ISOKINETIC BENCH PRESS AS A CRITERION MEASURE OF UPPER BODY POWER IN NCAA DIVISION I COLLEGE FOOTBALL PLAYER STARTERS AND NON-STARTERS

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ABSTRACT

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The purpose of this study was to investigate whether the isokinetic bench press could discriminate football-playing ability and to correlate the isokinetic bench press with other commonly used football upper and lower body power tests. National Collegiate Athletic Association (NCAA) Division I collegiate football players aged 18-26 years were divided into two groups by player ability: starters (Group 2) and non-starters (Group 1). On separate days, subjects performed the vertical jump, 40-yard dash, one-repetition maximum (RM) bench press and isokinetic bench press at 60, 180 and 300°/s. Pearson Correlation Coefficient analysis revealed significant correlations among all measures in the present study (height, weight, isokinetic peak force at 60°/s, 180°/s and 300°/s, vertical jump, 1-RM bench press and 40-yard dash). Height and weight negatively correlated with all measures, except the 40-yard dash, indicating that taller and/or heavier football players produced higher (slower) 40-yard dash times. Three 1 x 2 ANOVA's

($p<0.05$) were used to compare 40-yard dash times, vertical jump, and 1-RM bench press between starters and non-starters, respectively. Results indicated that 40-yard dash times of starters were significantly faster than non-starters, and no significant differences in vertical jump values and 1-RM bench press torque between starters and non-starters. Four x 2 ANOVA with repeated measures ($p<0.05$) analysis indicated that starters and non-starters produced significantly higher 1-RM bench press torque values than isokinetic bench press peak torque values at 60, 180, and 300°/s; higher isokinetic bench press peak torque values at 60°s/ than at 180 and 300°/s; and no significant difference between isokinetic bench press peak torque values at 180 and 300°/s. Three x 2 ANOVA with repeated measures ($p<0.05$) analysis indicated that football starters produced significantly higher isokinetic bench press peak torque values at 60°/s than non-starters. Conclusion: isokinetic bench press can be used as an upper body power test to discriminate between starters and non-starters.

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ISOKINETIC BENCH PRESS AS A CRITERION MEASURE OF UPPER BODY POWER IN NCAA DIVISION I COLLEGE FOOTBALL PLAYER STARTERS AND NON-STARTERS

Introduction

Football is a complicated skill intensive sport that requires power, agility, and quickness/speed (1). There are at least 19 specialized positions that make up 11 offensive and 11 defensive player positions. Each position requires different specific responsibilities and player abilities. (5) Therefore, the physical characteristics of football players vary according to position.

Collegiate football coaches select individuals who possess physical characteristics they believe necessary for success at certain positions to win football games. The qualities most coaches seek are: quickness, agility, balance, and power (1). Significant time, effort and resources are dedicated to player evaluation through strength, power, speed and agility tests (28). Consequently, football research is often dedicated to determination of the most definitive test(s) for prediction of football playing ability. (1, 4, 5, 8, 15, 23,28, 29)

Power and strength tests used to predict football-playing ability (1, 28) include: vertical jump (5, 8, 9, 10, 23, 26, 27, 28, 29, 34, 36), 40-yard dash (1, 5, 8, 23, 29), 10/20-yard sprint (23, 28), Margaria-Kalamen step test (1, 20, 29), broad jump (29), and Wingate anaerobic test (29), 1-RM bench press (3, 5, 6, 8, 11, 13, 14, 16, 17, 18, 19, 21, 23, 24, 28, 30, 31, 32, 35), squat (5, 8, 23, 28), power-clean (8, 23, 28), and Olympic snatch (28). Comparisons among tests are difficult and impractical due to differences in:

dependent variables, data collection techniques, and subject grouping stratifications (i.e. division, position, offense vs. defense, and starter vs. non-starters). Additionally, strength and power data are presented and analyzed as absolute, relative (force/body weight), percent change (delta), and as normalized values. Therefore studies that compare various types of test data to assess interrelationships among strength and power tests without standardization of tests produce erroneous conclusions to predict football-playing success. (1, 4, 5, 8, 15, 23, 28, 29)

Vertical jump ability has been identified as the most significant predictor of football playing ability and is an established test of lower-body power. The one-repetition maximum (1-RM) bench press, the power-clean, and the Olympic snatch are tests of upper-body power. The National Football League (NFL) 225 test consists of counting the number of repetitions completed with a 225 lb. load (21, 22). The range of repetitions varies from 0 to 30 and represents a measure of anaerobic muscular endurance and not power. However, the efficacy of these tests to predict football playing ability is inconsistent and controversial. (2).

While lower-body and upper-body power are vital in successful football competition. Most football tests focus on lower-body power, since two of the most commonly utilized upper-body power test require test skill acquisition of the entire body (power-clean and Olympic snatch). Consequently, the isotonic 1-RM bench press is the most commonly used upper-body football power test.

Power is a vital component of athletic performance and is often used to predict athletic success. Power is defined as the amount of work performed over time (31). Therefore, powerful individuals are able to recruit motor units quickly and will produce greater forces at higher velocities than less powerful individuals. Typically, as the velocity of movement increases, muscle force production decreases (31). Isotonic exercise involves movement through a range of motion with a constant load at variable velocities. Isotonic muscular contraction is limited to the load that can be moved at the weakest point in the range of motion, thus peak torque cannot be accurately assessed isotonically. Isokinetic machines allow maximal muscular contractions throughout the range of motion via accommodating variable resistance at pre-set and electronically controlled velocities. Isokinetic machines are designed to control velocity and reliably assess peak torque, average torque, endurance, work, and angular velocity (7, 12, 33). Therefore, the purpose of this study was to determine whether the isokinetic bench press could discriminate football-playing ability and to investigate the isokinetic bench press with other commonly used football upper and lower body power tests.

Methods

Subjects

Forty male NCAA Division-I college football players aged 18-23 years volunteered to participate in this study. Subjects were screened for any injuries or medical conditions via a health history questionnaire (see Appendix A). Prior to participation in the study, subjects read and signed a consent form (see Appendix B) approved by the University of Hawaii Human Studies Committee (see Appendix C).

Data Collection Procedures

All data were collected on separate days by the same investigator who is a National Athletic Trainers' Association, Board of Certification (NATABOC) Certified Athletic Trainer and National Strength and Conditioning Association (NSCA) Certified

Strength and Conditioning Specialist. Data collected were converted to reflect power per body weight (relative power) measures. Subjects were grouped according to playing ability. Starters (Group 1, n= 20) were classified as either first or second-string players, or the first or second player in the position depth chart who played the majority of the time during a game. Non-Starters (Group 2, n= 20) were classified as third or fourth string players, who had little to no game time. All subjects were experienced weight lifters who were familiar with the power testing procedures.

Vertical Jump Test. Vertical jump data were collected via the VERTEC, which is an adjustable column with 49 color-coded, moveable acrylic blades positioned at 1.27-cm (1/2-inch) intervals (5, 8, 22, 23, 28, 29, 34, 36). Subjects stood beneath the VERTEC machine, jumped up to reach the highest blade possible without taking any steps. The highest jump of 3-5 attempts was used as the criterion value. Vertical jump measurements were calculated by subtracting the subject's standing vertical reach height from the vertical jump criterion value. The Harman formula (9) was used to convert vertical jump values to power measures.

40-yard (36.59-meter) Dash Test. Forty-yard dash data were collected on a MONDO rubberized track surface via a SPEEDTRAP III Wireless Timing System (Brower Timing Systems) equipped with remote infrared sensors to measure sprint times to the nearest 0.01s. Time data collection began when subjects positioned on the starting line in a three-point stance lifted their hand from the starting line and stopped when subjects ran through the infrared beam. The fastest time recorded of one to five attempts was used as the criterion value.

