RELATIONSHIP BETWEEN SQUAT STRENGTH AND STANDING LONG JUMP PERFORMANCE AND SPRINT PERFORMANCE

A Thesis
by
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Abstract

RELATIONSHIP BETWEEN SQUAT STRENGTH AND STANDING LONG JUMP PERFORMANCE AND SPRINT PERFORMANCE

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It is well documented that maximal strength of the lower body plays a role in performance of common athletic movements involving the lower body. Less studied is the relationship of the depths and angles achieved during the standing long jump (SLJ) to other performance measures. In addition, ground reaction forces (GRF) in vertical and horizontal planes during the SLJ have not been studied. The purpose of this investigation was to examine horizontal displacement and the GRF attained in the SLJ with varying squat depths and projection angles. In addition, we investigated the relationships between squat strength, sprinting ability, and SLJ. Thirteen recreationally active males (age: 20.77±1.69 years; height: 176.11±4.52 cm; mass: 76.21±6.11 kg; squat 1RM: 118.00±54.70 kg; 1RMr: 1.78±0.30 kg/m; 5 yard sprint: 1.15±.05 s; 10 yard sprint: 1.86±.07 s; 40 yard sprint: 5.22±.17 s; SLJ: 229.62±14.19 cm) performed a one repetition maximum back squat (1RM), a 40 yard sprint with five and 10 yard splits, and 18 SLJs. Subjects randomly performed three jumps at each of the six types of jumps: self-selected angle (SSA), lower angle (LA), higher angle (HA), self-selected depth (SSD), deeper

depth (DD), and shallow depth (SD). A significant negative correlation was observed between the SLJ and five yard sprints (*r* = -0.74) and 10 yard sprints (*r* = -0.79), and a moderate correlation was observed between the SLJ and 40 yard sprints (*r* = -.050). A non-significant correlation was seen with the 1RM back squat relative to body mass (1RMr) and SLJ performance (*r* = 0.31), five (*r* = -0.47), 10 (*r* = -0.45), and 40 yard (*r* = -0.40) sprints. Vertical impulse (VI) generated during DD jumps was significantly greater than both SSD and LD; however, SD jumps produced a non-significant greater distance than DD and SSD. Horizontal impulse (HI) was not significantly different for any jump type. Resultant impulse (RI) and resultant velocity (RV) were all significantly greater in the HA condition compared to the LA and SSA. A moderate, non-significant correlation was observed between VI and distance jumped when all six jumps were considered (*r* = 0.41). No other correlations existed between GRFs and jump distance in all six jumps. There were moderate non-significant correlations with the best distance jumped from the self-selected trials and VI (*r* = 0.539), horizontal peak force (HPF) (*r* = 0.43), and resultant peak power (RPP) (*r* = 0.48). In conclusion, SLJ performance and sprinting times at 5, 10, and forty yards are well correlated. Sprinting at these distances also produced a moderate correlation with relative back squat strength. SLJ performance was only weakly correlated to relative back squat strength. In addition, VI only moderately correlated to SLJ performance while other measures of GRF showed nothing.

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Introduction

Many investigations have shown the relationship between relative strength and sprinting ability at distances ranging from 5-40 yards (Brechue, Mayhew, & Piper, 2010; McBride et al., 2009; Peterson, Alvar, & Rhea, 2006; Requena et al., 2009). Furthermore, several investigations have shown a relationship between vertical jumping performance, such as a countermovement jump (CMJ) and squat jump (SJ), and sprinting ability (Brechue, et al., 2010; Marques, Gil, Ramos, Costa, & Marinho, 2011; Maulder & Cronin, 2005; Requena, et al., 2009; Smirniotou et al., 2008; Vescovi & McGuigan, 2008; Young, Cormack, & Crichton, 2011). Relative squat strength has also been correlated to these vertical jumps (Brechue, et al., 2010; Peterson, et al., 2006; Stone et al., 2003). Limited data is available concerning standing long jump (SLJ) performance and measures of squat strength. Relative 1RM back squat and SLJ performance have been shown to be highly correlated (r = 0.814, $p < 0.01$) (Peterson, et al., 2006). Sprinting and horizontal jumps have also been studied less than their vertical counterparts, but some correlations have been found (Brechue, et al., 2010; Hudgins, Scharfenberg, Triplett, & McBride, 2012; Maulder & Cronin, 2005).

Significant negative correlations exist in football players relative squat strength and sprint times at both ten yards (r = -0.544, p = 0.024) and 40 yards (r = -0.605, p = 0.010), and approached significance at five yards (r = -0.4502, p = 0.069) (McBride, et al., 2009). Similar results were found at 36.6 meters ($r = -0.53$). This relationship was further shown with soccer players sprinting at 15m ($r = -0.47$, $p < 0.05$) (Requena, et al., 2009). These studies show a clear relationship between the ability to produce force in the back squat exercise and lower sprint times between five and 40 yards. Vertical jumping and its relationship to back squat strength have been well documented (Peterson, et al., 2006). Significant ($p < 0.01$) correlations ($r = 0.85$) with back squat strength and CMJ have been shown (Peterson, et al., 2006). Standing long jump performance has been less studied than vertical jumping in its relationship to the back squat exercise. A strong correlation ($r = 0.81$, $p < 0.01$) has been found between the two in one study involving collegiate athletes (Peterson, et al., 2006). Short sprinting ability at 5m has been correlated ($r = -0.70$) with CMJ height (Marques, et al., 2011). A weak correlation ($r = -0.43$) in football players between acceleration and CMJ height has also been found (Young, et al., 2011). Distances of 40 yards were also moderately correlated ($r = -0.78$) with jump height (Brechue, et al., 2010). Longer distance of 100m were also correlated with both the SJ and CMJ (Smirniotou, et al., 2008).

Correlations with collegiate sprinters found that triple jump performance correlated ($r = -0.71$ to -1.00) to race times that ranged from 60 to 5000M. A mixture of collegiate athletes have shown significant correlations with SLJ and both sprint acceleration ($r = 0.83$, $p < .01$) and sprint velocity ($r = 0.86$, $p < .01$). Stronger relationships were found with horizontal jumps than vertical jumps and their relationship to 20 meter sprint times (Maulder & Cronin, 2005). This would suggest that a SLJ might better predict performance of sprint times in comparison to vertical jumps. The need for the ability to produce force in both a vertical and horizontal direction during both SLJs and sprinting might offer some rationale for this, but little other research exists.

Depth of squatting during a CMJ has been shown to relate to vertical displacement in a SJ and CMJ (Kirby, McBride, Haines, & Dayne, 2011; McBride, Kirby, Haines, & Skinner, 2010). Squat depth during a SLJ and its relationship to horizontal displacement is unknown. While a vertical jump obviously involves a projection angle of about 90 degrees, a SLJ can be performed with varying angles of projection. The influence of changing projection angle in the SLJ to horizontal displacement has been examined in only one investigation of which I found (Wakai & Linthorne, 2005). The changes in ground reaction forces (GRF) in both the horizontal and vertical planes have not been studied during a SLJ. These variables may also change when the angle of projection and depth of the counter movement are changed. Through the use of computer models, optimal jump height should be achieved by an individual at the deepest squat depth (Bobbert, Casius, Sijpkens, & Jaspers, 2008; Domire & Challis, 2007). It has also been determined that a strong correlation exists between jump height and impulse produced during the concentric portion of a countermovement and static jump (Kirby, et al., 2011; McBride, et al., 2010). Both of these variables increased with increasing squat depths (Kirby, et al., 2011; McBride, et al., 2010). This occurrence of increased jump height from a larger depth can be explained by realizing that a deeper depth would give an individual a larger amount of time in the concentric portion of the jump. Since impulse is determined by force and time, a larger time would result in a larger impulse (Figure 1). This increased impulse would correlate to an increased take-off velocity and increase in jump height.

The SLJ is different from a normal vertical jump because the goal of the movement is to propel the center of mass (COM) forward instead of strictly upwards. The resultant distance jumped in a SLJ is also more than just the displacement of the COM. The distance between the feet and COM at take-off and landing also determines the final distance that is recorded. All of these variables are influenced by other factors such as the take-off projection angle of the subject (Wakai & Linthorne, 2005). It has been shown that lower take-off angles will result in a longer jump (Wakai & Linthorne, 2005). Researchers found that an optimal angle of projection may be between 19 and 27 degrees; however, the optimal angle may be even lower if spiked shoes were worn to increase traction at take-off (Wakai & Linthorne, 2005). Using lower take-off angles is thought to increase the resultant take-off velocity. This increase in velocity may be the most important aspect to a SLJ. Take-off velocity can be determined by impulse through previously mentioned kinematic functions.

