correlation between football players' grip strength and their 1RM ($r = .248$). Simple regression analysis also indicated that grip strength did not emerge as a significant predictor of upper body strength ($\beta = .248$, $p = .118$). The predictor explained 60% of variance in 1RM. One-way ANOVA was used to compare the groups and the scores are expressed relative to body weight. The results of statistics (see Table 2) showed that there was no significant difference between defensive players and offensive players' grip strength ($F(1,39) = .85$, $p = .36$, Eta-squared = .02) when scores are expressed rela-

Table 1. Means and standard deviation of football players' 1RM bench press and grip strength

Variables	n	Mean	SD
1RM Bench Press (kg)	41	123.90	23.81
Grip Strength (kg)	41	57.21	8.93

Table 2. The relative upper body strength and grip strength of offensive and defensive football players

Player Position	1RM Bench Press Test (kg)					
	Mean	SD	F	p	Eta-Squared	
Offensive (n = 17)	1.14	.25	6.96	.01	.15	
Defensive (n = 24)	1.33	.21				
Offensive Linemen (n = 7)	.99	.21	6.05	.03	.30	
Defensive Linemen (n = 9)	1.26	.23				
Offensive Backs & Receivers (n = 7)	1.30	.20	1.09	.31	.08	
Defensive Backs (n = 8)	1.42	.23				
Player Position	Grip Strength Test (kg)					
	Mean	SD	F	p	Eta-Squared	
Offensive (n = 17)	.56	.11	.85	.36	.02	
Defensive (n = 24)	.59	.12				
Offensive Linemen (n = 7)	.52	.06	.10	.75	.01	
Defensive Linemen (n = 9)	.50	.08				
Offensive Backs & Receivers (n = 7)	.62	.10	2.87	.11	.18	
Defensive Backs (n = 8)	.71	.10				

tive to body weight. When their player positions in the field were statistically analyzed, no significant difference was found between defensive linemen and offensive linemen ($F(1, 14) = .10$, $p = .75$, $\eta^2 = .01$) and also no significant difference was found between defensive and offensive backs in grip strength ($F(1, 13) = 2.87$, $p = .11$, $\eta^2 = .18$). However, the 1RM test results showed that defensive players were stronger than offensive players when scores were expressed relative to body weight ($F(1, 39) = 6.96$, $p = .01$, $\eta^2 = .15$). Similarly, defensive linemen scored significantly higher than offensive linemen ($F(1, 14) = 6.05$, $p = .03$, $\eta^2 = .30$) in 1RM. Lastly, one-way analysis of variance results showed that offensive backs and receivers did not significantly differ from defensive backs in strength as measured by 1RM ($F(1, 13) = 1.09$, $p = .31$, $\eta^2 = .08$).

DISCUSSION AND CONCLUSION

Although there are several researches examining the grip strength of athletes (Giardina et al., 1997; Fry et al., 2006; Tietjen-Smith et al., 2005), the relationship between grip strength and upper body performance has not been clearly explained. Therefore, the purpose of this study, specifically, were (1) to investigate if the grip strength could be used to predict upper body strength of college football players and (2) to compare grip strength and upper body strength of college football players according to their positions in the football field.

Strength training is an important part of a physical training program. A fair assessment of muscular strength can be determined by a variety of strength tests. Athletes' upper body strength is usually measured by the maximum amount of weight that can be lifted in one repetition maximum, or a given number of repetitions using free weights or resistance machine. Measurement of grip strength, however, can be an important part in muscular strength assessment by providing a quick estimation of athletes' upper body strength.

The results of this study showed that grip strength test did not predict the upper body

strength of college football players when we used the 1RM strength test as a standard test to measure upper body strength of players. This result is not consistent with some studies (Tietjen-Smith et al., 2005; Fry et al., 2006) indicating a direct correlation in grip strength and upper body strength and somewhat consistent with the study by Caterisano et al. (2001) reporting low correlation between the grip strength and the bench press 1RM in the trained male and female athletes. On the other hand, Caterisano et al. (2001) found a high correlation between the grip strength and the bench press 1RM in the untrained male and female groups.