1-RM Bench Press Test. One-RM bench press data were collected supine on a flat bench via a standard Olympic bar. Prior to data collection wooden calipers were used to measure drop distances using shoulder-width grip positions, with the arms fully extended and horizontally flexed 90° from the chest. Data collection began after a 5-10 repetition warm up at approximately 75% of the previous 1-RM bench press load. The highest 1-RM load of four to five attempts was used as the criterion value (3, 5, 6, 8, 11, 19, 23, 24, 28, 29).

Isokinetic Bench Press Test. Concentric isokinetic bench press data were collected via a Biodex Multi-Joint System 3 Pro Dynamometer (Biodex 3) in the following order at 60, 180, and 300°/s. The lift station was adapted with a prefabricated bench press attachment to simulate the isotonic bench press (see figure 1). Range of motion was set at 90° of elbow flexion to full elbow extension for every subject. Subjects performed a submaximal warm-up on the Biodex 3. No verbal encouragement was provided during data collection. Testing included two sets of five repetitions at each velocity with a 1.5-minute rest period between each set and five-minute rest period between each velocity. Subjects were instructed to extend their arm upward, simulating the concentric phase of the bench press, and instructed to passively allow the bar to be lowered to the starting position. The same verbal instructions were provided to all subjects prior to data collection (Appendix D).

Statistical Analyses

Four power measurements were used to assess football playing ability on Division I NCAA football starters and non-starters. Three 1 x 2 ANOVA's ($p<0.05$) were used to compare 40-yard dash times, vertical jump, and 1-RM bench press between starters and non-starters, respectively. Four x 2 and 3 x 2 ANOVA's with repeated measures ($p<0.05$) were used to compare isokinetic bench press peak torque at 60, 180, and 300°/s and 1-RM bench press and isokinetic bench press peak torque at 60, 180, and 300°/s between starters and non-starters, respectively. Tukey and Simple Effects post hoc tests were performed when significant differences or interactions were found. Subjects' height, weight, vertical jump, 40-yard dash, isokinetic bench press peak torque at 60, 180, and 300°/s, and 1-RM bench press were correlated via Pearson Correlation Coefficients. The Statistical Analysis System (SAS Institute, Inc., Cary, NC) was used to analyze all data.

Results

Age, height, and weight means and standard deviations for starters and non-starters are listed in Table 1. Subject demographic raw data are listed in Appendix E. One-RM bench press, vertical jump, and 40-yard dash means and standard deviations for starters and non-starters are listed in Table 2. One-RM bench press, vertical jump and 40-yard dash raw data are listed in Appendix E. The ANOVA summaries for 1-RM bench press, vertical jump and 40-yard dash data are presented in Tables 4, 5, and 6, respectively. Results indicated that starters had faster 40-yard dash times than non-starters. There were no significant differences between starters and non-starters for the 1-RM bench press and vertical jump. Isokinetic bench press peak torque means and standard deviations at 60, 180, and 300°/s for starters and non-starters are listed in Table 3. Isokinetic bench press peak torque at 60, 180, and 300°/s raw data are listed in Appendix E.

Table 1. Age, height, and weight means and standard deviations for starters and non-starters

Group*	Age (years)	Height (cm)	Weight (kg)
1	20 ± 1.14	184.06 ± 7.53	108.39 ± 20.38
2	20 ± 1.30	182.74 ± 5.09	104.14 ± 22.55
1 & 2 Averages	20 ± 1.20	183.40 ± 6.38	106.26 ± 21.33

* Group 1 (Starters), Group 2 (Non-Starters)

Table 2. 1-RM bench press, vertical jump and 40-yard dash means and standard deviations for starters and non-starters

Group*	1-RM Bench Press (ft-lb/lb)^	Vertical Jump (ft-lb/lb)~	40-yard Dash (sec)
1	2.299 ± 0.48	20.426 ± 3.70	5.06 ± 0.37
2	2.078 ± 0.51	18.861 ± 3.00	5.30 ± 0.35
1 & 2 Averages	2.191 ± 0.50	19.644 ± 3.40	5.18 ± 0.37

* Group 1 (Starters), Group 2 (Non-Starters)
^ denotes relative 1-RM bench press
~ denotes relative vertical jump power

Table 3. Isokinetic bench press peak torque means and standard deviations at 60, 180, and 300°/s for starters and non-starters

Group	IK^ @ 60°/s (ft-lb/lb)	IK^ @ 180°/s (ft-lb/lb)	IK^ @ 300°/s (ft-lb/lb)
1	1.201 ± 0.22	0.849 ± 0.13	0.743 ± 0.10
2	1.061 ± 0.22	0.794 ± 0.20	0.723 ± 0.25
1 & 2 Averages	1.131 ± 0.23	0.822 ± 0.17	0.733 ± 0.19

* Group 1 (Starters), Group 2 (Non-Starters)
^ denotes relative isokinetic bench press

Table 4. ANOVA Summary for 1-RM bench press of starters and non-starters

Source	df	F	P
Group	1	1.66	0.2053

Table 5. ANOVA Summary for vertical jump of starters and non-starters

Source	df	F	P
Group	1	1.07	0.3076

Table 6. ANOVA Summary for 40-yard dash of starters and non-starters

Source	df	F	P
Group	1	5.30	0.0274*

*significant at p<0.05

The ANOVA summary for isokinetic bench press at 60,180 and 300°/s and 1-RM bench press for starters and non-starters is presented in Table 7. Upper-body torque F value indicated significant ($p<0.05$) differences among isotonic 1-RM, isokinetic bench press at 60, 180, and 300°/s regardless of group. Tukey post hoc test results indicated significantly higher 1-RM bench press torque values than isokinetic bench press peak torque values at 60, 180, and 300°/s; higher isokinetic bench press peak torque values at 60°s/ than at 180 and 300°/s; and no significant difference between isokinetic bench press peak torque values at 180 and 300°/s.

The ANOVA summary for isokinetic bench press at 60, 180 and 300°/s for starters and non-starters is presented in Table 8. The F value revealed a significant interaction between groups and isokinetic bench press velocities. The simple effects post hoc test results indicated that starters produced greater peak torque values at 60°/s than non-starters.

Pearson Correlation Coefficient analysis revealed significant correlations among all measures in the present study (height, weight, isokinetic peak force at 60°/s, 180°/s and 300°/s, vertical jump, 1-RM bench press and 40-yard dash). Height and weight negatively correlated with all measures, except the 40-yard dash, indicating that taller and/or heavier football players produced higher (slower) 40-yard dash times. The demographic and performance correlations are presented in Appendix F.

Table 7. ANOVA Summary for isokinetic bench press at 60, 180, and 300°/s and 1-RM bench press for starters and non-starters

Source	df	F	P
Group	1	2.0100	0.1648
Velocity	3	372.49	<.0001*
Group vs. Velocity	3	1.3100	0.2753

*significant at $p<0.05$

Table 8. ANOVA Summary for isokinetic bench press at 60, 180, and 300°/s for starters and non-starters

Source	df	F	P
Group	1	1.690	0.2013
Velocity	2	163.07	<.0001*
Group vs. Velocity	2	3.600	0.0320

*significant at $p<0.05$

Discussion

Pearson Correlation Coefficient results of the present study are consistent with those of Berg et al., 1992; Black & Roundy, 1994; Fry & Kraemer, 1991; Mayhew et al., 1987; Miller et al., 2002, who also found that taller and/or heavier football players produced slower 40-yard dash times. Results of the present study indicated that 40-yard dash times of starters were significantly faster than non-starters Figure 1. These results are consistent with Arnold et al. (1980) and Seiler et al. (1990) who reported that 40-yard dash times for starting backs and linebackers were faster than non-starters; Black & Roundy (1994) and Fry & Kraemer (1991) who reported that the defensive line, linebackers, defensive backs, quarterbacks, and tight end starters had significantly faster 40-yard dash times than non-starters.