Previous research has demonstrated that strength is a good predictor of jump height and running performance, but the relationship between strength and SLJ performance (horizontal displacement) has been studied less. SLJ performance and its relationship to running ability has only been moderately studied but has the potential to be a better predictor of running performance than vertical jumps (Maulder & Cronin, 2005). The greater depths obtained during a vertical jump, such as the CMJ or SJ, has been shown to increase jump height, but the results of different depths obtained during a SLJ have not been studied previously (Kirby, et al., 2011; McBride, et al., 2010). The resulting horizontal displacement from a SLJ in relation to projection angle and its possible varying relationship to squat strength and sprinting ability is also not clear. GRF in both the vertical and horizontal planes have also not been studied previously. The purposes of this investigation were to examine the relationships between squat strength, sprinting ability, and SLJ, and to examine horizontal displacement and the GRF attained in the SLJ with varying squat depths and projection angles.

Methods

Subjects

Thirteen (n = 13) recreationally active male subjects (20.77 ± 1.69 years) between the ages of 18 and 25 were recruited from the general population (Table 1). All subjects had greater than two years of regular strength and/or power training. Participants were asked to complete the AHA/ACSM screening tool to ensure physical preparedness required in this study. Subjects who were at moderate or high risk of a cardiovascular event were excluded. This study was approved by the institutional review board at Appalachian State University. All subjects signed an informed consent form prior to testing.

Study Design

Participants in this investigation visited the Holmes Convocation Center's Neuromuscular & Biomechanics Laboratory (NBL) for two testing sessions that lasted approximately one hour each. The two sessions were separated by at least 48 hours. On day one, height and weight were obtained for each subject. After a standardized five minute warm-up on a cycle ergometer, each subject's five, ten, and 40 yard sprint ability were determined. This was followed by a one repetition maximum (1RM) back squat exercise to determine the subjects' maximum strength. On day two, subjects randomly performed a set of jumps as outlined below after the same five minute warm-up they completed on day one.

1RM Strength Testing

The squat test involved a warm-up protocol involving 2 sets of 8-10 repetitions at 30%, 4-6 repetitions at 50%, 2-4 repetitions at 70%, and 1 repetition at 90% of an estimated 1RM or 1.5-2.5 times their bodyweight, depending on training status. The load prescription was subject to the research assistant's discretion. Subjects were allowed up to 3-4 attempts at increasing weights to obtain their 1RM. Each subject began the squat by standing with his feet shoulder-width apart, with the barbell positioned on his upper back. He needed to squat down to a knee angle of 80 degrees, as determined by the researcher, and return to a standing position. Squat performance was monitored by a Certified Strength & Conditioning Specialist (CSCS), in accordance with the National Strength & Conditioning Association guidelines.

Jumping Procedures

On day two, subjects performed a total of 18 trials of a standing long jump with one minute of rest allowed between each trial. Subjects performed three jumps at each of the six types of jumps: self-selected angle (SSA), lower angle (LA), higher angle (HA), self-selected depth (SSD), deeper depth (DD), and shallow depth (SD). Subjects randomly chose SSD or SSA to be performed first. DD and SD always directly followed SSD while HA and LA always directly followed SSA (Figure 2). For the SSA and SSD jumps, subjects were instructed to think of the jumps as a normal SLJ. To attain a LA jump, subjects were told to stay lower to the ground at take-off and were instructed to jump more vertically in the HA compared to their SSA. To complete a DD jump, subjects were instructed to attain a greater amount of hip, knee, and ankle flexion; and in the SD, less hip, knee, and ankle flexion in comparison to the SSD condition. It was emphasized that no matter the jump trial, maximal horizontal displacement was the goal. All jumps were performed with the subjects standing on a force plate with their toes on a line marked with athletic tape. The subjects were instructed to drop down slightly and then explode upwards and outwards attempting to jump as far (horizontally) as possible. The distance jumped was determined by a tape measure secured to the floor. Standing long jump performance was monitored by a Certified Strength & Conditioning Specialist (CSCS), in accordance with the National Strength & Conditioning Association guidelines.

Sprinting

Sprint times of the 40 yard dash as well as five yard and ten yard splits were measured using an infrared timing system (Brower Timing Systems, Draper, UT) performed on a standard track surface. The researcher started the clock based on the subjects' first initial movements. No assistance such as running or starting technique was given during the study, nor was any encouragement given. The subject was instructed to run as fast as possible during the test and to make sure to run all the way through the clearly marked finish line.

Data Analyses

The data from all jumps was collected and analyzed using a force plate (Kistler Instrumente AG Winterthur, CH-8408 Winterthur, Schweiz). Using the horizontal and vertical forces generated, actual angle of projection was determined. Peak power, relative impulse, peak force, and velocity were computed from the force plate and were recorded. Total horizontal displacement was also recorded with a tape measure.

Statistical Analyses

T-tests were used to determine differences in PF, PP, JH and relative VI between the different squat depths and angles. Pearson's product correlations were utilized to determine if any relationships existed between selected variables. The significance level was set at $p \leq 0.05$ for all statistical analyses. All statistical analyses were completed using a statistical software package (SPSS Version 20.0, SPSS Inc., Chicago, IL).

Results

A significant negative correlation was observed between the SLJ and five yard sprints (r = -0.74) (Figure 3). A significant negative correlation was observed between the SLJ and 10 yard sprints (r = -0.79) (Figure 4). A moderate negative correlation was observed between the SLJ and 40 yard sprints (r = -0.50) (Figure 5). A non-significant correlation was seen with the 1RM back squat relative to body mass (1RMr) and SLJ performance (r = 0.31) (Figure 6). Non-significant negative correlations were observed between 1RMr and sprinting performances of five (r = -0.47), 10 (r = -0.45), and 40 yards (r = -0.40) (Figure 7-9). Vertical impulse (VI) generated during DD jumps was significantly greater than both SSD and LD; however, SD jumps produced a non-significant greater distance than DD and SSD (Table 2). Horizontal impulse (HI) was not significantly different for any jump type. Resultant impulse (RI) and resultant velocity (RV) were all significantly greater in the HA condition compared to the HA and SSA. A weak, non-significant correlation was observed between VI and distance jumped when all six jumps were accounted for (r = 0.41). No other correlations existed between GRFs and jump distance in all six jumps. There were weak to moderate, non-significant correlations with the best distance jumped from the self-selected trials and VI (r = 0.539), horizontal peak force (HPF) (r = 0.43), and resultant peak power (RPP) (r = 0.48) (Table 3).

Discussion

This investigation found that five, ten, and 40 yard sprints were correlated to SLJ performance in recreationally trained collegiate males. Similar results were shown previously (Brechue, et al., 2010; Maulder & Cronin, 2005; Peterson, et al., 2006). Many investigations have shown the relationship between relative strength and sprinting ability at distances ranging from 5-40 yards long (Brechue, et al., 2010; McBride, et al., 2009; Peterson, et al., 2006; Requena, et al., 2009). The present study only discovered moderate or weak correlations. Furthermore, the 1RMr was only weakly correlated with SLJ performance. The differences found in this study may relate to the training history of the subjects. Although all were physically active, some participated more in weight training programs and others participated more in general sports. Weight training's effects on jumping and sprinting ability have been well documented (Comfort, Haigh, & Matthews, 2012; Cormie, McGuigan, & Newton, 2010; Harries, Lubans, & Callister, 2012; Keiner, Sander, Wirth, & Schmidtbleicher, 2013; Otto, Coburn, Brown, & Spiering, 2012). Increases in speed in young soccer players have been demonstrated with additional back and front squat training (Keiner, et al., 2013). Rugby players were shown to decrease 20m sprint time during eight weeks of strength and power training (Comfort, et al., 2012). It was concluded that resistance training has a positive effect on vertical jump performance after a meta-analysis of 25 different studies (Harries, et al., 2012). The involvement in other sporting activities may also allow participants to jump farther and run faster, but their lack of participation with weight training, more specifically the back squat, may cause lower 1RMr values (Cormie, et al., 2010). Both back squat training and power training with vertical jumps could increase jump performance and sprinting ability, but only the back squat training group increased their 1RMr values (Cormie, et al., 2010). Kettle bell power training and weight training could also increase jumping performance, but only the weight training group improved strength (Otto, et al., 2012). Also, taller subjects may have been at an advantage during the SLJ because of their ability to increase the start of their COM upon take-off and stretch their legs out at the end of the jump to achieve a greater distance jumped without increasing the actual amount their COM moved (Lees, Vanrenterghem, & De Clercq, 2004). They also could have been at a disadvantage for the back squat due to their need to push a weight for a longer period of time throughout the squat motion.

VI was increased during the DD condition in comparisons to both SSD and SD. This result was expected since the greater flexion of the ankle, knee, and hip joints that you have (the lower you go) the more time you have to generate force. Since impulse is the product of force and time, the increases seen make sense. VI has only previously been studied in vertical jumps and researchers found similar results to an increased impulse (Kirby, et al., 2011; McBride, et al., 2010). The previous studies, however, showed an increase in performance (jump height), but the present study only found moderate correlations and found no differences in SLJ performance between groups. This may be explained by the lack of increase in HI and RI between trials. The lack of change in RI would mean no change in RV which would also mean that the COM was not propelled any further. The only increases seen in RI and RV were seen in the HA jumps. Increases in RV were seen previously at lower angled jumps, and was thought to be the reason for increased SLJ performance (Wakai & Linthorne, 2005). LA jumps in this investigation however did not prove to have a greater RV or SLJ distance. The increase in RV would mean that the potential for their COM to be propelled further would be increased; however, there are many other factors that contribute to SLJ performance in addition to the change of COM (Wakai & Linthorne, 2005). As previously demonstrated, raising a subject's COM through the use of an arm swing contributed to 28% of the performance increase from the arm swing (Lees, et al., 2004). The ability to stretch out their legs in front of their COM at the end of the jump could also help enhance SLJ performance (Wakai & Linthorne, 2005). Furthermore, take off angle is a factor that could change SLJ performance (Wakai & Linthorne, 2005). These variables were not measured, so it is uncertain which of these may have led to a lack of performance increase after RI and RV were increased.