Moreover, one reason for the inconsistency that can be Tietjen-Smith et al. (2005) examined the relationship between grip strength and overall body strength among old females. This study, however, examined young American college football players' both upper body and grip strength. As Caterisano et al. (2001) indicated that the existence of a significant correlation between grip strength and 1-RM bench press may depend on the type of resistance training typical of the individual being tested. Notably, the current study serves one of the few studies to examine young college football players' upper body and grip strength. A similar study, however, should be performed with a larger number of participants. Then, the results of a study of this type could possibly be more accurate in determining the relationship between grip strength and 1RM.

Although the present study seems to cover a widely studied area for understanding college football players' upper body strength, it specifically examined the upper body strength and grip strength of college football offensive and defensive players. There was no significant difference between defensive players and offensive players' grip strength when scores are expressed relative to body weight, although defensive college players were stronger than offensive football players when 1RM scores are expressed to relative body weight. Defensive linemen were stronger than offensive linemen according to the 1RM when scores are expressed to relative body weight. However, no significant difference was found between

defensive linemen and offensive linemen's grip strength scores. This study also found that defensive backs were similar in strength with offensive backs and offensive receivers in terms of the actual 1RM when scores are expressed to relative body weight. The findings of the current study are consistent with the study of Berg et al. (1990) reporting strength differences between offensive and defensive college football players. The conclusion of the authors was that the defense was stronger when their scores were expressed relative to body weight. However, no significant difference was found between defensive and offensive backs in grip strength.

The current study indicates that both tests' applicability may not be identical for athletes. Therefore, coaches, athletic trainers, and fitness professionals in evaluating strength and planning resistance training programs should be careful about the accuracy of predicted 1RM's by

using grip strength test. Coaches, on the other hand, can apply more appropriate and effective strength training strategies to improve their players' needs by knowing the grip strength and upper body strength differences among player positions although this study found that grip strength test results did not have the same trends with the 1RM test. Because the present study is one of the few studies to examine relationships between grip strength and upper body strength in a college football setting, more research is needed to confirm or refute this finding.

Corresponding Address (Yazışma Adresi):