The vertical jump was the only power test utilized in all of the football studies relative to player ability (1, 4, 5, 8, 15, 23, 28, 29). Results of the present study revealed no significant differences in vertical jump values between starters and non-starters these findings are consistent with those of Arnold et al. (1980) and Seiler et al. (1990) Figure 2. This concurrence may be due to the fact that position comparisons were not made in the present study or the Arnold et al. (1980) and Seiler et al. (1990) studies allowing balancing of the starters and non-starters and washing out more finite differences in ability which were revealed by matching positions in other studies. Conversely studies that revealed significant differences in vertical jump data involved comparison by positions (8, 15, 23, 28), not football playing ability (starters vs. non-starters).

The isotonic 1-RM bench press is an established football upper-body power/ strength assessment test (4, 5, 8, 15, 23, 28). Results of the present study failed to reveal significant differences in 1-RM bench press values between starters and non-starters, this lack of differences may be attributed to the comparison by ability and not position Figure 3. Berg et al. (1992) and Mayhew et al. (1987) converted 1-RM bench press data into absolute and relative values and revealed conflicting results. Their contradictory findings may be attributed to the extreme differences in the football player numbers and abilities. Subjects in the Berg et al. (1992) study were NCAA Division I football players from 40 different institutions and eight different conferences. Subjects in the Mayhew et al. (1987) study were NCAA Division II football players from three institutions. Although Black & Roundy (1994), and Fry & Kraemer (1991), analyzed absolute 1-RM bench press data by individual positions, defensive/offensive line, linebackers, and offensive backs starters generally produced more force than non-starters.

To date the isotonic 1-RM bench press and the isokinetic bench press of football players has not been investigated or compared. Results of the present study indicated that starters and non-starters produced higher 1-RM bench press values than all isokinetic bench press peak torque velocity values; and higher isokinetic bench press peak torque values at 60°/s than at 180 and 300°/s Figure 4. The higher isotonic 1-RM bench press values of both groups may be attributed to the training and testing effect as all subjects trained and tested regularly with the isotonic bench press. The higher isokinetic bench press torque values revealed at 60°/s by all subjects may be attributed to the similarity in velocity of movement with regard to the isotonic 1-RM and isokinetic bench press at 60°/s and the learning effect at 180, and 300°/s.

Results of the present study indicated that football starters produced significantly greater isokinetic peak torque values at 60°/s than non-starters Figure 5. This significant

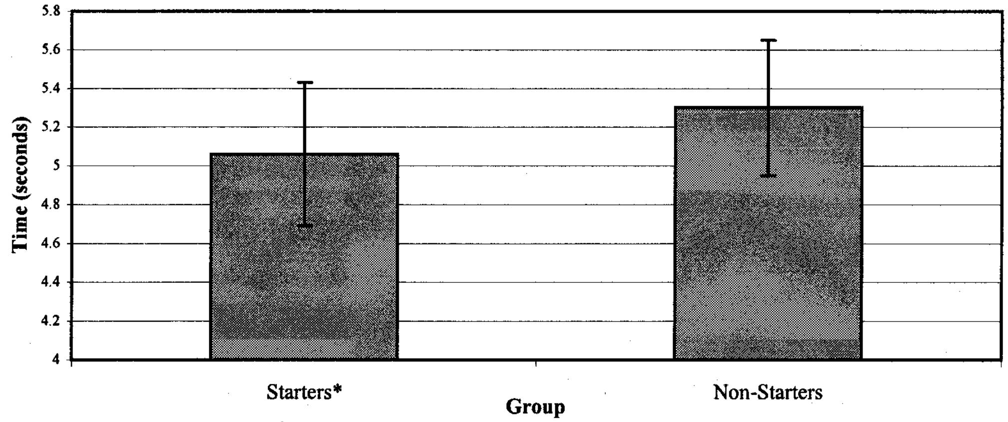

Figure 1. 40-yard dash means and standard deviations for starters and non-starters in seconds

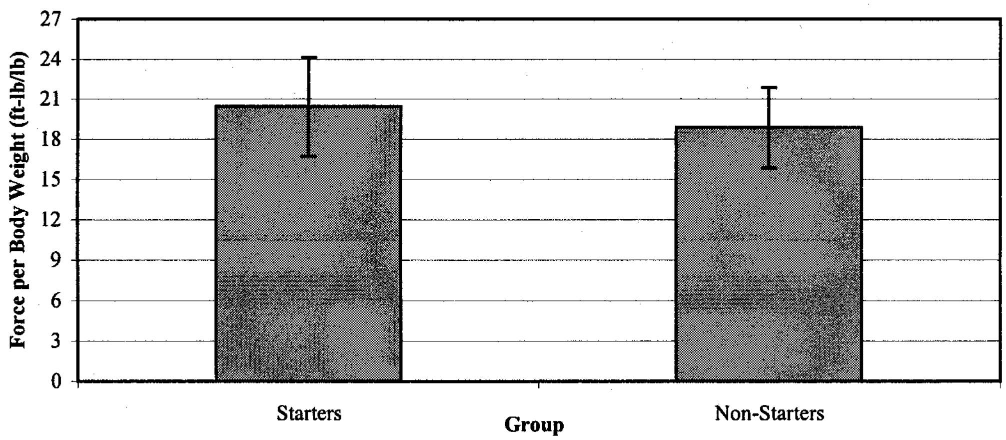

Figure 2. Vertical jump means and standard deviations for starters and non-starters in foot-pounds/pound

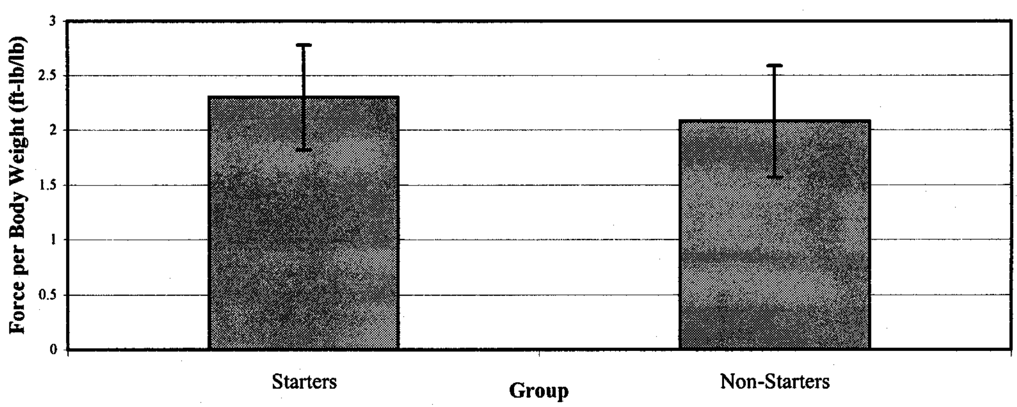

Figure 3. One-repetition maximum bench press means and standard deviations for starters and non-starters in foot-pounds/pound