To better control for some of these factors, arm swing should have been eliminated. Arm swing can contribute an additional ~15% to take-off velocity and raises COM at take-off (Ashby & Delp, 2006; Cheng, Wang, Chen, Wu, & Chiu, 2008). The arm swing also enables the jumper to swing the arms backwards during the flight phase to alleviate excessive forward rotation and position the body segments properly for landing (Ashby & Delp, 2006). Therefore, some of the extra distance gained from take-off position and landing position may have been minimized. Restricted arm movement also reduces activation levels of the ankle, knee, and hip joint torque (Ashby & Delp, 2006).

SLJ performance and sprinting times at five, ten, and forty yards are well correlated. Sprinting at these distances also produces a moderate correlation with relative back squat strength. SLJ performance was only weakly correlated to relative back squat strength. In addition, VI only moderately correlated to SLJ performance while other measures of GRF showed nothing. The reasons for the lack of association may be explained by the complexity of the SLJ in comparison to vertical jumps. The technique involved in producing the maximal amount of horizontal displacement requires more than the simple displacement of the body's COM. For this reason, it may be harder to show relationships between the SLJ and GRF and strength measures; however, the similarities of the need of both vertical and horizontal force generation in both sprinting and the SLJ may still prove the usefulness of the SLJ has a performance measure and predictor of performance. More research will need to be done on the factors that enable optimal SLJ performance.

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Table 1: *Subject Anthropometrics and Strength and Power Measurements* (Mean ± SD)

Subject #:	n = 13
Age, years	20.77 ± 1.69
Height, cm	176.11 ± 4.52
Body Mass, kg	76.21 ± 6.10
Body Fat, %	13.15 ± 5.18
Squat 1RM, kg	118.00 ± 54.70
Squat 1RMr, kg/bm	1.77 ± 0.29
Five Yard Sprint, s	1.15 ± 0.05
10 Yard Sprint, s	1.86 ± 0.07
40 Yard Sprint, s	5.22 ± 0.17
SLJ, cm	229.62 ± 16.79

Table 2: T-test p values between jump trials

	SLJ Distance	VI	VPF	HI	HPF	RPF	RI	RV	RPP
DDvSD	0.135	0.000	0.001	0.859	0.013	0.001	0.968	0.968	0.015
HAvLA	0.495	0.855	0.308	0.749	0.177	0.520	0.001	0.001	0.006
SSDvDD	0.991	0.008	0.085	0.675	0.079	0.054	0.853	0.853	0.105
SSDvSD	0.153	0.092	0.017	0.519	0.348	0.021	0.878	0.878	0.249
SSAvHA	0.628	0.804	0.892	0.357	0.262	0.896	0.275	0.274	0.622
SSAvLA	0.240	0.985	0.386	0.605	0.731	0.468	0.032	0.033	0.046

*VI = Vertical Impulse, VPF = Vertical Peak Force, HI = Horizontal Impulse, HPF = Horizontal Peak Force, RPF = Resultant Peak Force, RI = Resultant Impulse, RV = Resultant Velocity, RPP = Resultant Peak Power.

Table 3: Correlation table of force plate GRF v 1RMr, 5, 10, 40 yard sprints, and SLJ performance.

	VI	VPF	HI	HPF	RPF	RI	RV	RPP
1RMr	0.064	0.568	0.300	0.539	0.599	0.181	0.181	0.351
5 yard	-0.120	-0.558	-0.266	-0.672	-0.616	-0.281	-0.280	-0.570
10 yard	-0.434	-0.556	-0.046	-0.524	-0.596	-0.356	-0.356	-0.662
40 yard	-0.307	-0.548	0.137	-0.323	-0.553	-0.576	-0.576	-0.701
SLJ	0.536	0.282	-0.070	0.433	0.338	0.275	0.275	0.483

*VI = Vertical Impulse, VPF = Vertical Peak Force, HI = Horizontal Impulse, HPF = Horizontal Peak Force, RPF = Resultant Peak Force, RI = Resultant Impulse, RV = Resultant Velocity, RPP = Resultant Peak Power.

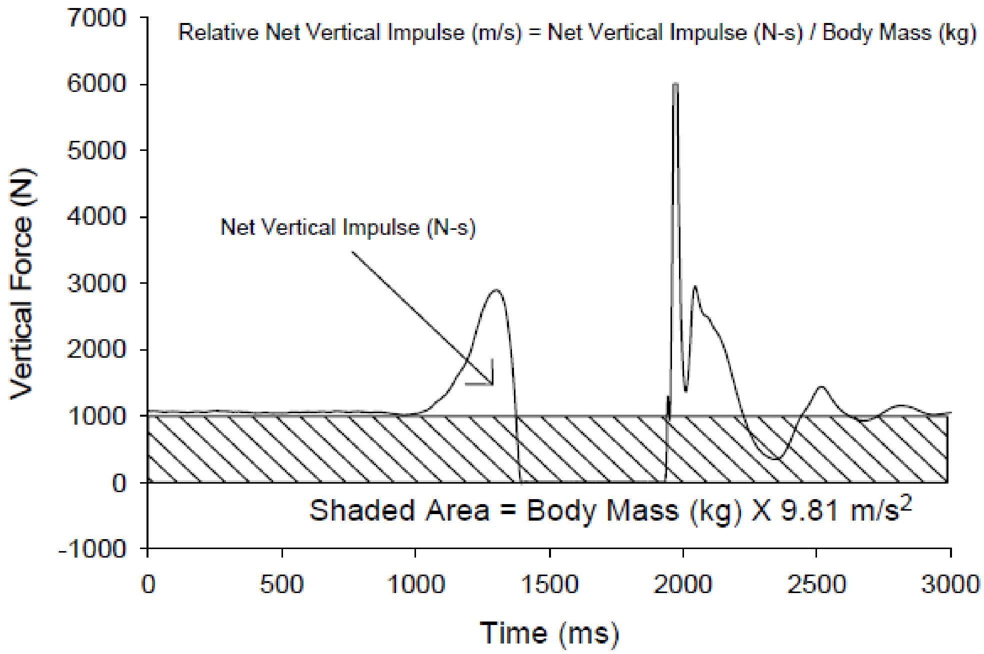

Figure 1: An example of a force-time curve showing relative net vertical impulse.

