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The Importance of Lower Body Strength and Power for Future Success in Professional Men's Basketball

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Abstract: *Heavy resistance exercise is often prescribed for collegiate basketball players to enhance game performance, but few data are available concerning the transference of lower body strength and power to the opportunity to play professionally after college. This study investigated if lower body muscular power and strength measures obtained during the barbell squat are related to future professional playing opportunities. The data was collected over a seven year period from a collegiate men's basketball program (n=37; X±SD, age=20.0±1.4 yrs, hgt=1.98±0.09 m, bw=94.5±11.8 kg). Lower body strength was determined from 1 repetition maximum (1RM) tests of the parallel high-bar squat. Maximum lower body squat power was determined from speed squat testing across a load spectrum (30-90% 1RM) while an external tethered dynamometer or a 3-D video motion capture system quantified barbell power. Repeated measures ANOVA with Tukey's HSD post hoc, Spearman ρ correlations, and Cohen's D effect sizes were used to analyze the results. Subjects who subsequently played in the NBA or in professional leagues elsewhere had greater lower body strength and power. This was mainly attributed to their greater body mass, since strength and power relative to body mass was not different between the groups. Even without statistically significant differences, effect sizes consistently indicated moderate to large differences between the NBA and other professional groups when compared to those who did not play professionally. Regardless, lower body strength and power were related to post-collegiate playing opportunities, with greater values related to higher levels of professional play.*

Key words: *player evaluation, sport, assessment, sports testing, college sports.*

Introduction

In the modern world, basketball is one of the most popular and internationally played sports. A large number of participants, especially young adults, contemplate and work towards achieving a goal of playing at various levels of professional basketball competition. While many foreign countries host various well established and successful professional basketball teams allied with multiple international basketball federations, the National Basketball League (NBA) is still considered the highest level of competition.

Basketball is a sport that involves continuous repetitive numbers of sprints with short recovery times and requires players to possess high levels of agility, strength, anaerobic and aerobic conditioning in order to satisfy all physiological demands *(Hoffman, 2003)*. Previous research revealed that a professional basketball player during a competitive game in duration of 48 minutes changes movement 997 ± 183 times with a direction change every 2 seconds *(McInnes, Carlson, Jones, McKenna, 1995)*. Considering that during a regulation game period an average player performs approximately 105 ± 52 high-intensity sprints, we can conclude that 15% of game time is spent at a high-intensity level *(McInnes, Carlson, Jones, McKenna, 1995)*. Sport specific and sport performance coaches are always in search of any variable that can serve as a reliable and valid indicator for the overall sport performance. For a long time, development of athlete strength characteristics, especially lower body, was believed to be highly correlated with improvement in overall athletic performance. While it is beneficial for basketball players to possess certain levels of upper body strength, exponential improvements in squat 1RM performance demonstrated superior relationship with maximal vertical jump, speed and agility variables when compared to improvements in 1RM bench press *(Hoffman, Tenenbaum, Maresh, Kraemer, 1996)*. Besides direction changes (i.e., agility), ability to quickly cover the distance and rapidly accelerate can be highly beneficial during fast break opportunities. Considering that a length of an NBA basketball court is 28.65m, the ability to beat the defender and gain an initial sprint advantage can lead to a potential scoring opportunity. When studying a cohort of elite basketball players, researchers found that 5m and 10m sprint performances were highly correlated with lower body 1RM squat values, which emphasized the importance of incorporating squat as one of the most fundamental lower body exercises in a typical strength and conditioning program for basketball players (*Chouchani, Brughelli, Chamari, Levin, Abdelkrim, Laurencille, Castagna, 2009)*. Furthermore, while lower body strength is highly related to change of direction performance, eccentric maximal strength by itself can serve as a reliable indicator of change of direction ability *(Spiteri, Nimphius, Hart, Specos, Sheppard, Newton, 2014*). A recent meta-analysis demonstrated the importance of lower body resistance training and strength transfer for sprint performance improvements up to 3.11% *(Seitz, Reyes, Tran, deVillarreal, Haff, 2014)*. Other research has emphasized the importance of sport performance tests that are highly applicable to the nature of the sport and playing position. It is suggested that 5m and 10m sprint ability combined with agility tests such as a T-test or 5-0-5 test, should be incorporated into power-related testing since they highly correlate with on-court basketball performance *(Wen, Dalbo, Burgos, Pyne, Scanian, 2018)*. Based on previously reported data, we can recognize the importance of properly designed strength and conditioning programs focused on enhancing in-game basketball performance requirements.