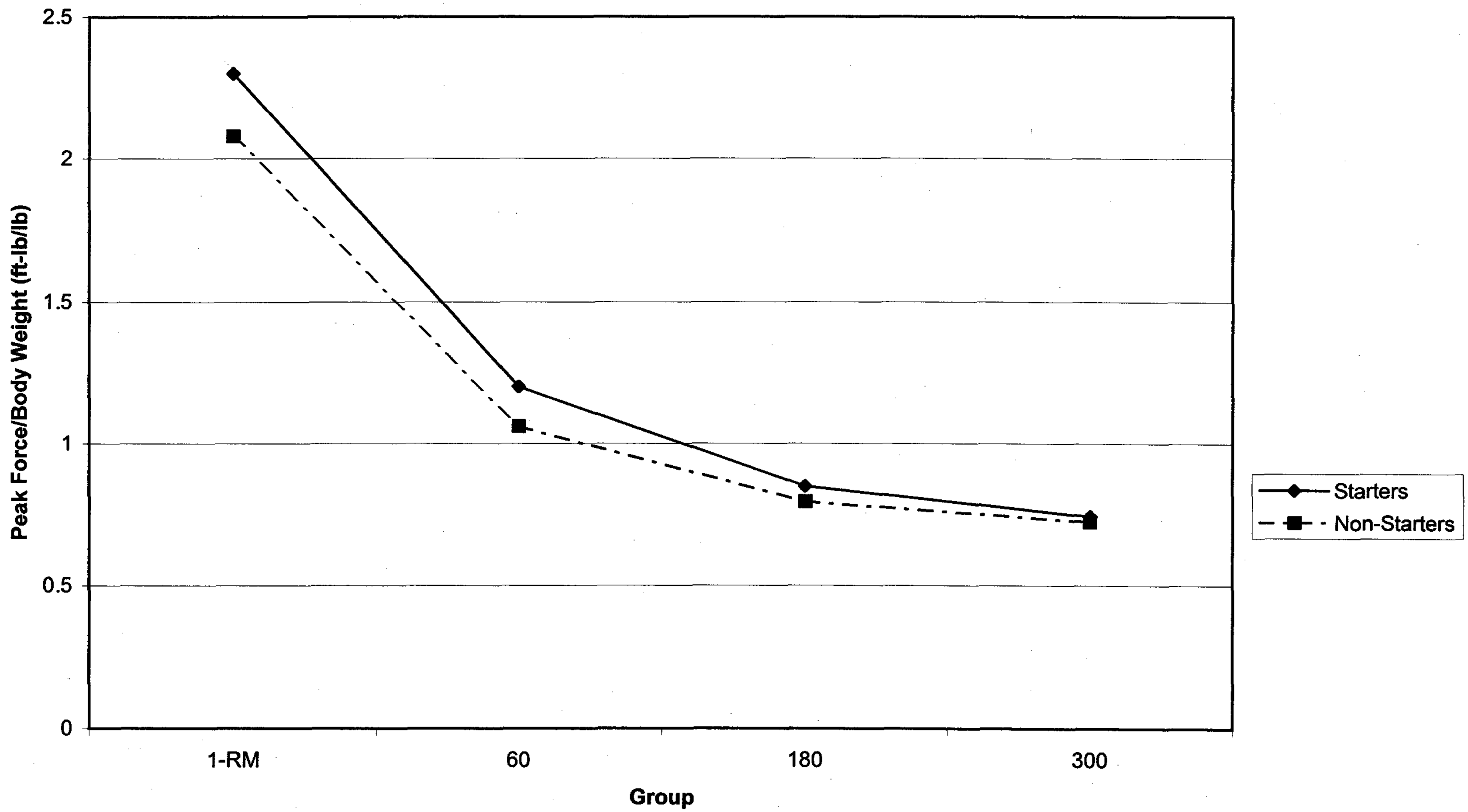

Figure 4. 1-RM and isokinetic bench press peak torque per body weight at 60, 180, and 300°/s

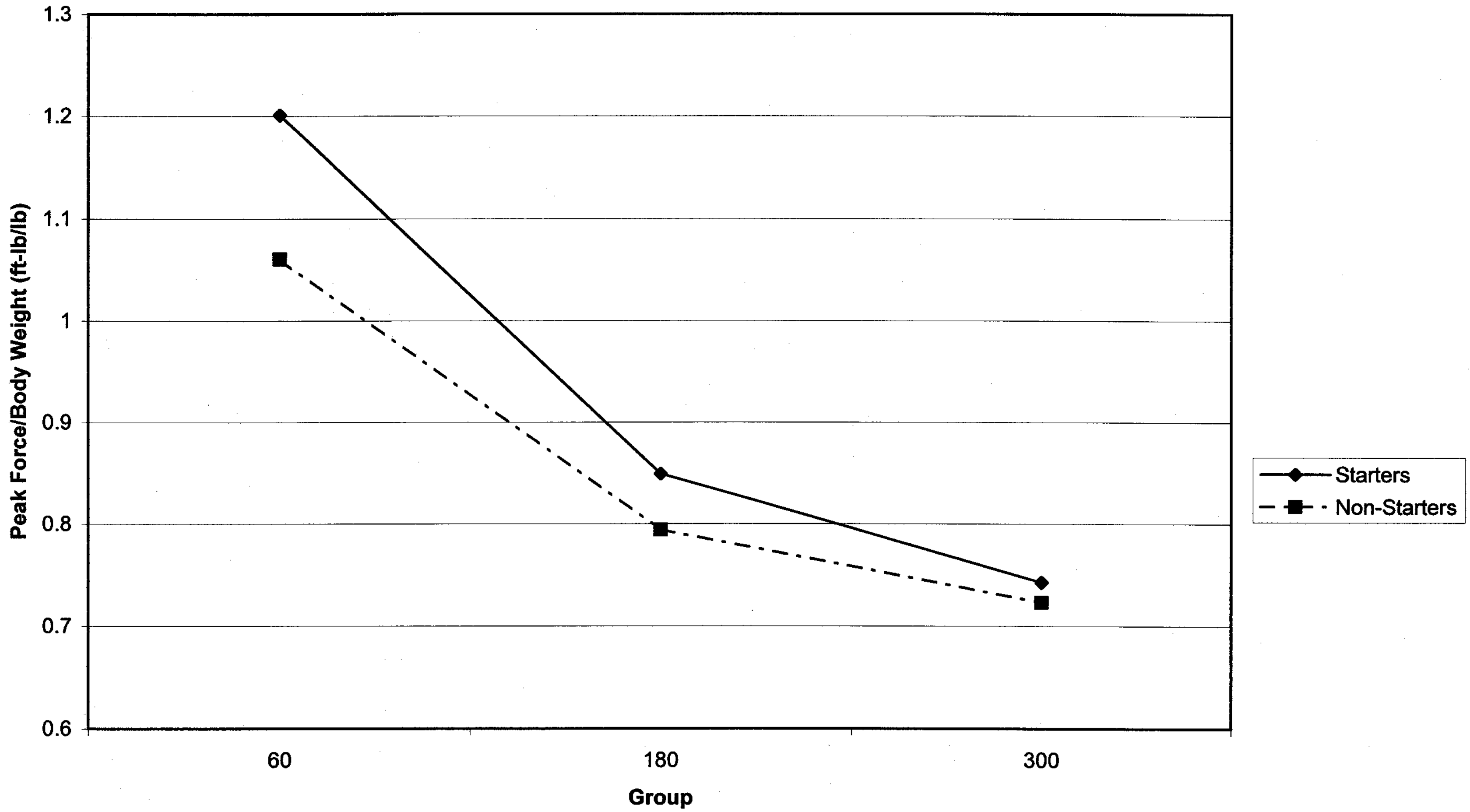

Figure 5. Isokinetic bench press peak torque per body weight at 60, 180, and 300°/s

difference was not revealed at the higher velocities. This contrast and lack of significant differences between groups at the higher velocities may be attributed again to the training effect associated with regular isotonic bench press exercise at the similar velocity of approximately 60°/s. Since subjects were not allowed to train or become intimately familiar with the novel isokinetic bench press experience at 180 and 300°/s peak torque production of both groups may have been affected by a learning effect. It is well documented that as isokinetic velocity increases subjects require more training to eliminate the learning effect (25). Training at high isokinetic velocities can provide valuable information relative to individual power since the ability to recruit muscle fibers decreases as velocity increases, thus torque production decreases. Powerful individuals have the ability to recruit motor units faster than less powerful individuals and thus produce greater torque. This information may be especially beneficial for football players whose responsibilities require upper-body power.

Conclusion

Isokinetic bench press can be used as an upper body power test to discriminate between starters and non-starters.

Recommendations for Future Studies

1. Replicate the study and incorporate isokinetic bench press training prior to testing.
2. Replicate the study by incorporating isokinetic bench press training into normal resistance training workouts.
3. Replicate the study comparing positions and isokinetic bench press test.
4. Replicate the study by utilizing different isokinetic bench press velocities.
5. Replicate the study using a larger sample size.