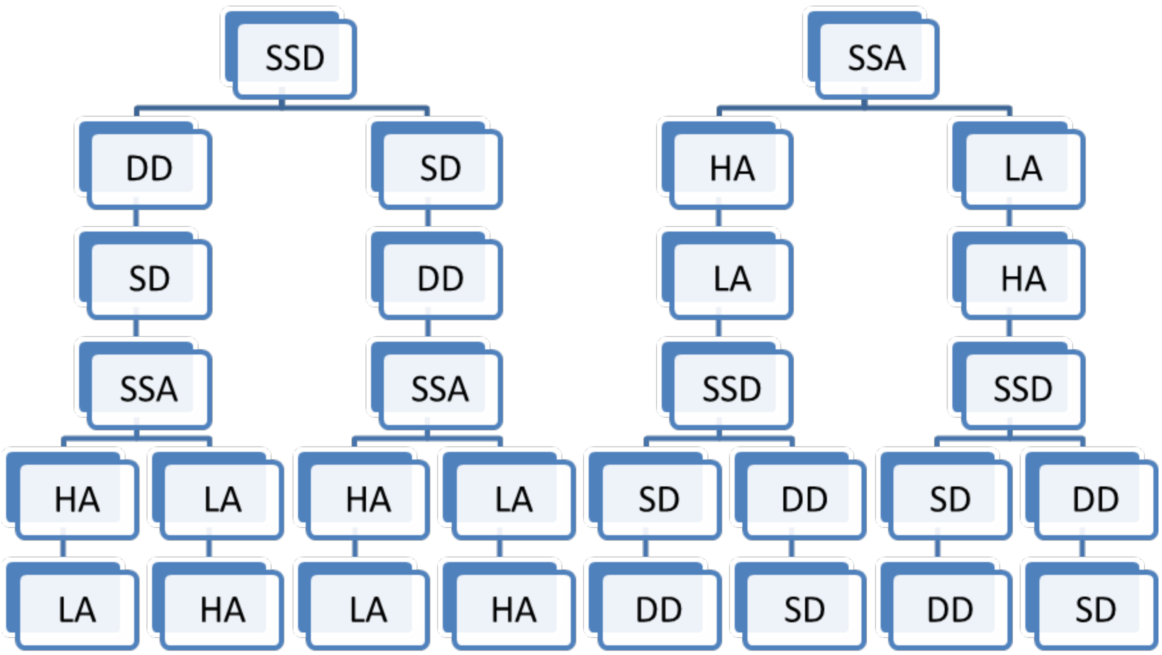

Figure 2: Tree diagram of jump trial selection

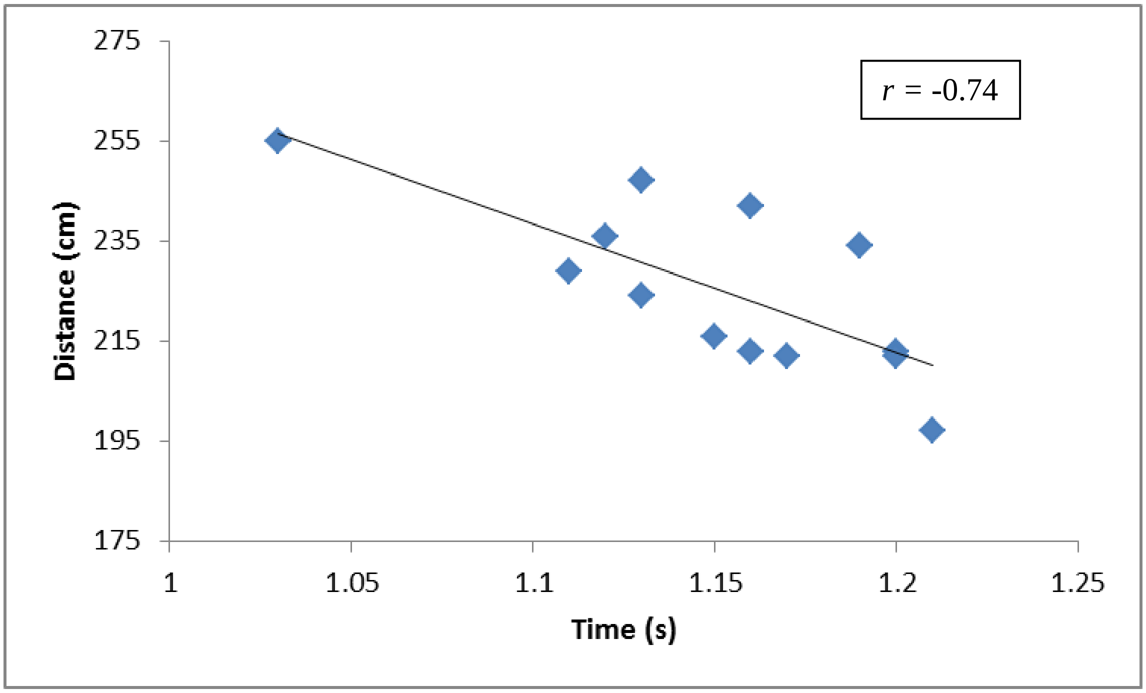

Figure 3: Correlation of SLJ performance and five yard sprint time.

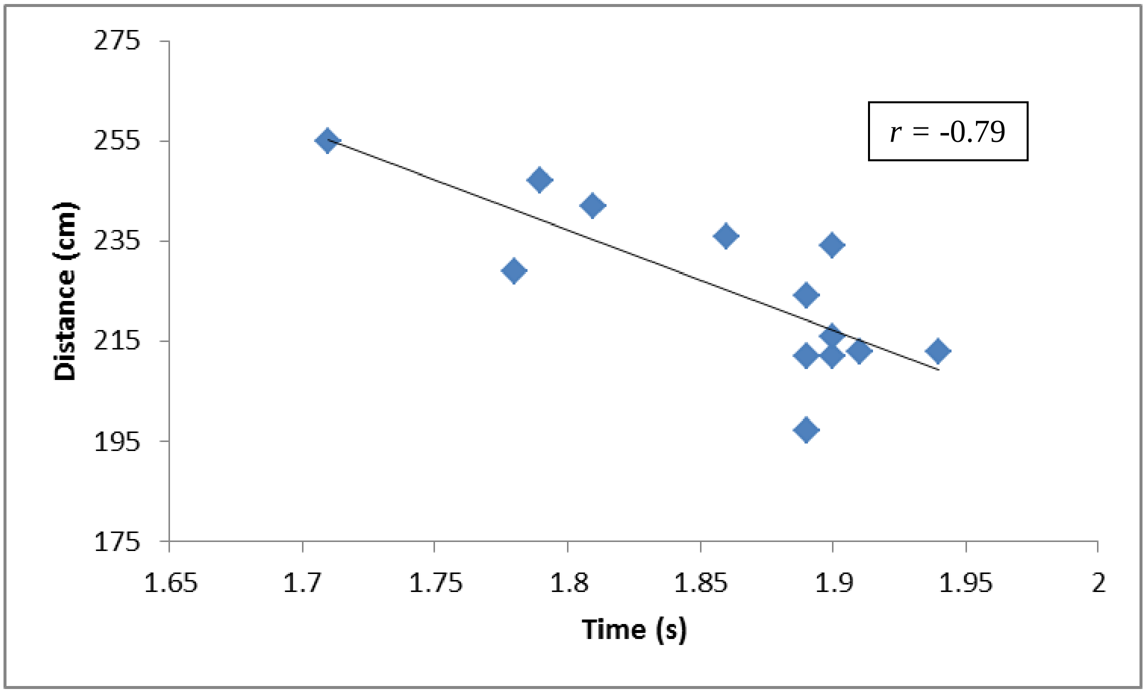

Figure 4: Correlation of SLJ and 10 yard sprint time.

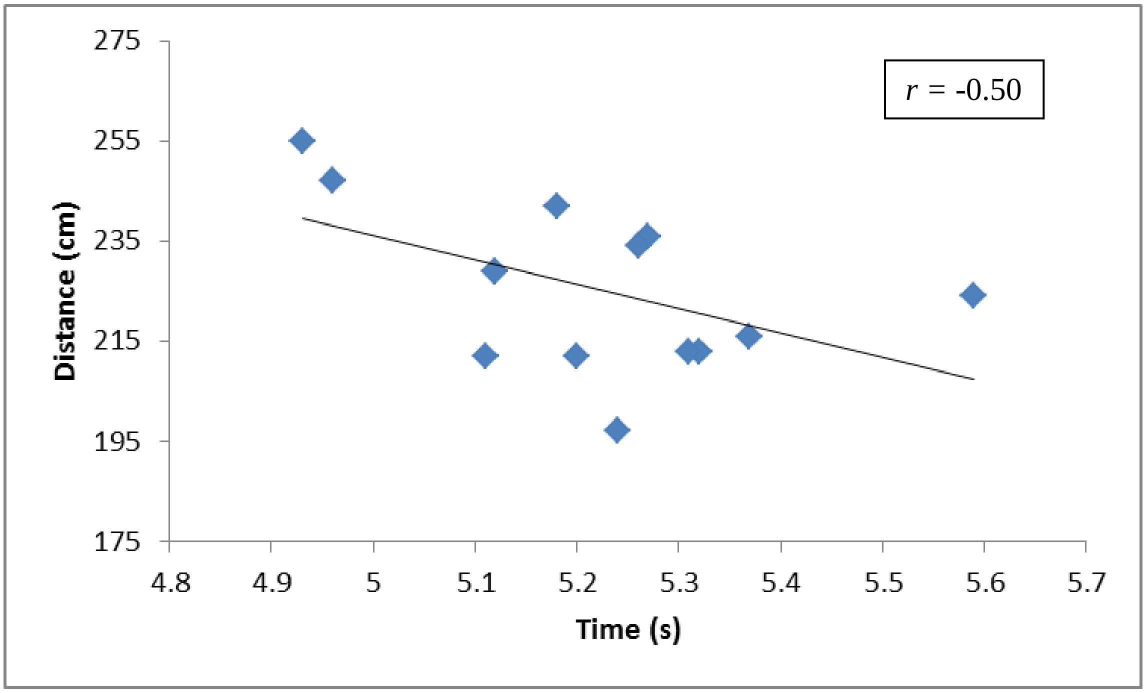

Figure 5: Correlation of SLJ and 40 yard sprint time.