Bülent AĞBUĞA, PhD

Pamukkale University

School of Sport and Technology Sciences

Kınıklı Kampüsü, Denizli

e-mail: bakboga@yahoo.com

KAYNAKLAR

1. Ağbuga B, Slovak JP, Konukman F, Yılmaz I. (2009). Comparison of division II college offensive and defensive football players' upper body strength across one maximum repetitive test and the NFL 225-test. *Journal of Human Kinetics*, 21, 75-82.
2. Baechle TR. (1994). Essentials of strength training and conditioning. *Champaign, Human Kinetics*.
3. Balogun JA, Akomolafe CT, Amusa LO. (1991). Grip strength: effects of testing posture and elbow position. *Archives of Physical Medicine and Rehabilitation*, 72, 280-283.
4. Barker MT, Wyatt RL, Johnson MH, Stone HS, O'Bryant CP, Kent M. (1993). Performance factors, psychological factors, physical characteristics and football playing ability. *Journal of Strength and Conditioning Research*, 7, 224-233.
5. Berg K, Latin RW, Baechle TR. (1990) Physical and performance characteristics of NCAA Division I football players. *Research Quarterly. Exercise and Sport*, 61, 395-401.
6. Bomp T. (1996). Antrenman Kuramı ve Yöntemi. Ankara: Başırgan Yayınevi.
7. Bohannon RW. (1997) Reference values for extremity muscle strength obtained by hand-held dynamometer from adults aged 20 to 79 years. *Archives of Physical Medicine and Rehabilitation*, 78, 26-32.
8. Brown LE, Weir JP. (2001). Asep procedures recommendation I: Accurate assessment of muscular strength and power. *The Journal of Exercise Physiology-online*, 4, 1-21.
9. Brzycki M. (1993) Predicting a one-rep max from reps-to-fatigue. *Journal of Physical Education, Recreation and Dance*, 64 (1), 88-90.
10. Budoff, J. (2004). The prevalence of rotator cuff weakness in patients with injured hands. *Journal of Hand Surgery*, 29 (6), 1154-1159.
11. Caterisano A, Yurich S, Bonfiglio C, Fowler A, Greer B, Brown CW. (2001). The correlation between maximal grip strength and 1RM bench press: the effects of Sport specific resistance training and gender. *Medicine & Science in Sports & Exercise*, 33(5(S1)), S244.
12. Fleck SJ, Kramer WJ. (1997) Designing Resistance Training Programs (2nd ed.). Campaign, IL: *Human Kinetics*.
13. Fry AC, Ciroslan D, Fry MD, LeRoux CD, Schilling BK, Chiu LZ. (2006) Anthropometric and performance variables discriminating elite American junior men weightlifters. *Journal of Strength and Conditioning Research*, 20 (4), 861-866.
14. Fry AC, Kraemer WJ, Weseman CA, Conroy BP, Gordon SE, Hoffmann JR, et al. (1991) The effects of an off-season conditioning program on starters and non-starters in women's intercollegiate volleyball. *The Journal of Applied Sport Science Research*, 5, 174-181.
15. Giardina D, Leslie H, Raridon L, Zimmer D. (1997) Relationship of grip strength and forearm size to bat

velocity in college female softball players. *IAHPERD Journal*, 30 (2).

16. **Guy M, Piatt C, Himmelberg L, Ballmann K, Mayhew JL.** (1996). Isometric strength measurement as predictors of physical performance in college men. *IAHPERD Journal*, 30,18-19.
17. **Kuramoto AK, Payne G.** (1995) Predicting muscular strength in women: A preliminary study. *Research Quarterly for Exercise and Sport*, 66, 168-172, .
18. **Mayhew JL, Ware JS, Bemben MG, Wilt B, Ward TE, Farris B, et al.** (1999) The NFL-225 test as a measure of bench press strength in college football players. *Journal of Strength and Conditioning Research*, 13, 130-134.
19. **Mayhew JL, Ware JS, Clemens CT, Coco B.** (2001) Accuracy of prediction equations for determining 1RM bench press, squat and dead lift in college football players. *Journal of Human Movement Studies*, 40, 423-436.
20. **McGee KJ, Burkett LN.** (2003). The national football league combine: A reliable predictor of draft status? *Journal of Strength and Conditioning Research*, 17, 6 - 11.
21. **Rantanen J.** (1992) "Occupational Health Services in Europe" *NIVA Nordic News Letter*, 4, 2-6.
22. **Slovak JP.** (1996) The utilization of the 225-test to predict one repetition maximum bench press with college football players. Unpublished doctoral thesis, Texas A&M University-Commerce.
23. **Tietjen-Smith T, Smith S, Martin M, Henry R, Weeks S, Bryant A.** (2005) Grip strength in relation to overall strength and functional capacity in very old and oldest old females. *Physical and Occupational Therapy in Geriatrics*, 24 (4), 63-78.
24. **Turbeville SD, Cowan LD, Asal NR, Owen WL, Anderson MA.** (2003) Risk factors for injury in middle school football players. *The American Journal of Sports Medicine*, 31(2), 276-281.
25. **Wilson GJ.** (1994). Strength and power in sport. In Bloomfield, J. et al. (Eds.) *Applied anatomy and biomechanics in sport*, (pp. 110-208). Melbourne: *Blackwell Scientific Publications*.
26. **Zatsiorsky VM.** (1995) *Science and Practice of Strength Training*. Champaign, IL: *Human Kinetics*.