PART 2

REVIEW OF LITERATURE

Football Performance Studies Overview

Powerful athletes who possess the speed and explosiveness required for success in sprinting, jumping, and tackling dominate the sport of football. Power tests are vital tools for football success. However, since football positions and responsibilities vary widely prediction of successful playing ability from currently utilized football tests are often ambiguous. Football Tests used to quantify power/strength include: vertical jump, 40-yard sprint, 10/20-yard sprint, Margaria-Kalamen step test, broad jump, and Wingate anaerobic test, 1-RM bench press, squat, power-clean, and Olympic snatch these test primarily assess lower body power. The 1-RM is the primary upper body power test used in football, however safety issues and time constraints that have led the 1-RM bench press to be viewed as dangerous and impractical (35). As a result, strength coaches have moved to sub-maximal testing such as the 5-RM, YMCA-bench press test (13), or 225-repetition test (18) to estimate 1-RM bench press strength.

Performance variables compared by position

Miller, White, Kinley, Congleton and Clark (2002) investigated the relationship among body composition, body weight, player position and training period on performance tests used in football. Subjects were 261 Division I-A college football players who were divided into three groups by position: A (wide receivers, defensive backs, running backs), B (linebackers, kicker, tight ends, quarterbacks and specialists), and C (linemen). Performance tests included collecting 1-RM bench press, back squat, power clean, vertical jump, 20-yard shuttle and 40-yard dash data twice at unequal test intervals. One-RM data were recorded when the subject could not lift and or lower the selected weight with proper technique. Vertical jump data were collected via Vertec apparatus, and 20-yard shuttle and 40-yard dash data were collected via an electronic timer. Skinfold data were collected at the chest, abdomen, and mid-thigh sites via Skyndex electronic caliper that utilized the Jackson and Pollock formula to calculate body density. Data were normalized by subtracting the first percent change (delta) score by the last, then dividing by the first score.

Results indicated no linear regression relationships between performance and group or training period. A nonlinear increase in power clean, bench press and squat performance was observed as training time increased. No statistically significant trend was apparent between the vertical jump, 20- and 40-yard dash. Body weight increases positively correlated with power clean and vertical jump performance for all groups. Body fat increases negatively correlated with power clean and vertical jump performance in all groups. Increases in body fat were also negatively correlated with 20-yard shuttle and 40-yard dash in Group C. Group C (linemen) were stronger than Group A (wide receivers, running backs and defensive backs) for all measures (power clean, bench press, squat and vertical jump).

Sawyer, Ostarello, Suess, and Dempsey (2002) investigated the relationship between football playing ability and power performance on player position. Subjects were 40 Division I-A football players who were divided into three groups: 1) offensive and defensive line, 2) wide receivers and defensive backs, and 3) running backs, tight ends and linebackers. Performance tests included 1-RM bench press, squat, power clean, Olympic snatch, vertical jump, 9.1 and 18.2 m (10 and 20 yard) dashes, and shuttle run. One-RM data were recorded when the subject could not lift and or lower the selected weight with proper technique. Vertical jump data were collected via Vertec, 20-yard dash data were collected via photoelectric timing gates, and shuttle run data were collected via an electronic timer. Following testing, two offensive and two defensive coaches individually ranked each subject's football playing ability from highest (1) to lowest (21), disregarding position following testing. The average of the two coaches' ranking became the subject's football playing ability score.

Pearson product moment correlations were used to compare the relationships between football playing ability, anthropometric, and performance measures. The 18.2-m dash significantly correlated to football playing ability for Groups 2 and 3. The shuttle run significantly correlated to football playing ability for only Group 3. The bench press and power clean were significantly correlated with football playing ability for the defense group only. The vertical jump was the only measure that significantly correlated with football playing ability in all groups (offense, defense and position groups) and was the only measure used in all five regression equations. Forward stepwise regression was used to develop predictive models for football playing ability for each group. Results indicated the offensive and defensive line had greater absolute squat, bench press, and power clean strength, while the wide receiver and defensive back group had the lowest absolute squat, bench press and power scores. The vertical jump was the prime predictor variable in forward stepwise regression equations for each group.

Seiler, Taylor, Diana, Layes, Newton and Brown (1990) investigated the interrelationships among anaerobic power tests to determine if initial acceleration and maximal speed can be differentiated by football player position. Subjects were 41 University of Arkansas football players who were divided into three groups by position: group 1 backs (running backs, defensive backs, quarterbacks and wide receivers); group 2 linebackers (tight ends, full backs, and linebackers); group 3 linemen (defensive and offensive interior linemen). Wingate anaerobic test data were collected via a Monark cycle ergometer. The standing five-jump test consisted distance data collected when subjects jumping off two feet, landed on one foot and completing four additional jumps for distance, alternating legs before landing with both feet together. The Margaria-Kalamen test consisted of subjects running up a flight of nine stairs. Vertical jump data were collected via the highest chalk mark of the middle finger on a wall. Five and 40-yard dash time data were collected via a Dekan two-channel photoelectric timing system on an indoor Astroturf surface. Data collected were converted into absolute and relative power values for the Wingate anaerobic, vertical jump, and Margaria-Kalamen step tests.

A one-way ANOVA ($p<0.05$) was used to determine performance differences among the three position groups, followed by Scheffe post hoc tests to assess differences between specific groups. Results indicated that backs and linebackers produced similar power output/unit of body weight and the linemen produced less power output/unit body weight. Product moment correlations were used to examine inter-relationships between performances values and related measures. Forty-four of 45 correlations among power variables were significant ($p<0.05$). The common variance among variables suggested a high specificity among tests, however the authors concluded that the 40-yard dash was a poor predictor of initial acceleration and is not specific to the demands of a football team.

Performance variables compared by ability and/or football positions

Black and Roundy (1994) conducted a survey to investigate the relationships among size, strength, power and speed of football players by position and playing status. Subjects were 1,618 NCAA Division IA football players from 11 institutions divided into 16 groups by individual positions: nose tackle, defensive tackle, defensive end, inside linebacker, outside linebacker, cornerback, free safety, strong safety, offensive center, offensive guard, offensive tackle, tight end, wide receiver, quarterback, fullback and running back. Performance tests included collecting 1-RM bench press and back squat, vertical jump and 36.6-m dash data. The responding universities administered different tests, therefore the numbers of subjects in each group varied. Data collected were analyzed using absolute values.

A two-way (2x16) ANOVA was used to determine statistical significance ($p<0.05$) for each dependent variable (weight, bench press, back squat, vertical jump and 36.6-m dash) and Fisher's least significant difference test was used to determine post hoc multiple comparisons when significant F ratios were present. Significantly greater bench press strength for starters was observed for 10 of the 16 positions. Significantly greater squat strength for starters was observed for 6 of the 16 positions. Significantly faster 36.6-m dash times for starters were observed for 7 of the 16 positions. Significantly higher vertical jump values for starters were observed at the outside linebacker, cornerback, and wide receiver positions. Investigators used a bi-serial correlation coefficient test to assess the relationship between starters and non-starters scores that resulted in similar significant differences when compared the ANOVA. Generally, players who scored high on strength, power and speed tests were usually starters.

Berg, Latin and Baechle (1992) conducted a survey to investigate the relationships among size, strength, speed, and body composition of football players by individual positions. Subjects were 880 NCAA Division IA football players from 40 institutions divided into eight groups by individual positions: offensive line, quarterback, offensive back, tight end, wide receiver, defensive line, linebacker and defensive back. Performance tests included collecting 1-RM bench press and squat, vertical jump, body composition, and 40-yard dash data on starters only. Data collection methods of all tests were not consistent for each school. Bench press and squat data were also calculated into absolute and relative values.

Results indicated that the wide receivers had the greatest height, weight, body fat percentage, 40-yard dash times, power, absolute and relative 1-RM bench press, and squat values and the smallest vertical jump mean values. The quarterbacks, tight ends and defensive backs possessed the greatest vertical jump and smallest height, weight, body fat percentage, and 40-yard dash time mean values. The offensive line group had the smallest absolute and relative bench press and squat means.