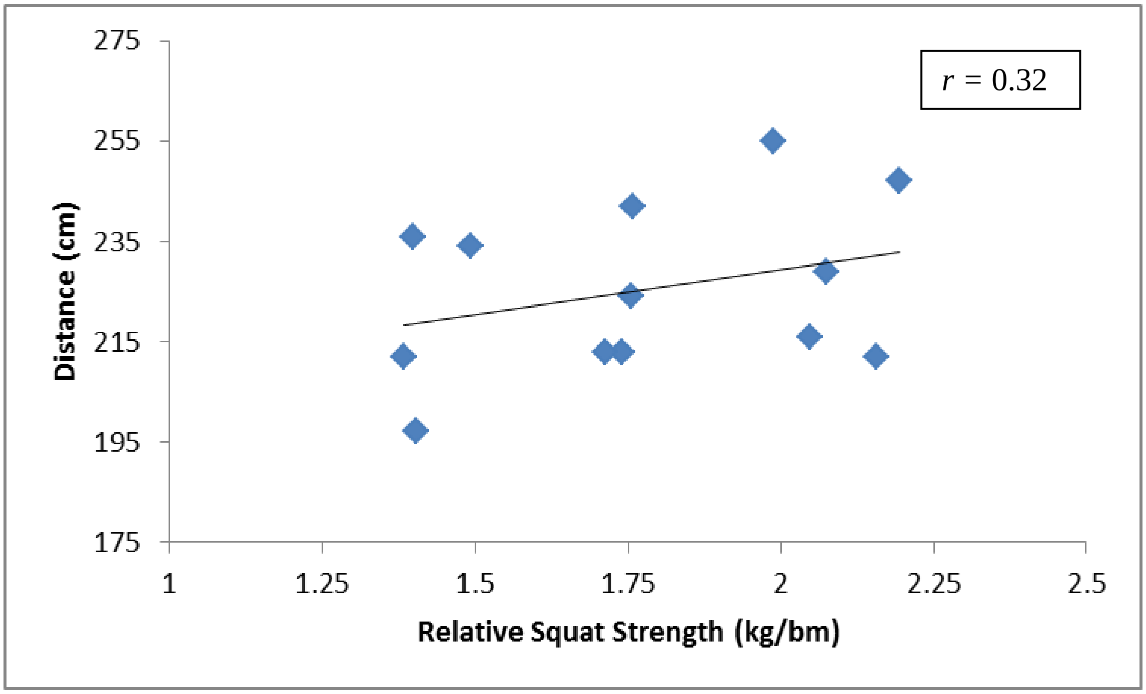

Figure 6: Correlation of SLJ to 1RMr

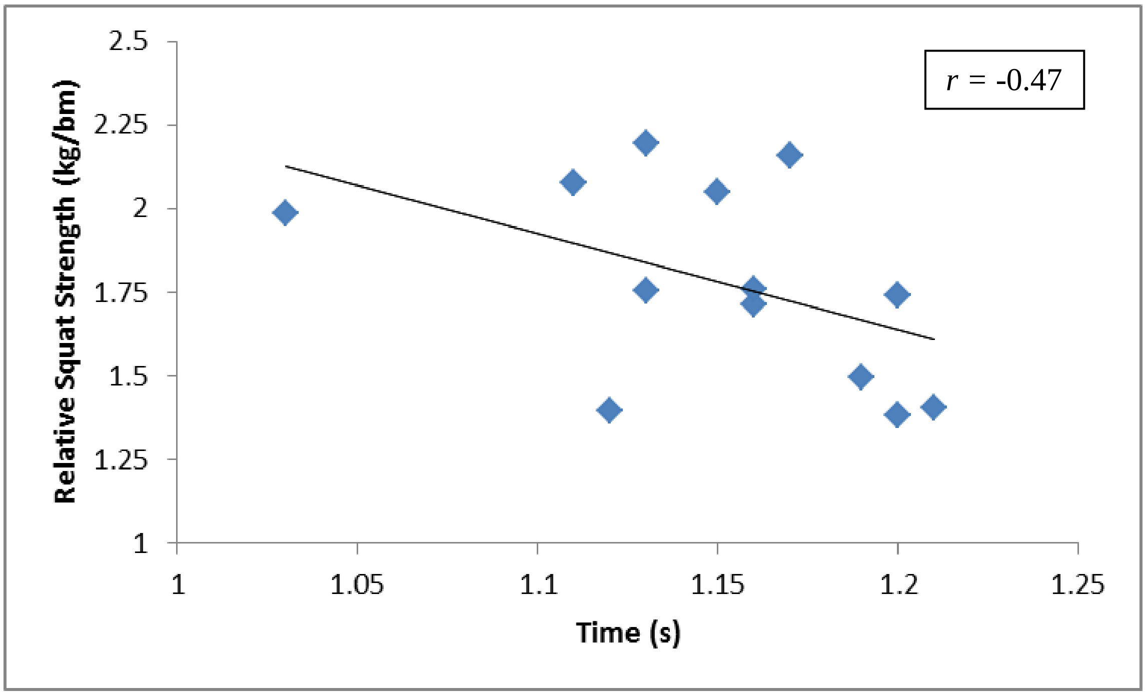

Figure 7: Correlation of 1RMr and 5 yard sprint time.

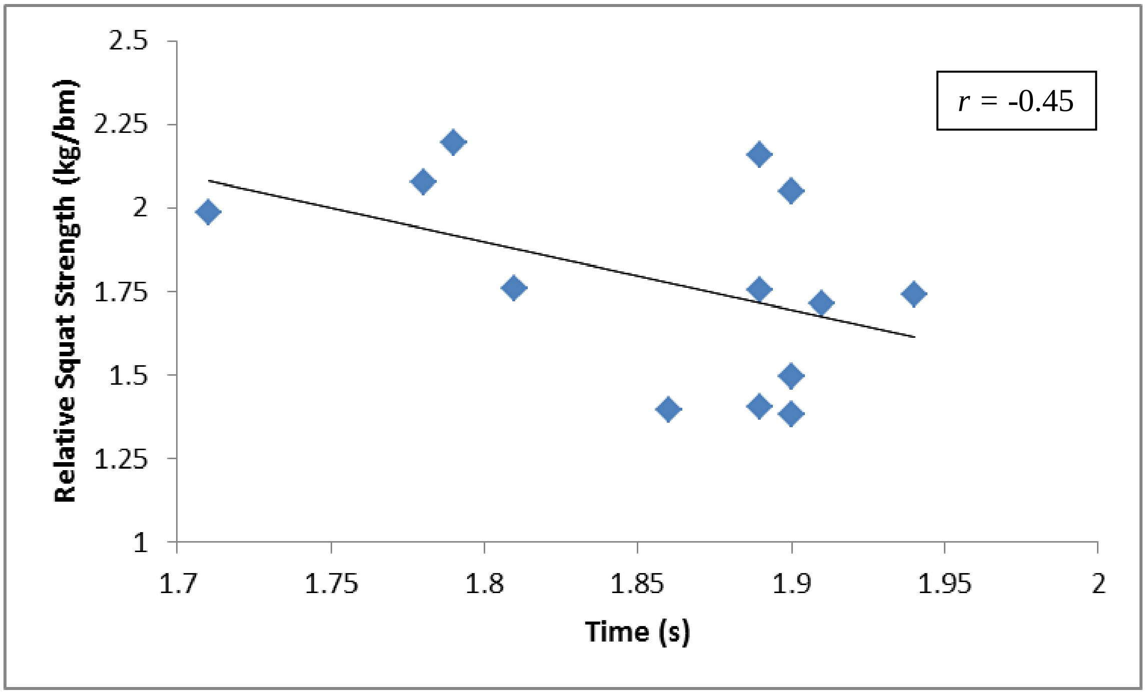

Figure 8: Correlation of 1RMr and 10 yard sprint time.

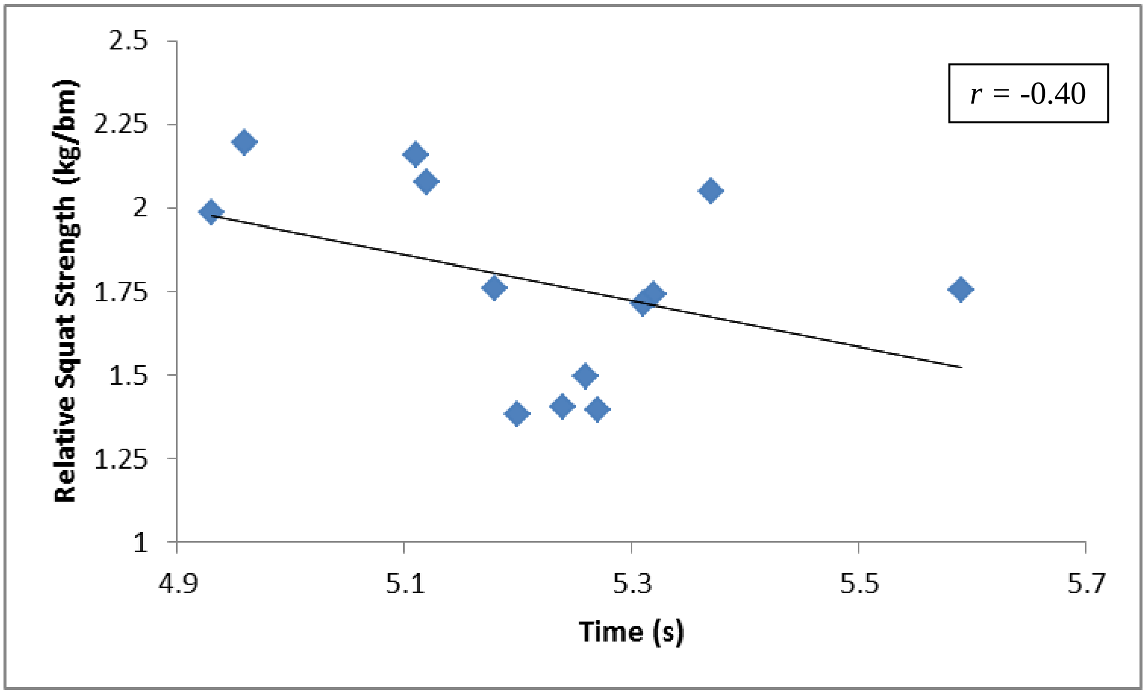

Figure 9: Correlation of 1RMr and 40 yard sprint time.