In the game of basketball, there are five distinct playing positions: point-guard, shooting-guard, small-forward, power-forward and center. It is important to consider that anthropometric differences and on-court tasks are not identical and are highly dependent on playing position which can greatly influence physiological demands. Previous research has revealed significant differences in anthropometric characteristics between playing positions even though these differences were not significant selection criteria for professional levels of play *(Sallet, Perrier, Ferret, Vitelli, Baverel, 2005; Delextrat, Cohen, 2009).* When Wingate anaerobic tests, suicide runs, T-tests and single leg jump tests were administrated to national caliber female basketball players, it was found that guards possess superior peak and mean power outputs compared to forwards for each of these tests *(Delextrat, Cohen, 2009).* A similar study focusing on professional male basketball players found that T-test, 10m and 30m sprint performance were superior for forwards and guards when compared to centers, however centers exhibited greater lower body leg flexor strength *(Koklu, Alemdaroglu, Kocak, Erol, Findikoglu, 2011)*. It has also been reported that VO_2 max capacities for male basketball players can range between 42-59 $ml•kg^{-1}•min^{-1}$ and indicated that despite non-significant differences guards tend to have higher VO_2 max values on both professional and collegiate levels of competition *(Hoffman, 2003; Sallet, Perrier, Ferret, Vitelli, Baverel, 2005).* However, basketball players need to rely on aerobic capacity, and research indicates that anaerobic capacity is a greater predictor for level of competition than aerobic capacity *(Hoffman, 2003; Sallet, Perrier, Ferret, Vitelli, Baverel, 2005)*. Additionally, basketball shooting performance is highly corelated with anaerobic capacity and explosive power *(Pojskic, Sisic, Separovic, Sekulic, 2018).* Besides differences in playing position, training regimen and anaerobic capacity, Gonzales and colleagues found that starters at the collegiate basketball level of competition were more likely to have higher vertical jump power outputs compared to non-starters. Similarly, starters at the NBA level of competition had greater capability to increase vertical jump power even though squat power values were not significantly different from non-starters *(Gonzales, Hoffman, Rogowski, Burgos, Manalo, Weise, Fragala, Stout, 2013; Gonzales, Hoffman, Scallin-Perez, Stout, Fragala, 2012).*

Each year, basketball players have a chance to participate in the NBA draft combine where each basketball player demonstrates their performance capabilities. When body size, power-quickness and upper-body strength were observed, surprisingly body size was one of the most significant positive markers for determining successful future basketball performance, while power-quickness did not reach significance *(Teramoto, Cross, Rieger, Maak, Willick, 2018).* The findings of this study are contrary to our expectations and the previously mentioned research emphasizing the importance of power-quickness characteristics. In addition, it is important to mention that the NBA possesses a specific playing style where a major emphasis is placed on scoring. Even though steals, and offensive and defensive rebounds play critical roles in the overall quality of a player, the ability to score is an important skill for future success. Furthermore, it was reported that the ability to score during a collegiate career is positively related to future NBA draft positions *(Berri, Brook, Fenn, 2011).*

It is interesting to note that lower body strength testing is not integrated into NBA draft combine procedures. Based on the previously presented research we can assume that there is a potential positive relationship between lower body strength and power and on-court playing performance. Even though physical and performance testing at the NBA draft combine have been effective for many years, we also realize that additional forms of athlete testing of collegiate basketball players may potentially help identify important performance characteristics that contribute to later professional capabilities. Hence, the purpose of this study was to determine the qualities of lower body strength and power for male collegiate basketball players who subsequently play professional basketball. Our hypothesis was that lower body muscular strength and power measures obtained during barbell squat testing may serve as good indicators for prospective drafting success and the ability to compete in various professional basketball leagues.

METHODS

Members of an NCAA Division-I collegiate men's basketball team over a seven year period were subjects for this study (n=37; X±SD, age=20.0±1.4 years, height=1.98±0.09 m, body weight=94.5±11.8 kg). Data were analyzed for each player who had completed his collegiate playing career. This was either due to using all years of their playing eligibility (4 or 5 years) according to NCAA regulations, or due to becoming a professional player before their eligibility was completed. Players were divided into three groups; one group who continued playing basketball professionally in the National Basketball Association (NBA; n=10), another group who played professionally in the other basketball leagues around the world (Pro; n=8), and the final group who did not continue to play basketball after their collegiate careers were completed (Non-Pro; n=19).