Fry and Kraemer (1991) conducted a survey to investigate the relationship among football positions, playing ability, and caliber of play on performance tests used in football. Subjects were 981 NCAA football players from 19 institutions divided into six position groups (offensive backs, offensive line, receivers, defensive line, linebackers, and defensive backs), three divisions (Division I, II, and III), and two ability groups (starters and non-starters). The responding universities administered different tests, therefore the numbers of subjects in each group varied. Performance tests included collecting 1-RM bench press, back squat, power clean, vertical jump and 36.6 meter sprint (40-yard dash). One-RM data were recorded when the subject could not lift and or lower the selected weight with proper technique. Vertical jump data were collected via the highest point touched on a measuring tape attached to an adjacent wall. Data collected were analyzed using absolute values and were only used if the protocols were similar to the instructions specified in the survey.

One x 3 and 1 x 14 ANOVA's were used to compare test performance by division and player position, respectively. A 2 x 3 ANOVA was used to compare player ability and division for each position group. Tukey post-hoc multiple comparisons were used to determine significant differences ($p<0.05$). Eta coefficients were used to compare test scores and division. Point bi-serial correlations were used to compare test scores and playing ability. Results indicated the offensive back starters produced significantly higher bench press, squat and power clean values than non-starters. The offensive line group starters produced significantly higher bench press and vertical jump values than non-starters. The receiver group starters produced significantly higher bench press, power clean, 36.6-m sprint (40-yard dash) and vertical jump values than non-starters. All starter values in the defensive line group were significantly higher except the squat. Bench press, 36.6-m sprint (40-yard dash), and vertical jump starter values were significantly higher than non-starter values. All starter values of the defensive backs group were significantly higher than non-starter values except the bench press. The authors acknowledged that Division I athletes possessed significantly higher performance values than Division III athletes, and starters produced significantly higher values than non-starters in all six performance tests.

Mayhew, Levy, McCormick, and Evans (1987) conducted a survey to compare absolute and relative strength and power performance tests used in football. Subjects were 336 NCAA Division II football players from three institutions, divided into two groups: linemen, and backs. The responding universities administered different tests, therefore the numbers of subjects in each group varied. Performance tests included collecting 1-RM bench press, squat, power clean, vertical jump, and 40-yard dash data. One-RM data were recorded when the subject could not lift and or lower the selected weight with proper technique. Vertical jump data were recorded as subject jumped as high as possible and touched a measuring tape attached to an adjacent wall. Hand-help stopwatches were used to collect 40-yard dash times of 282 subjects. Absolute data collected were converted into relative power for 1-RM bench press, squat and, power clean tests.

Means and standard deviations were calculated for absolute and relative strength all four measures. Results indicated that linemen were significantly taller, heavier and produced greater absolute strength values than backs for all four measurements. Backs demonstrated significantly greater speed and jumping ability than linemen and produced greater relative strength values than linemen for all four measures. All four measures were not highly correlated and were considered independent aspects of strength. Multiple regression results to predict performance from strength measures indicated that body weight and power clean were significant prediction factors for speed and jumping ability.

Arnold, Brown, Micheli and Coker (1980) conducted a study to investigate college football playing success of 56 University of Arkansas football players. Dependent variables included: anatomical data (genu varum, tibial torsion, and internal and external hip rotation) collected via a goniometer; (hip abduction, knee extension, knee flexion and plantar flexion strength) collected via a cable tensiometer; anaerobic power data collected via the Margaria-Kalamen step test; 40-yard dash data collected via a Dekan photoelectric timing system; and balance ability via the Fleishmann's static balance test collected via a one by twelve inch board with the length of the foot parallel to the length of the board.

Polynomial regression and step-wise multiple regression was used to analyze the data. Following statistical analysis, tibial torsion, genu varum, height, body weight, Margaria-Kalamen step test and knee flexion were revealed as the best predictors of football playing ability. The use of a cable tensiometer and Fleishmann's static balance test were not effective predictors of football playing ability.

Reliability of the Biodex Multi-Joint System 3 Dynamometer

The reliability of the Biodex System 3 Dynamometer, a multi-joint testing and rehabilitation system has been established via several investigations (Kaminski, Drouin, and Valovich). However, no studies have documented the reliability of additional Biodex attachments such as the lift station, or other multi-joint attachments.

Drouin (2001) and Valovich (2001) examined the mechanical reliability of isokinetic velocity, torque and position measurements. Velocity was validated by placing a weighted lever arm into a gravity dependent position, and recording the velocity through a 90° range of motion. Torque was validated by hanging six different calibrated weights (5, 15, 25, 35, 50, 65 lb) from the lever arm, and recording torque using Biodex software. Position was validated by moving an un-weighted lever arm in 5° increments throughout the allowable range of motion. All measures were compared using Biodex criterion measures and protocols. Intra-class correlation coefficients were 0.99 for position and torque, and 0.97-0.99 for velocity, indicating the Biodex System 3 Dynamometer is valid and accurate measure of torque and position. Both studies however, found a systematic shift in velocity at velocities at or exceeding 300°/s.

Kaminski and Dover (2001) examined the physiological reliability of concentric isokinetic ankle (inversion and eversion) peak and average torque. Subjects were seated in the dynamometer chair with their knee and hip flexed to approximately 45°, and their talocrural joint plantar flexed to approximately 10°. Subjects performed five maximal test repetitions at 30°/s and 10 test repetitions at 120°/s according to the manufacturer's recommended protocol. After seven days, subjects returned to repeat the testing procedure. Intra-class correlation coefficients (ICC) for right-eversion were 0.54 (30°/s) and 0.68 (120°/s); left-eversion were 0.76 (30°/s) and 0.77 (120°/s); right inversion were 0.87 (30°/s) and 0.92 (120°/s); and left-inversion were 0.84 (30°/s) and 0.82 (120°/s) indicating the Biodex System 3 Dynamometer is a reliable measure of ankle inversion/eversion peak and average torque measures.

APPENDIX A

HEALTH HISTORY QUESTIONNAIRE

University of Hawaii at Manoa
Department of Kinesiology & Leisure Science
Medical History Form for Activity Courses

Name ______________________________ Date of Birth ______________

Parents' Names ______________________________ Date ______________

Address ____

Home Phone ____________ Work Phone ______________ Other ____________

Emergency contact person (if parents are not available).

Name ______________________________ Relationship ______________

Home Phone ______________________________ Work Phone ______________

Hospital Preference ______________________________ Phone ______________

Doctor Preference ______________________________ Office Phone ______________

Please identify any condition that you have or had that might restrict your participation in physical activity. If you answer yes to any of the following, please describe the proper aid requirements on the back of this sheet.