Appendix A

Institutional Review Board Documentation

Office Use Only
_____-_____

Request for Review of Human Participant Research
Appalachian Human Research Protection Program
IRB # *(To be filled out by IRB Administration)*

Instructions: ***Complete and send the request form electronically to irb@appstate.edu.***
Note: *checkboxes can be checked by putting an "x" in the box.*

Section I: Study Description

1. Study Title: Relationship Between Impulse and Standing Long Jump Performance

2. Study Description: *Please describe briefly the objectives of the study with the purpose, research question and any relevant background information.* The measurement of impulse during vertical jumping has been found to be correlated to jump height. This shows that the impulse can be an important measurement to assist in optimizing athletics performance. However, the analysis impulse and its possible relationship to the standing long jump, which involves both vertical and horizontal movement, have not been performed. The purpose this study will be to see if impulse is correlated with standing long jump performance (distance jumped).

3. Principal Investigator(s) and responsible faculty member if student is the PI: Jeffrey M. McBride Department(s): HLES

4. By submitting this request, the Principal Investigator (and responsible faculty member if PI is a student) accepts responsibility for ensuring that all members of the research team: 1) complete the required CITI training and any other necessary training to fulfill their study responsibilities, 2) follow the study procedures as described in the IRB approved application and comply with *Appalachian's Guidelines for the Review of Research Involving Human Subjects* and all IRB communication and 3) uphold the rights and welfare of all study participants.

The parties (i.e., the IRB and the Principal Investigator and responsible faculty member if PI is a student) have agreed to conduct this application process by electronic means, and this application is signed electronically by the Principal Investigator and by the responsible faculty member if a student is the PI.

My name and email address together constitute the symbol and/or process I have adopted with the intent to sign this application, and my name and email address, set out below, thus constitute my electronic signature to this application.

Dr. Jeffrey M. McBride
mcbridejm@appstate.edu
PI Name PI Email address

Responsible Faculty Name if PI is a student Responsible Faculty Email address if PI is a student

5. Do you plan to publish or present off-campus? [ ] No [X] Yes
6. Does this research involve any out-of-country travel? [X] No [ ] Yes

7. Type of Research, check all that apply: [X] Faculty Research [ ] Dissertation/Thesis/Honor's Thesis
[ ] Product of Learning [ ] Class Project – Course Number:
[ ] Educational Research Involving Normal Education Practices
[ ] Other: describe

8. Source of Funding [X] Not Funded [ ] Funds Awarded [ ] Funds Pending
[ ] Federally Funded [ ] University Funded: describe

If funds awarded/pending, provide sponsor name, Sponsored Programs number:
Attach a copy of the contract/grant/agreement.

9. Is another institution engaged in the research (i.e., an agent of another institution will obtain informed consent, interact with participants to obtain information, or access private identifiable information about participants)?
[X] No [ ] Yes If yes, list institution(s) and whether that IRB will review or rely on the ASU IRB.

10. What, if any, relationship exists between the researcher(s) and agencies (e.g., schools, hospitals, homes) involved in the research? *Attach statement of approval (e.g., letter of agreement) from any agencies that will be involved with the research.* N/A (no agencies involved).

Section II: Research Personnel

Enter each team member (including PI) in the table below. (*A member of the research team is defined as one who will: 1) access participants' private identifiable information, 2) obtain informed consent **or** 3) interact with participants.)*

Name	**Role** (e.g., PI, co-I, Research Assistant, Research Coord., Faculty Advisor, etc.)	**Responsibilities**: Select all that apply from the list of Responsibilities below (e.g., "a, b, c")	**Receive IRB Correspondence** (Y/N)? If yes, provide preferred email address.
Jeffrey M. McBride	PI	a,b,c,f,g,h,j,l,m	mcbridejm@appstate.edu
Kevin Kijowski	Co-I	a,b,c,f,g,h,j,l,m	kijowskikn@appstate.edu
Daniel Knorr	Co-I	a,b,c,f,g,h,j,l,m	knorrdp@appstate.edu
Justin Blatnik	Co-I	a,b,c,f,g,h,j,l,m	blatnikja@appstate.edu

(Note: If you need additional room, you can add rows by going to right click, insert, and then insert rows below. Personnel changes made after IRB approval can be submitted via email with the above information.)

Responsibilities:

a. Screens potential participants	**h**. Conducts physical exams
b. Obtains Informed Consent	**i**. Collects biological specimens (e.g., blood samples)
c. Has access to identifiable data	**j**. Conducts study procedures
d. Administers survey	**k**. Dispenses medications
e. Conducts interviews	**l.** Supervises exercise
f. Enters subject data into research records	**m.** Educates participants, families, or staff
g. Analyzes data with identifiable information	**n.** Other: describe

Note: In some cases, expertise to perform study procedures (e.g., blood draws, interviewing participants about sensitive topics) should be documented by the IRB to show that risks to participants is minimized. The IRB uses the Research Personnel Form to document investigator expertise.

Section III: Conflict of Interest

1. Are there any known or potential conflicts of interest related to this research?

Conflict of interest relates to situations in which financial or other personal considerations may compromise or involve the potential/have the appearance for compromising an employee's objectivity in meeting University responsibilities including research activities.

Examples of conflicts of interest include but are not limited to: an investigator has equity in a business that conducts research in a related area; an investigator will receive an incentive/bonus based on the number or speed of enrollment or outcome of a study; or an investigator or family member is a consultant, holds an executive position or serves as a board member of the research sponsor or its holdings.

[X] No [ ] Yes If yes, describe and explain how participants will be protected from the influence of competing interests.

Section IV: Participant Population and Recruitment

1. Number of participants sought: 20

2. Targeted Participant Population (check all that apply):

X	Adults (>= 18 yrs old)		College Students (only 18 or older)
	Minors (< 18 yrs old) Age range:		College Students (under 18 may participate)
	Minorities		Prisoners
	Institutionalized Participants		Cognitively or emotionally impaired
	Inpatient participants		Non-English speaking
	Outpatient participants		Pregnant Participants
	International research		Employees of a profit or non-profit organization

3. Federal regulations have established guidelines for the equitable selection of participants. Are participants an appropriate group to bear the burdens of this research?

[X] Yes [ ] No If no, please explain:

Are participants a subset of the population most likely to receive the benefits of this research?

[X] Yes [ ] No If no, please explain:

4. Explain any inclusion and exclusion criteria for the study: Subjects must be male and between the ages of 18 and 25. They must have greater than 2 years of strength and power training. During orientation, Participants will be asked to complete the AHA/ACSM screening tool to ensure physical preparedness required in this study. Subjects who are at moderate or high risk of a cardiovascular event will be excluded.

5. Recruitment Procedures (how will you find participants?)

- [ ] Student Subject Pool; indicate pool:
- [x] Email/Mailing/Handout
- [ ] Website ad/Newspaper ads/Flyers/Postings
- [ ] School children with request sent to parents
- [ ] Participants will be approached by staff members
- [ ] Other (explained below)

Recruitment Email: Subjects are needed for a study investigating the relationship between muscle force and standing long jump performance. Qualifications for the study are males between the ages of 18-25 with at least 2 years of strength and power training. If interested contact Daniel Knorr (knorrdp@email.appstate.edu) at 262-408-9750.

A copy of any recruitment materials must be submitted with this application.

6. Explain details of recruitment (e.g., obtain list of student emails from Registrar's office and send them recruitment email): Subjects will be males between the age of 18 and 25 will be recruited from the general population based on the criteria stated in Section IV (#4). Subjects will not be excluded solely on the basis of race, color, or any other demographic characteristic other than age and gender. Females will no be included in this investigation in order to be with previous research concerning this topic which has involved male subjects only. Participants from this study WILL NOT be recruitted from Dr. Jeffrey McBride's classes.

7. Does the research include any compensation, monetary inducements, or reimbursement for participation in this research study?

[X] No [ ] Yes If yes, explain payment schedule:

Section V: Informed Consent Process

1. Explain how informed consent will be obtained. *If applicable, include information about: the setting, whether participants will have an opportunity to ask questions, and the roles of any non-research personnel involved. If potential participants or their legally authorized representatives (e.g., parents) are non-English speaking, please explain how the investigator will identify these participants and ensure their ability to understand information about the study to provide consent.* Seven days prior to the first day of data collection participants will be given an informed consent upon entering the Neuromuscular & Biomechanics Laboratory. A verbal explanation of research procedures will be given, and subjected will also be instructed to read through the information and ask questions at any time. The Primary Investigator (McBride) or a co-investigator (Kijowski, Blatnik, Knorr) will be available as they read through the form to answer any questions.