Maximal parallel barbell squat strength (1 repetition maximum; 1RM) was determined during a regular weight room training session, from which loads were determined for each subject at 30%, 40%, 50%, 60%, 70%, 80% and 90% 1RM. Squat power testing was performed during a training session approximately two weeks later. After a brief warm-up, each subject was instructed to perform 1-3 maximal effort speed-squats at each intensity, with increasing loads for each set. As the load increased, subjects were allowed to perform fewer repetitions per set with the minimum being one repetition at the highest load. Each subject descended at a volitionally controlled velocity, followed by a maximal velocity ascension from the bottom position. Proper depth for each squat was determined by one or more members of the testing team. Acceptable squat depth in this study was set as the posterior thigh parallel to the ground. Repetitions that did not descend to appropriate squat depth were not recorded.

Squat mean powers for the barbell were determined in one of two manners. Initially, an external dynamometer (Tendo, Fitrodyne, Bratislava, Slovakia) was attached by a nylon tether to the end of the barbell (Eleiko, Halmstad, Sweden) to determine mean barbell power. Barbell loads to the nearest kg (no body mass) were entered into the external dynamometer, so the results represent external barbell power. Results were monitored for each load to determine when power began to decrease with increasingly heavier loads. In the event that the mean power recorded had not begun to decrease at the highest intensity, additional heavier loads (5-7% increases) were lifted until mean power exhibited a decrease. Data collected in the later stages of the study were collected using a 3-D camera motion capture system that monitored barbell movements (EliteForm, Lincoln, NE). This system sampled data at 30 Hz, and calculated kinetic and kinematic variables of interest in a manner similar to the Tendo unit. Agreement between these devices for mean power during the barbell squat exercise at all measured relative intensities was consistently within the 95% CI and exhibited a mean difference between the testing modalities of 17.5 W (unpublished data).

The repetition with the greatest mean concentric bar power for each relative load was used for data analysis. For each subject, a 2^{nd} order polynomial regression, forced through the origin, was calculated to find the line of best fit for the bar power-load relationship. The peak of each subject's bar power-load curve was identified as the individual's maximum squat bar power. An example curve with the resulting maximum power is shown in Figure 1.

Figure 1. *Example curve for a squat bar power-load curve as used in the present study.*

A 2nd order polynomial curve that was fitted to the data and forced through the origin. The maximum bar power is indicated by the arrow.

Statistical Analyses

Results are reported as X±SD. A 1 x 3 ANOVA was used to determine differences between the three groups of subjects, with significant main effects further examined with Tukey HSD post hoc analyses. Additionally, Cohen's D effect sizes using pooled group standard deviations were used to compare group data as compared to the Non-Pro group. Spearman rho (ρ) correlations identified relationships between subject groups and maximum squat power. Additionally, a X^2 analysis was used to determine if each of the player positions (i.e., centers, forwards, guards) were similarly represented in each subject group (NBA, Pro or Non-Pro). The resulting data for each subject was analyzed using SPSS statistical software (Version 25, SPSS Inc. Chicago, IL, USA). Due to the exploratory nature of this project, significance levels were set at p<0.10.

Results

Results of the group comparisons indicate significant differences between the NBA and the Non-Pro groups for body weight, 1RM squat strength, and maximum squat bar power (p<0.10; see Figure 2). When squat strength and bar power were adjusted for body weight, no differences between groups were observed (data not shown). Spearman **ρ** correlation coefficients between the player groups and body weight, 1RM squat strength, and maximum squat barbell power were all significant (p<0.05). Additionally, effect sizes for the NBA group compared to the Non-Pro group were large for every variable (D= 0.83-0.97), and moderate to moderately-large for the Pro group (D= 0.47-0.73). A X^2 analysis indicated there were no differences between groups for player position distributions (p<0.05).

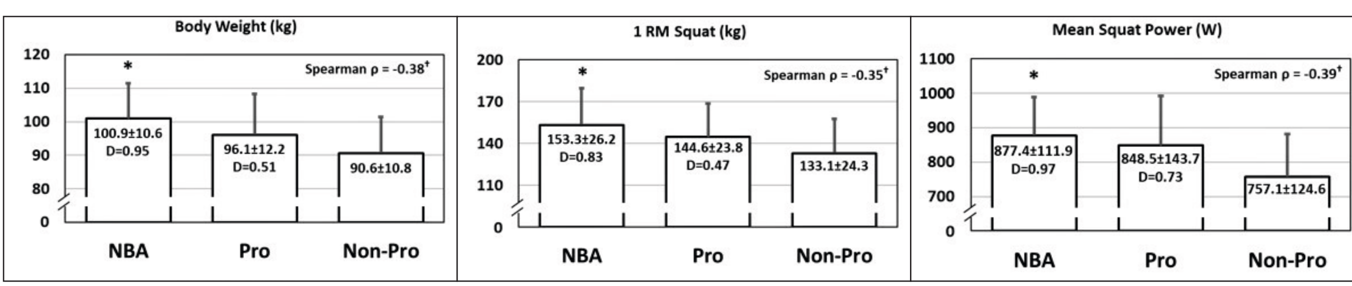

Figure 2. *Group comparisons (X±SD) for body weight, 1 RM squat strength, and maximum squat bar power.*