A. General Conditions	Circle One	Circle One or Both
1. Fainting Spells	Yes No	Past Present
2. Headaches	Yes No	Past Present
3. Convulsions/epilepsy	Yes No	Past Present
4. Asthma	Yes No	Past Present
5. High blood pressure	Yes No	Past Present
6. Kidney problems	Yes No	Past Present
7. Intestinal disorder	Yes No	Past Present
8. Hernia	Yes No	Past Present
9. Diabetes	Yes No	Past Present
10. Heart disease/disorder	Yes No	Past Present
11. Dentalplate	Yes No	Past Present
12. Poor vision	Yes No	Past Present
13. Poor hearing	Yes No	Past Present
14. Skin disorder	Yes No	Past Present
15. Allergies	Yes No	Past Present
specific ______________		Past Present
______________		
16. Joint dislocation or separations	Yes No	
Specify ______________		Past Present
______________		Past Present
17. Other ______________		Past Present
______________		Past Present

B. Injuries	Circle One	Circle One or Both
1. Toes	Yes No	Past Present
2. Feet	Yes No	Past Present
3. Ankles	Yes No	Past Present
4. Lower Legs	Yes No	Past Present
5. Knees	Yes No	Past Present
6. Thighs	Yes No	Past Present
7. Hips	Yes No	Past Present
8. Lower Back	Yes No	Past Present
9. Upper Back	Yes No	Past Present
10. Ribs	Yes No	Past Present
11. Abdomen	Yes No	Past Present
12. Chest	Yes No	Past Present
13. Neck	Yes No	Past Present
14. Fingers	Yes No	Past Present
15. Hands	Yes No	Past Present
16. Wrists	Yes No	Past Present
17. Forearms	Yes No	Past Present
18. Elbows	Yes No	Past Present
19. Upper arms	Yes No	Past Present
20. Shoulders	Yes No	Past Present
21. Head	Yes No	Past Present
Specify ______________		
22. Others ______________		Past Present
______________		Past Present

OVER

APPENDIX B

AGREEMENT TO PARTCIPIATE IN FORM

AGREEMENT TO PARTICIPATE IN

Prediction of Isotonic Bench Press Power via Isokinetic Exercise, Margaria-Kalamen Step tests, and Arm Volume

Joy K. Nakasuji, BS, ATC, CSCS
Graduate Student
University of Hawaii
College of Education
Department of Kinesiology and Leisure Science
1337 Lower Campus Road, PE/A Complex, Room 231
Honolulu, HI 96822

Phone #: 956-7144

1) Description
Thank you for participating in Fred Greener's study (thesis) "prediction Equations as an Alternative to 1-RM Testing." This "Agreement to Participate" represents an addition of 3 measurements, to Fred's study, isokinetic bench press, step test, and arm volume assessment. The principle investigator for this study (thesis) is a graduate student pursing a Master's degree in Athletic Training. The purpose of this study is to assess power using a Biodex System 3 Isokinetic Dynamometer Margaria-Kalamen step test and arm volume. This information will be utilized to formulate prediction equations to determine 1-repetition maximum (1-RM) bench press. Isokinetic exercise involves muscle contraction at a constant speed/velocity. The actual test will include maximal repetitions at 3 speeds/velocities. The Margaria-Kalamen step test involves a timed sprint up a 9 step staircase three steps at a time.

2) Procedures

Thank you for agreeing to participate in this additional piece of the study. Thus far you should have completed a medical history questionnaire, and PAR-Q (participation questionnaire) with Fred Greener. The first thing that you will be asked to do is to place your arm up to the arm pit in a rectangular column filled with room temperature water to measure the volume of your arm. Arm volume measurement will take 5 minutes. The next part of this study will include the isokinetic bench press test. Prior to the actual test, you will participate in a practice session to familiarize you with the Biodex System III Isokinetic Dynamometer and how isokinetic exercise feels at the 3 test speeds/velocities. The protocol for the familiarization and actual test are the same. The protocol will consist of three sets of fifteen repetitions at 60, 90, and 180 degrees per second. At least five minutes of rest will be provided to you between the familiarization/practice, the test will take 20 minutes to complete. The last part of this study involves the Margaria-Kalamen step test. This is a timed sprint up 9 stairs 3 steps at a time that begins with a 6 meter sprint to the base of the staircase.

A timing system (touch plates) will be utilized to record your start to finish time. Prior to the actual step test, you will be instructed on the test procedures and allowed a practice, the practice and test sessions will take no more than 5 minutes. The total time for these additional measurements will be 30 minutes and will be performed in the Department of Kinesiology & Leisure Science Research Laboratory (B-108), located across the Duke Kahanamoku Swimming Complex.

3) Confidentiality

The entire protocol will be held confidential. The researchers and you will be the only persons present in the laboratory while these measurements are being assessed, your name or identity will not be shown or indicated on any report of these data. All data and subject (identity) information will be kept under lock and key in the Department of Kinesiology & Leisure Science Research Laboratory. These materials will be permanently disposed of in a period not longer than 5 years.

4) Right to Withdraw

This exercise is strictly voluntary and you may withdraw at any time without prejudice.

5) Benefits

Upon completion of the study, you will receive a better understanding of your strength and power. After the study is finished your results will be provided to you upon request. The proposed research is aimed at formulating an accurate prediction equation for a 1-RM bench press, an indicator of muscular power. Participating in this research may increase your strength gains by allowing the strength and conditioning specialists to have a more accurate measurement of muscular power.

6) Risks

Due to the high intensity of the activity involved, there is always the risk of injury; and, although very remote, possibly a cardiac event. In the event of any physical injury from the research procedure, only immediate and essential medical treatment is available. You should understand that if you are injured in the course of this research procedure that you alone may be responsible for the costs of treating your injuries.

Certification

I certify that I have read and that I understand the foregoing, that I have been given satisfactory answers to my inquiries concerning project procedures and other matters and that I have been advised that I am free to withdraw my consent and to discontinue participation in the project or activity at any time without prejudice.

I herewith give my consent to participate in this project with the understanding that such consent does not waive any of my legal rights, nor does it release the principal investigator or the institution or any employee or agent thereof from liability for negligence.

Signature of Participant:________________________________Date:__________

Signature of Investigator:________________________________Date:__________

If you cannot obtain satisfactory answers to your questions or have comments or complaints about your treatment in this study, contact: Committee on Human Studies, University of Hawaii, Spalding Hall 252B, 2540 Maile Way, Honolulu, HI 96822

Phone: (808) 956-5007

APPENDIX C

COMMITTEE ON HUMAN STUDIES APPROVAL LETTER

MEMORANDUM

December 11, 2002

TO: Joy K. Nakasuji, ATC, CSCS
Principal Investigator
Department of Kinesiology & Leisure Science

FROM: William H. Dendle
Executive Secretary

SUBJECT: CHS #12116- "Predictions of Isotonic Bench Press Power Via Isokinetic Exercise, Margaria-Kalamen Step Tests & Arms Volume"

Your project identified above was reviewed by the Chair of the Committee on Human Studies through Expedited Review procedures. The project qualifies for expedited review by CFR 46.110 and 21 CFR 56.110, Category (7) of the DHHS list of expedited review categories.

This project was approved on December 10, 2002, for one year. If in the active development of your project you intend to change the involvement of humans from plans indicated in the materials presented for review, prior approval must be received from the CHS before proceeding. If unanticipated problems arise involving the risks to subjects or others, report must be made promptly to the CHS, either to its Chairperson or to this office. This is required in order that (1) updating of protective measures for humans involved may be accomplished, and (2) prompt report to DHHS and FDA may be made by the University if required.

In accordance with the University policy, you are expected to maintain, as an essential part of your project records, all records pertaining to the involvement of humans in this project, including any summaries of information conveyed, data, complaints, correspondence, and any executed forms. These records must be retained for at least three years from the expiration/termination date of this study.

<u>The CHS approval period for this project will expire on December 10, 2003</u>. If your project continues beyond this date, you must submit a continuation application to the CHS at least four weeks prior to the expiration of this study.

We wish you success in this endeavor and are ready to assist you and your project personnel at any time.

Enclosed is your certification for this project.

Enclosure

APPENDIX D

STANDARDIZED VERBAL INSTRUCTIONS

Standardized Verbal Instructions

You are going to be asked to perform one to two warm-up repetitions (50% effort), followed by five maximal repetitions (100% effort) of concentric bench press contractions at each speed. The warm-up repetitions allow you to feel how fast the bar will be allowed to move. Continue doing the repetitions until I tell you to stop. Remember to push the bar up as fast and hard as you can and allow the bar to return to the starting position before immediately performing the next repetition. No verbal encouragement will be given to you during the test. Just remember to push the bar up as fast and hard as you can.

If at any time during the exercise you experience severe discomfort or feel that you must terminate the exercise, please tell me immediately. Any questions? You will begin the exercise when I say, "GO!"