2. If applicable, describe the safeguards in place to protect the rights and welfare of any vulnerable participants *(e.g., children, prisoners, pregnant persons, or any population that may be relatively or absolutely incapable of protecting their interests through the informed consent process).* N/A

3. Select factors that might interfere with informed consent:

X	None known
	Research will involve current students in a course/program taught by member of research team
	Participants are employees whose supervisor is recruiting/requiring participation
	Participants have a close relationship to research team
	Other (please specify/indicate any relationship that exists between research team and participants):

For selected factors, describe any efforts to mitigate:

4. Will participants sign a consent form?
[X] Yes [ ] No

If no, participants must still be provided with a statement regarding the research and one of the following criteria must be met and selected and followed:

[ ] The only record linking the participant and the research is the consent document and the principal risk is potential harm resulting from a breach of confidentiality, and the research is not FDA-regulated. Each participant will be asked whether he/she wants documentation linking the participant with the research and the participants wishes will govern; OR

[ ] The research presents no more than minimal risk of harm and involves no procedures for which written consent is normally required outside of the research context.

5. Are you requesting a modification to the required elements for informed consent for participants or legally authorized representatives?
[X] No [ ] Yes If yes, address criteria to waive elements of consent:

Section VI: Study Procedures

1. Projected data collection dates: September 20, 2012 to November 10, 2012

2. Describe research procedures as they relate to the use of human participants. *Information should include what participants will be asked to do, duration of procedures, and frequency of procedures*. Participants in this investigation will visit the Holmes Convocation Center's Neuromuscular & Biomechanics Laboratory (NBL) for two testing sessions lasting approximately one hour each. The two sessions will be separated by at least 72 hours. On Day 1 participants will be asked to complete the AHA/ACSM screening tool to ensure physical preparedness required in this study. Subjects who are at moderate or high risk of a cardiovascular event will be excluded. Height and weight will then be obtained for each subject. Subjects one repetition maximal strength in the squat will then be determined. The squat test will involve a warm-up protocol involving 2 sets of 8-10 repetitions at 30%, 4-6 repetitions at 50%, 2-4 repetitions at 70%, and 1 rep at 90% of an estimated 1RM or 1.5-2.5x their bodyweight, depending on training status. The load prescription will be subject to researcher assistant's discretion and will also determine the load to be used for each set. Subjects will then be allowed up to 3-4 attempts at increasing weights to obtain their 1RM, increases will be subject to research assistant's discretion and recommendations. Subjects begin the squat by standing with their feet shoulders width apart, barbell positioned on their upper back. They will squat down to 80 degrees as determined by the researcher, and return to a standing position. The knee angle will be measured prior to attempts and adjustable stoppers will be set there. On Day 2 subjects will perform six trials of a standing long jump with 2 minutes of rest allowed between each trial. Subjects will begin by standing on a force plate and will place their toes on a line marked with athletic tape. The subjects will be instructed to drop down slightly and then explode upwards and outwards attempting to jump as far (horizontally) as possible. The distance jumped will be determined by a tape measure secured to the floor. Squat and standing long jump performance will be monitored by a Certified Strength & Conditioning Coach (CSCS), as regulated by the National Strength & Conditioning Association. Injury potential with the squat and standing long jump is no more than that of any other type of resistance training exercise or other general types of exercise which includes muscle strains or pulls.

3. Participants' identification (check one):

- [ ] Information is collected so that participants CANNOT be identified directly (by names, images or other identifiers) or indirectly (by linking responses to participants).
- [X] Information is collected so that participants CAN be identified, either directly or indirectly, by the research team but identifying information will not be disclosed publicly.
- [ ] Information is collected so that participants CAN be identified, either directly or indirectly, by the research team and identifying information will be disclosed publicly.

4. Check all locations of study procedures that apply:

	N/A – online survey
X	Appalachian campus, indicate building: Holmes Convocation Center, Neuromuscular & Biomechanis Laboratory
	School system(s):
	Human Performance Lab, NCRC
	Off-campus location(s). List:

5. Data collection

5a. Please check all data collection activities involved in this study:

	Paper Surveys / Questionnaires
	Online Surveys / Questionnaires Name of Survey Provider:
	Telephone Surveys / Questionnaires Name of Survey Provider:
	Standardized Written / Oral / Visual Tests
	Interviews
	Focus Groups
	Tasks
	Public Observation
	Classroom Observation/Work Site Observation
	Voice, video, digital or image recordings made for research purposes
	Materials (i.e., data, documents, records/specimens) that have been collected or will be collected for **non research** purposes
	Collection or study of materials (i.e., data, documents, records/specimens) that are publicly available or if the information is recorded so that participants cannot be identified, directly or indirectly through identifiers
	Materials (i.e., data, documents, records/specimens) that have been collected for

- [ ] another research project
- [X] Moderate exercise and muscular strength testing
- [ ] Other:

5b. If your study does not involve biomedical procedures skip to question #6.
Otherwise, select all data collection activities that apply:

- [ ] Blood samples by finger stick, heel stick, ear stick or venipuncture

Indicate the type of participants and how much blood will be drawn:

- [ ] from healthy, non pregnant adults who weigh at least 110 pounds
- [ ] from other adults or children
- [ ] How many times per week will blood be drawn?
- [ ] How much blood will be drawn at one time?
- [ ] How much blood will be drawn in an 8-week period?
- [ ] How often will collection occur?

- [ ] Noninvasive procedures to collect biological specimens for research purposes
- [ ] Sterile Surgical/Invasive procedures
- [ ] Banking of biological materials
- [ ] Noninvasive procedures to collect data such as use of physical sensors applied to surface of body and electrocardiography
- [ ] Procedures involving x-rays (e.g., DEXA scan for body composition)
- [ ] Ingestion of wholesome foods without additives
- [ ] Ingestion/application of substances other than wholesome foods without additives
- [ ] Clinical study of a drug/medical device
- [ ] Obtaining medical data from a health care provider, health plan or health care clearinghouse
- [ ] Genetic Testing
- [ ] Other: describe

5c. Is this research FDA-regulated (i.e., It is an experiment that involves one or more of the following test articles: foods/dietary supplements that bear a nutrient content/health claim, infant formulas, food/color additives, drugs/medical devices/biological products for human use)?

[ ] No [ ] Yes

6. Is deception involved?

[X] No [ ] Yes If yes, please describe:

7. Does the data to be collected relate to any illegal activities (e.g., immigration status, drug use, abuse, assault)?

[X] No [ ] Yes If yes, please describe:

Section VII: Confidentiality and Safeguards

1. In most cases, the research plan should include adequate provisions to protect the privacy of subjects. How will the confidentiality of participants be maintained (e.g., how will access to participants be controlled)?
Subjects will be referred to only by subject code and all data and results will be kept in a locked file cabinet in the Neuromuscular & Biomechanics Laboratory. The key to the subject code will be destroyed within two years of collecting data. Individual data will not be reported in results of final publication.

2. Will collected data be monitored to ensure the safety of subjects (e.g., survey includes a question about suicidality so the investigator will…)?

X	No		Yes	If yes, please explain procedures to ensure safety of participants:

3. Describe what will be done with the data and resulting analysis:
The data will be analyzed and statistical significance testing will be performed for interpretation of the results. A manuscript will be submitted for publication and the study will be presented at a national conference.

4. Describe measures you are taking to safeguard study data (check all that apply):

	Data is not linked to identifying information
X	Maintain consent forms in a separate location from data
X	Using subject codes on <u>all</u> collected data and maintaining the key linking subject codes with identifiable information in a separate location from data
X	Locking cabinets/doors. List location: Neuromuscular & Biomechanics Laboratory
X	Data kept in area with limited public access. List location: Neuromuscular & Biomechanics Laboratory
X	Password protected computers
	Encryption
	PDAs and removable media (e.g., CDs, etc.) will be kept in a secure location. List location:
	Other, please describe:

5. Data Sharing

5a. What type of data will be shared? (*Note: Sharing includes releasing, transmitting and providing access to <u>outside</u> of the research team.)* Check all that apply:

	Data collected anonymously
	Anonymized or De-linked data. Identity was once associated with data/specimen but identifying information destroyed
X	Coded and linked data (Data is coded. With the code, the data may be linked back to identifiers, but the link back to identifiers will not be shared.)
	Identifiable Data (e.g., names, email addresses, date of birth, IP addresses) Indicate which secure method(s) of transmission will be used:

5b. If identifiable data will be shared within or outside of the research team, please explain how it will be shared (check all that apply):

- [ ] Secured Website. Please provide name of website:
- [ ] Encrypted email
- [ ] U.S. Postal Service or other trackable courier services
- [ ] Fax in a secured area
- [ ] Shared drive with password protection
- [ ] Personal delivery by member of research team
- [ ] Private telephone conversation to member of research team
- [ ] Other, please describe:

6. Secure Disposal: *Note: consent forms should be stored for 3 years after study completion.*

6a. How long will the data be stored?

	1 year after study conclusion	X	5 years after study conclusion
	Indefinitely		Data without identifiers stored indefinitely
	Other, please describe (e.g., sponsor requirements):		

6b. How will data be destroyed?