*NBA (n=10) are players drafted by the NBA, Pro (n=8) are players who signed contracts with other professional leagues, and Non-Pro (n=19) are players who did not play after college. *p<0.10 different from Non-Pro †p<0.05 for Spearman ρ correlations.*

Discussion

Based on our findings, high levels of lower body strength and power of collegiate basketball players are associated with the future ability to compete at professional levels of competition. The barbell squat is one of the most fundamental lower body exercises, and is often incorporated into resistance training regimens of basketball players. With the development of technology designed to measure and record resistance exercise kinetic and kinematic data during individual training sessions and over long training phases, we are now capable of quantifying important variables that may be associated with future performances and the ability to compete at the highest level of basketball competition, the NBA.

There are number of previous reports across a broad spectrum of sports that demonstrated strong relationships between weight room performances and sport performances *(Kraemer, Ratamess, Fry, Triplett-Mcbride, Koziris, Bauer, Lynch, Fleck, 2000; Lucero, Fry, LeRoux, Hermes, 2019; Fry, Honnold, Hudy, Roberts, Gallagher, Vardiman, Dellasega, 2011, Fry, Kraemer, Weseman, Conroy, Gordon, Hoffman, Maresh, 1991)*. Furthermore, one of the studies reported differences in performance characteristics between three American football divisions of the National Collegiate Athletic Association (NCAA) level of play, and found that tests such as vertical jump, sprint ability and power cleans were significantly different among the groups *(Fry, Kraemer, 1991)*. The cohort of basketball players analyzed in the present study was purposely recruited by the coaching staff to play at one of the highest ranked basketball programs in NCAA Division-I level. It is assumed that their performance and basketball playing skills were highly superior compared to many of their peers, thus, attracting interests of the basketball coaches and resulting in the opportunity to compete at this level of competition. Even within this elite cohort of basketball players, however, individual differences in performance variables were obvious. Our subject pool included all basketball players that were eligible to compete within the span of seven basketball seasons. This time frame also included high level prospects that pursued an NBA career upon completion of just one year of playing eligibility at the collegiate level. Regardless of their length of stay at the collegiate level of competition, our results indicate that as long as player's lower body strength and power may have contributed to their ability to secure playing position at the NBA level of competition or other professional levels.

In addition, when physical performance variables were observed between three professional divisions in a European professional basketball league, Korkmaz et al. found that the major factors that could potentially be used to distinguish between an individual's ability to play at their particular level of competition were vertical jump performance and lean body mass *(Korkmaz, Karahan, 2012)*. Even though vertical jump was not measured in the present study, it is well-established that improvements in 1RM squat strength is positively related with improvements in vertical jump performance *(Comfort, Stewart, Bloom, Clarkson, 2014; Channell, Barfield, 2008; Wisloff, Castagna, Helgerund, Jones, Hoff, 2004)*. Therefore, we may assume that our observations of statistically significant differences between the NBA players and the other groups are related to the findings of the Korkmaz et al. *(Korkmaz, Karahan, 2012)*. In addition, since heavy squats are consistently being performed in the weight lifting room, we can potentially use these already collected data as valid and reliable measures in additions to other assessments such as vertical jump testing. With performance monitoring devices such as used in this study, we may be able to decrease testing times and establish supplementary variables of interest that can provide us with a better understanding of individual athletic performance potential.

A recently published article indicated that the average height for all the players participating in the NBA in 2008 was 195.6cm, which is slightly lower when compared to the 198cm average height of the players participating in this study (Davidson, 2011). It has been reported that body size is one of the most important factors for selection success in the NBA draft *(Teramoto, Cross, Reiger, Maak, Willick, 2018)*. Based on our data, we can conclude that lower body strength and power, as examined in this study, might provide an additional insight bedsides body size that would aid in determining prospects for the future NBA draft potential. Future research should focus on determining how weight room performance variables translate to competition performances in other sports, and which other kinetic and kinematic variables should be incorporated.

Conclusion

In conclusion, these data supports the importance of lower body strength and power for enhanced opportunities to play at the professional level in men's basketball. Lower body strength and power were related to post-collegiate playing opportunities, with greater values being related to higher levels of professional play. Each of these variables are readily enhanced with a properly designed strength and conditioning program, suggesting that including exercises that enhance muscle hypertrophy as well as strength and power such as squats and power cleans should be included in a regular training program for this sport.

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