APPENDIX E

SUBJECT RAW DATA

Appendix E-1. Subject demographic raw data

Subject	Group*	Position^	Off/Def~	Age (yr)	Height (cm)	Weight (kg)
1	NS	DB	D	19	177.8	89.09
2	NS	DB	D	21	176	88.64
3	NS	DL	D	22	188	106.8
4	NS	DL	D	20	188	134.5
5	NS	LB	D	19	170.8	86.82
6	NS	LB	D	20	176.5	95.91
7	NS	LB	D	21	186.7	97.27
8	NS	OL	O	21	180.3	114.1
9	NS	OL	O	20	196.9	141.8
10	NS	OL	O	18	184.2	114.1
11	NS	OL	O	18	188	133.2
12	NS	OL	O	20	194.3	149.1
13	NS	OL	O	18	193	138.6
14	NS	QB	O	20	180.3	87.73
15	NS	QB	O	20	196.9	109.1
16	NS	QB	O	19	186.7	98.64
17	NS	RB	O	20	184.2	101.4
18	NS	RB	O	20	180.3	99.09
19	NS	WR	O	19	174.6	85.45
20	NS	WR	O	18	177.8	96.36
21	S	DB	D	20	176.8	83.64
22	S	DB	D	19	181.6	77.27
23	S	DB	D	21	184.2	79.55
24	S	DB	D	21	174.8	84.55
25	S	DL	D	20	184.4	112.3
26	S	DL	D	21	194.3	103.6
27	S	LB	D	21	182.9	99.55
28	S	LB	D	19	176.8	97.73
29	S	LB	D	21	180.3	110.5
30	S	LB	D	20	182.9	100.9
31	S	LB	D	20	180.3	99.09
32	S	OL	O	19	186.7	133.2
33	S	OL	O	19	183.9	121.8
34	S	OL	O	22	190	146.8
35	S	OL	O	20	189.2	152.3
36	S	OL	O	18	188	131.7
37	S	QB	O	21	182.9	85.45
38	S	RB	O	20	180.6	97.27
39	S	WR	O	22	176.5	82.73
40	S	WR	O	23	177.8	83.18

* denotes Group 1 Starters (S) and Group 2 Non-Starters (NS)

^ denotes positions: defensive backs (DB), defensive linemen (DL), linebackers (LB), offensive linemen (OL), quarterbacks (QB), running backs (RB), wide receivers (WR)

~ denotes Defense (D) and Offense (O)

Appendix E-2. 1-RM bench press, vertical jump and 40-yard dash raw data

Subject	1-RM Bench Press* (ft-lb/lb)	Vertical Jump^ (ft-lb/lb)	40-yard Dash (sec)
1	3.1661	24.146	4.87
2	2.9468	23.91	4.76
3	1.9822	17.454	5.36
4	1.74	15.365	5.96
5		22.033	5.20
6		18.341	
7	2.3963	20.691	5.22
8	2.3396	18.958	5.26
9	1.9442	13.895	5.95
10	2.3024	15.955	5.42
11	1.6625	16.19	5.65
12	2.4413	14.336	5.87
13	2.0351	17.739	5.40
14	2.2033	19.827	5.04
15	1.8987	18.066	5.30
16	1.0834	19.236	5.17
17	1.9569	19.823	5.15
18	1.6576	17.608	4.90
19		23.426	5.10
20	1.5657	20.226	5.21
21	1.9381	21.782	4.80
22	2.5928	29.744	4.70
23	3.0558	23.607	4.48
24	3.2017	22.301	4.82
25	2.37	20.244	4.84
26	2.7119	21.434	4.82
27	2.2029	19.436	4.90
28	2.7234	18.494	5.06
29		19.185	5.27
30	2.0587	20.642	4.91
31		20.001	
32	1.7361	17.773	5.39
33	1.7043	13.329	5.68
34	1.9621	15.089	5.69
35	1.7633	17.058	5.75
36	1.8267	18.053	5.39
37	2.1215	19.725	5.15
38	1.9972	21.504	4.90
39	2.4161	22.845	4.84
40	2.993	26.271	4.70

* denotes relative 1-RM bench press

^ denotes relative vertical jump power

Appendix E-3. Isokinetic bench press at 60, 180, and 300°/s raw data

Subject	IK^ @ 60°/s (ft-lb/lb)	IK^ @ 180°/s (ft-lb/lb)	IK^ @ 300°/s (ft-lb/lb)
1	1.3141	0.9781	1.1776
2	1.1959	0.9245	0.7959
3	1.1949	0.8034	0.7487
4	0.7524	0.5667	0.5088
5	1.3782	0.9503	1.1415
6	1.137	0.8181	0.8431
7	1.1464	0.7318	0.4155
8	1.0733	0.971	0.7318
9	0.9843	0.7323	0.5997
10	1.1028	0.753	0.75
11	0.6823	0.6033	0.5906
12	1.0954	0.781	0.6515
13	0.7983	0.552	0.4497
14	1.26	0.9111	0.8453
15	0.7774	0.63	0.5856
16	0.6643	0.462	0.2704
17	1.0819	0.7551	0.744
18	1.0406	0.6475	0.4908
19	1.4489	1.3108	1.1495
20	1.0813	1	0.9743
21	1.1873	1.1044	0.7597
22	1.3149	0.896	0.8149
23	1.4532	0.9156	0.7543
24	1.3605	1.0319	0.9438
25	0.8414	0.7577	0.631
26	1.2038	0.9258	0.8212
27	1.2711	0.8697	0.8316
28	1.3677	0.9092	0.7226
29	1.1744	0.7943	0.7081
30	1.1566	0.8591	0.6391
31	1.7269	0.9634	0.6843
32	1.0374	0.8831	0.754
33	1.0945	0.7806	0.7125
34	0.9333	0.7267	0.6897
35	0.9015	0.674	0.5508
36	1.0719	0.7136	0.5993
37	0.9656	0.6869	0.7273
38	1.2519	0.7607	0.7816
39	1.22	0.6892	0.8713
40	1.4849	1.0442	0.861

^ denotes relative isokinetic bench press

APPENDIX F

CORRELATION MATRIX

Appendix F-1. Demographic and performance correlations

	Height (cm)	Weight (lb)	IK^ 60°/s (ft-lb/lb)	IK^ 180°/s (ft-lb/lb)	IK^ 300°/s (ft-lb/lb)	VJ~ (ft-lb/lb)	1-RM BP* (ft-lb/lb)	40-yd Dash (s)
Height (cm)	1.000000	0.72052 <.0001	-0.59664 <.0001	-0.60016 <.0001	-0.63384 <.0001	-0.56567 0.0001	-0.37393 0.0269	0.57289 0.0002
Weight (lb)		1.000000	-0.60580 <.0001	-0.51764 0.0006	-0.50709 0.0008	-0.79962 <.0001	-0.46668 0.0047	0.86226 <.0001
IK^ 60°/s (ft-lb/lb)			1.000000	0.77159 <.0001	0.64170 <.0001	0.56726 0.0001	0.73233 <.0001	-0.61265 <.0001
IK^ 180°/s (ft-lb/lb)				1.000000	0.77916 <.0001	0.53849 0.0003	0.61402 <.0001	-0.50535 0.0014
IK^ 300°/s (ft-lb/lb)					1.000000	0.49758 0.0011	0.59554 0.0002	-0.42704 0.0084
VJ~ (ft-lb/lb)						1.000000	0.59531 0.0002	-0.86653 <.0001
1-RM BP* (ft-lb/lb)							1.000000	-0.59329 0.0002

^denotes isokinetic bench press peak force
~denotes vertical jump
*denotes bench press

APPENDIX G

HYPOTHESES

Hypotheses

1. There will be no difference in isokinetic bench press at 60, 180, and 300°/s between starters and non-starters.
2. There will be no difference in isokinetic bench press at 60, 180, 300°/s, and isotonic bench press between starters and non-starters.
3. There will be no difference in vertical jump between starters and non-starters.
4. There will be no difference in isotonic 1-RM bench press between starters and non-starters.
5. There will be no difference in 40-yard dash times between starters and non-starters.

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