X	Paper will be shredded		Biological samples will be destroyed by:
X	Destroy electronic files from computer/PDAs/removal media (CDs, diskettes) by: Deletion		
	Other, please describe:		

Section VIII: Risk and Benefits of Study

1. The risks to participants must be reasonable in relation to anticipated benefits, if any, to participants and the importance of the knowledge that may be reasonably be expected to result. Select all applicable:

[X] Participants of the study may directly benefit by (describe)*:* Subjects will receive their individual results from the study and provided with comparative norms to provide them with knowledge of their current standing long jump performance while being taught correct squat and standing long jump form. [*Note that compensation is not considered a benefit.]*

[X] Society may benefit from the study by (describe): Subjects will be informed of their valued participation in expanding the body of knowledge in the area of exercise science.

2. Describe the potential risks (e.g., psychological, legal, physical, social harm, loss of confidentiality) to any individual participating in this project: Injury potential associated with the squat and standing long jump is no more than that of any other types of resistance training exercise or other general types of exercise which includes muscle strains or pulls.

3. Assessment of level of risk:

- [X] Risks (including physical, emotional, social, legal or financial) are the same as encountered in daily life or during the performance of routine physical or psychological examinations or tests (minimal risk).
- [ ] Risks are more than minimal in that either: a) the probability of harm or discomfort anticipated, or b) the magnitude of harm or discomfort anticipated is greater than that encountered in daily life.
- [ ] Information to be collected could cause participants to be at risk of criminal or civil liability if responses are disclosed outside of the research setting.
- [ ] Information to be collected could be damaging to participant's financial standing, employability, or reputation if disclosed outside of the research setting.

4. Describe procedures for protecting against, or minimizing, the potential risks: Each subject will be given proper instruction and adequate monitoring during the squat and standing long jump. During this time they will be given time to ask questions. A Certified Strength and Conditioning Coach (CSCS), as regulated by the National Strength & Conditioning Association, will monitor the testing and training procedures. They will also be first aid and CPR certified.

5. If human subject data/specimens will be used for future research that is not described above, please explain. (Future use of data/specimens should be disclosed to the participant in the informed consent.) Data from this study may be used in a future study comparing different subject populations with different training statuses. N/A

Please check any materials below that will be submitted with your application. Note: please submit as separate files.

- [ ] Recruitment wording
- [X] Consent form(s)
- [ ] Letter(s) of Agreement
- [ ] Research Personnel Form(s)
- [X] Instruments (Survey questions, interview questions, etc.)
- [ ] Copy of grant/contract/agreement
- [ ] Other (please describe):

Consent to Participate in Research
Information to Consider About this Research

Relationship Between Impulse and Standing Long Jump Performance

Principal Investigator: Jeffrey M. McBride

Department: Health, Leisure & Exercise Science

Contact Information:

Jeff McBride, (828-262-6333) (mcbridejm@appstate.edu)
045 Convocation Center
Boone, NC 28607

What is the purpose of this research?

The measurement of impulse (muscle force) during vertical jumping has been found to be related to maximal jump height. This shows that the impulse can be an important measurement to assist in optimizing jumping performance. However, the analysis impulse and its possible relationship to the standing long jump, which involves both vertical and horizontal movement, have not been performed. The purpose this study will be to see if impulse is correlated with standing long jump performance (distance jumped).

Why am I being invited to take part in this research?

You are being invited to take part in this research because you are male between the ages of 18 and 25 and because of your experience in strength and power training.

Are there reasons I should not take part in this research?

You are free to withdraw from the study at any time without penalty. You are free not to answer any questions or respond to experimental situations that you choose without penalty. There may be circumstances under which the investigator may determine that you should not continue to participate in the study. To participate in this study you should be physically fit. You will be asked to complete a health screening tool to ensure you’re able to participate in this study.
If you volunteer to take part in this study, you will be one of approximately 20 people to do so. **What will I be asked to do?**

You will be asked to visit the Holmes Convocation Center’s Neuromuscular & Biomechanics Laboratory (NBL) for two testing sessions lasting approximately one hour each. The two sessions will be separated by at least 72 hours. On Day 1 you will be asked to complete the AHA/ACSM screening tool to ensure physical preparedness required in this study. If you are at moderate or high risk of a cardiovascular event you will be excluded. Your height and weight will then be obtained. You then will perform a one repetition maximal strength test (1RM) in the squat The squat test will involve a warm-up protocol involving 2 sets of 8-10 repetitions at 30%, 4-6 repetitions at 50%, 2-4 repetitions at 70%, and 1 rep at 90% of an estimated 1RM or 1.5-2.5 x your bodyweight. You will then be allowed up to 3-4 attempts at increasing weights in order to obtain your 1RM. The squat test will involve standing with your feet shoulders width apart with a barbell positioned on your upper back. You will squat down by bending your knees and return to a standing position. On Day 2 you will perform six trials of a standing long jump with 2 minutes of rest allowed between each trial. You will begin by standing on a force plate and will place your toes on a line marked with athletic tape. You will be instructed to drop down slightly and then explode upwards and outwards attempting to jump as far (horizontally) as possible. The distance jumped will be determined by a tape measure secured to the floor.

What are possible harms or discomforts that I might experience during the research?

Squat and standing jump performance will be monitored by an individual who is a Certified Strength & Conditioning Coach (CSCS) as regulated by the National Strength & Conditioning Association as well as being certified in first aid and CPR. Injury potential with the squat and standing long jump is no more than that of any other type of resistance training exercise or other general types of exercise which includes muscle strains or pulls.

What are possible benefits of this research?

We do not know if you will receive any benefits by taking part in this study. This research should help us learn more about training to manipulate impulse and therefore standing jump performance. By participating in this study you will be given information concerning your standing long jumping performance.

Will I be paid for taking part in the research?

There will be no financial compensation for participating in this study.

How will you keep my private information confidential?

Your information will be combined with information from other people taking part in the study. When we write up the study to share it with other researchers, we will write about the combined information. You will not be identified in any published or presented materials. Confidentiality of your records will be maintained at all times during and after your involvement in this study. Individual data collected will remain confidential and will not be disclosed in any published document or shared with anyone but the experimenters.

What if I get sick or hurt while participating in this research study?

If you need emergency care while you are at the research site, it will be provided to you. If you believe you have been hurt or if you get sick because of something that is done during the study, you should call your doctor or if it is an emergency call 911 for help. In this case, tell the doctors, the hospital or emergency room staff that you are taking part in a research study and the name of the Principal Investigator. If possible, take a copy of this consent form with you when you go. Call the principal investigator, Dr. Jeff McBride (828-262-6333) as soon as you can. He needs to know that you are hurt or ill.

If you are injured during the study, there are procedures in place to help attend to your injuries or provide care for you. Costs associated with this care will be billed in the ordinary manner, to you or your insurance company. However, some insurance companies will not pay bills that are related to research costs. You should check with your insurance about this. Medical costs that result from research-related harm may also not qualify for payments through Medicare, or Medicaid. You should talk to the Principal Investigator about this, if you have concerns.

Who can I contact if I have a question?

The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the Principal Investigator at 828-262-6333 (Jeff McBride). If you have questions about your rights as someone taking part in research, contact the Appalachian Institutional Review Board Administrator at 828-262-2130 (days), through email at irb@appstate.edu or at Appalachian State University, Office of Research and Sponsored Programs, IRB Administrator, Boone, NC 28608.

Do I have to participate? What else should I know?

Your participation in this research is completely voluntary. If you choose not to volunteer, there will be no penalty and you will not lose any benefits or rights you would normally have. If you decide to take part in the study you still have the right to decide at any time that you no longer want to continue. There will be no penalty and no loss of benefits or rights if you decide at any time to stop participating in the study. This research project has been approved by the Institutional Review Board (IRB) at Appalachian State University. This study was approved on 10/17/12. This approval will expire on 10/16/13 unless the IRB renews the approval of this research.

I have decided I want to take part in this research. What should I do now? The person obtaining informed consent will ask you to read the following and if you agree, you should sign this form:

- I have read (or had read to me) all of the above information.
- I have had an opportunity to ask questions about things in this research I did not understand and have received satisfactory answers.
- I understand that I can stop taking part in this study at any time.
- By signing this informed consent form, I am not giving up any of my rights.
- I have been given a copy of this consent document, and it is mine to keep.

Participant's Name (PRINT) Signature Date

Vita

Daniel Paul Knorr was born in Milwaukee, Wisconsin, on June 15th, 1989. After graduating from Homestead High School, he attended the University of Wisconsin – La Crosse and graduated with honors with a Bachelor of Science in Exercise and Sport Science – Strength and Conditioning Concentration and Nutrition minor. After graduating, he went straight to pursue his Master of Science Degree from Appalachian State University in August 2011. Here, he took a graduate assistantship in the exercise science lab under Dr. Rebecca Battista. Daniel was awarded his Masters of Science from Appalachian State University in May 2013. Daniel plans to pursue a career in the strength and conditioning field coaching elite athletes of all ages. Daniel's parents are Margaret and James Knorr who reside in Thiensville, Wisconsin.